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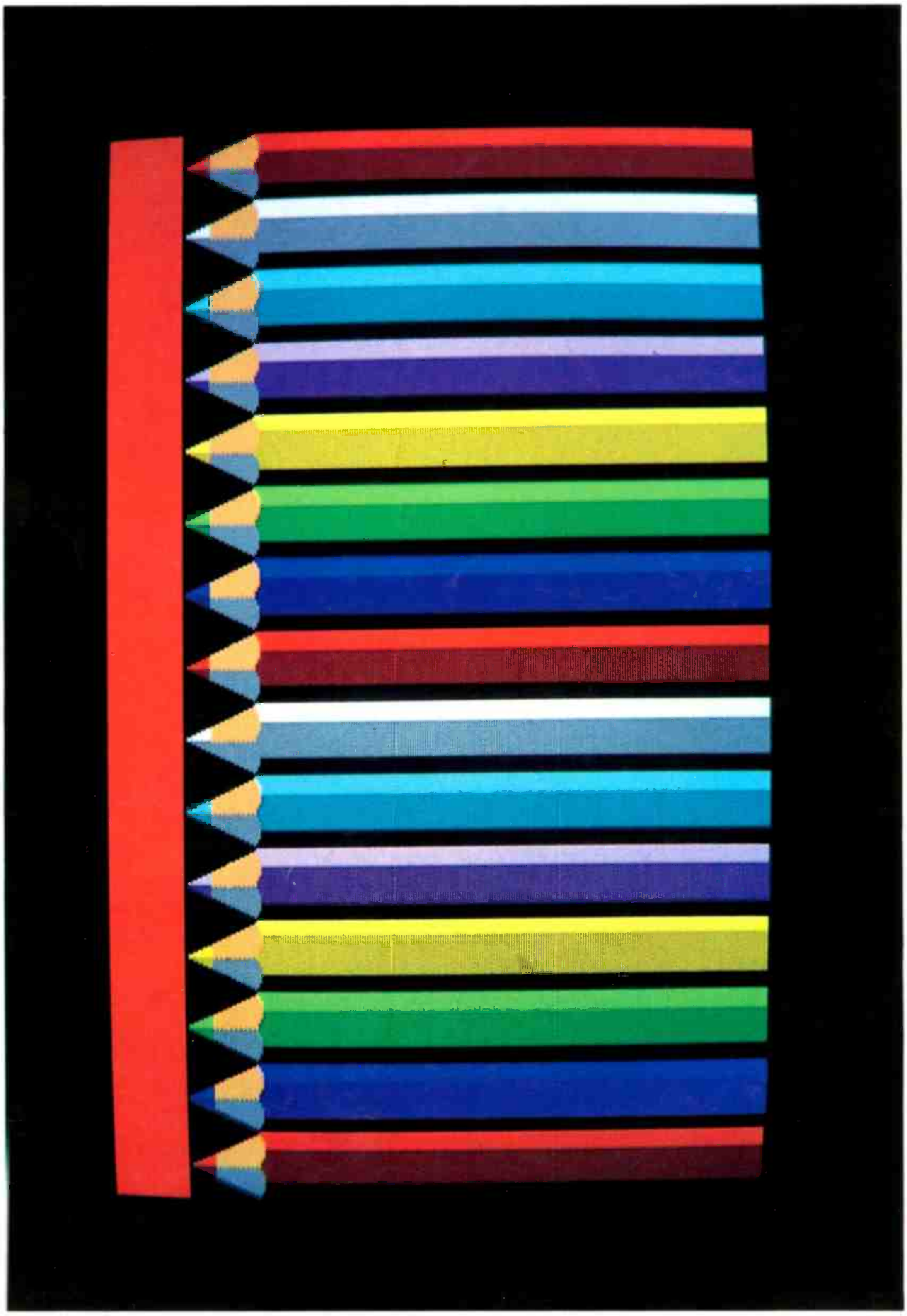

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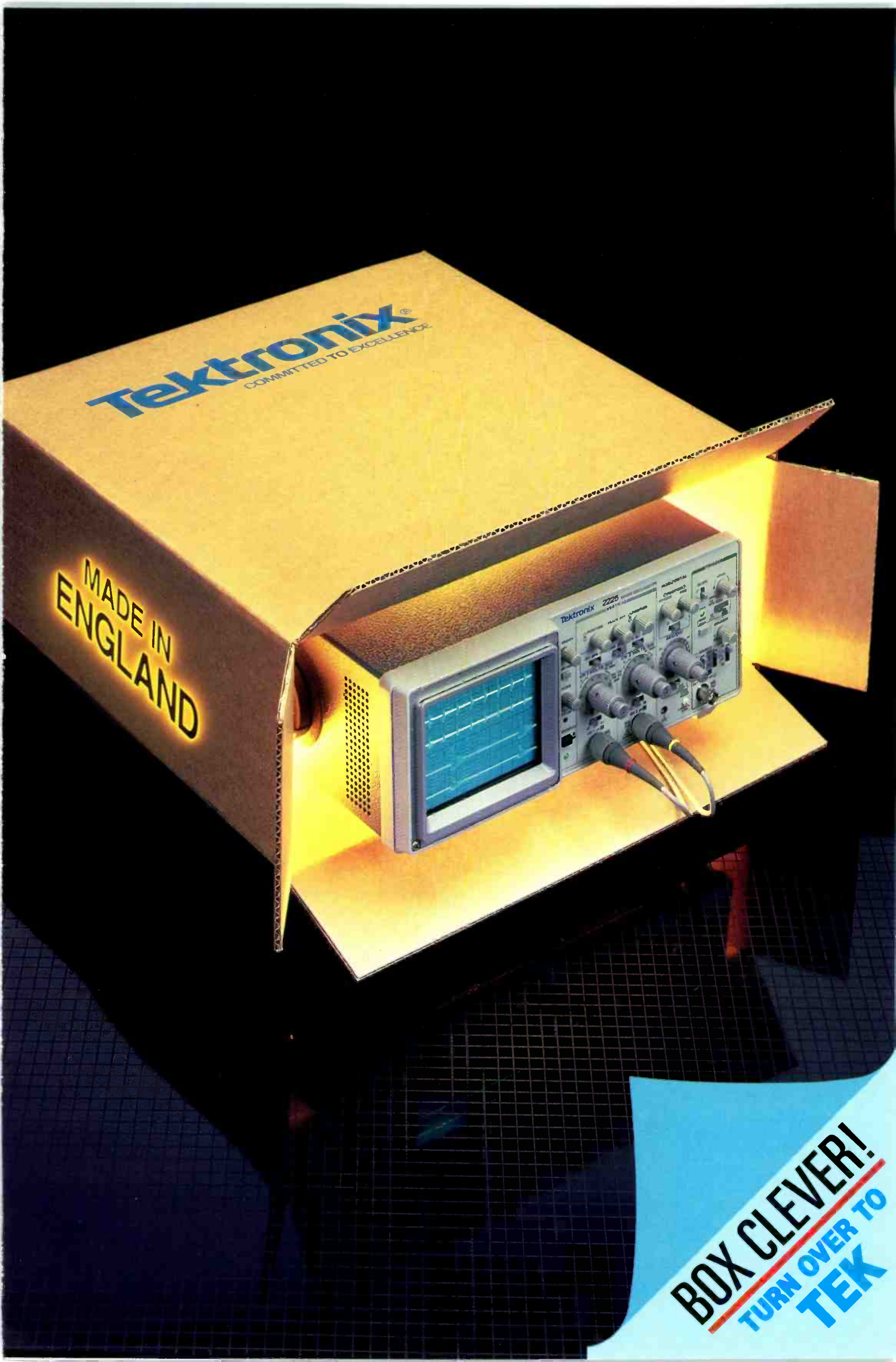

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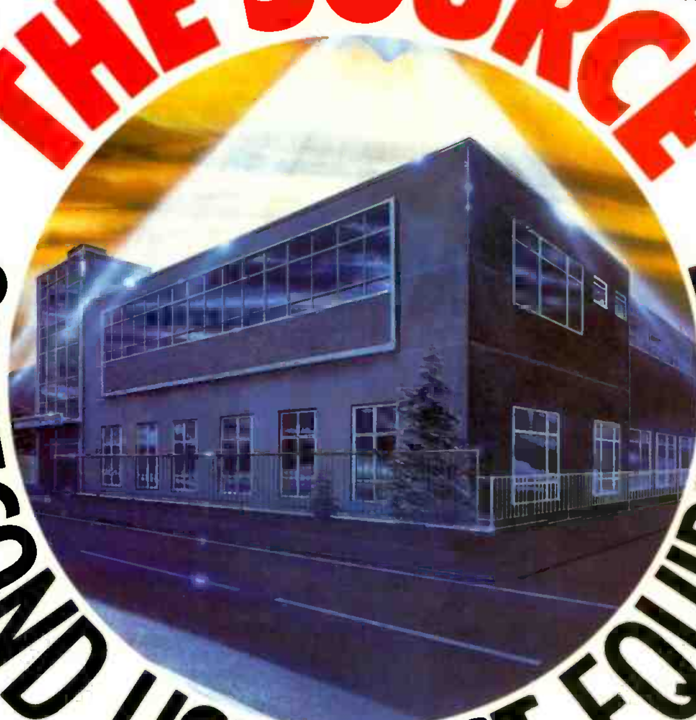

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Science education

After over a century of technology, science and engineering still possess a disreputable image, and it is costing this country dear. Furthermore, it is possible that it is already too late to do anything about it.

There is a profound, but seldom defined feeling in this country that engineering, together with any occupation concerned with selling, comes slightly below house-breaking as a career that one might recommend to a high-flying school-leaver.

Further, although teaching is (or was) considerably more respectable as a profession than any kind of engineering, a teacher forced to confess to being of the scientific persuasion immediately loses several points in the upwardly mobile section of society. Even if this is unimportant to a dedicated imparter of knowledge, what is important is that the equipment needed to teach science or engineering properly is in extremely short supply. Books are scarce, money (both for supplies and for salaries) is short and, if it were not for the shower of computers recently and inexplicably rained on astonished teachers, the feeling of being in the wrong century must be overpowering.

The problem is a circular one – it possesses positive feedback, which is dangerously close to locking the whole system up. Starting anywhere in the system, it goes like this: low status and lack of facilities and low salaries drive science teachers away from the profession; the number of university entrants reading science or engineering is falling; fewer graduates in these subjects are available to teach the next generation; fewer university entrants... And all the time, of course, there are fewer good graduates going into industry, for precisely the same reasons.

There is probably only one feasible way to break the spiral. A good grounding in maths and science is obviously of first importance in any approach to a career in our field. If the teaching of these subjects is to be made attractive, there must be no more attempts at it by unqualified people, pressed into it by a lack of anyone more able. The requirements for new teachers should be brought back up to the proper level and salaries made to compare reasonably well with those in industry, perhaps with assistance from that industry.

"Cut-backs" have been made the scapegoat for shortcomings in virtually every sector of education, but this stage of teaching – GCSE science and mathematics – is possibly a more sensitive part of the system than any other, where available resources must be applied in a responsible manner. If it is thought necessary to provide computers for all, well and good: but they should not displace more conventional aids to education, like teachers, books and apparatus.

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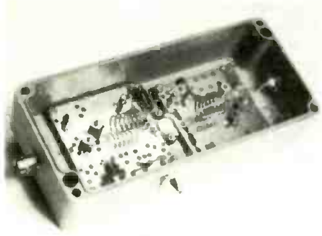

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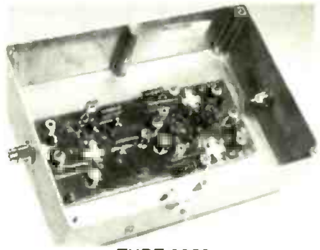

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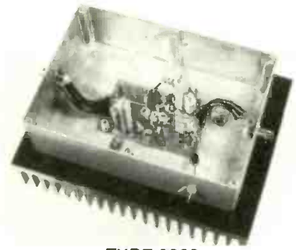

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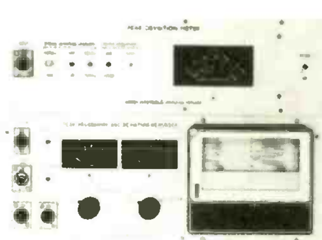

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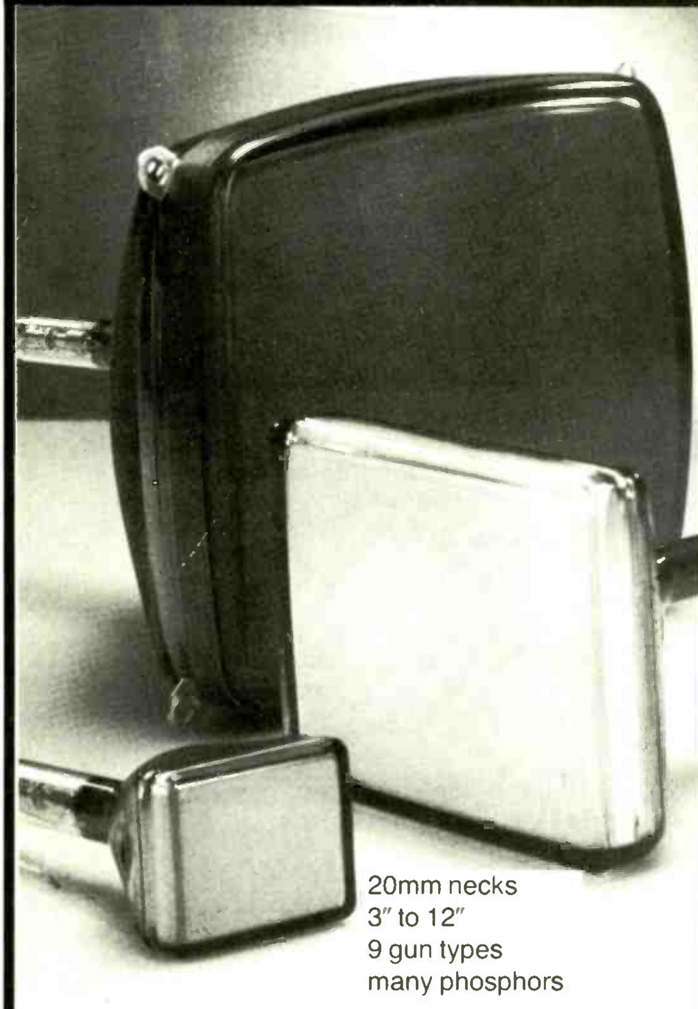

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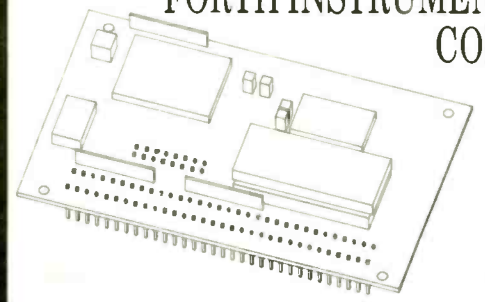

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Logic analysis – an introduction

Logic analysers are basic tools for the development of microprocessor applications. As processors become more complex and fast it is necessary for the analysers to keep up with them. We explore some of the facilities available on analysers.

The introduction of the microprocessor brought along with it a complexity that needed new tools for development and test applications; specifically, logic analysers, in-circuit emulators, word pattern generators and memory and other device programmers. Since then more complexity has been packed into less chip space and there is a constant challenge for instrument manufacturers to keep up with the latest devices.

The increasing complexity of integrated circuitry needs to be reflected in the increasing complexity of the tools. At the same time they should be easy to use so there is also a trend towards concealing the complexity in interfaces that make them more friendly and avoid the appearance of complexity.

As micro electronic components get cheaper it is necessary for the tools also to be low-cost for the user to gain any advantage in their use, which tends to divide the market between the high-end devices that can cope with the latest micro-technology and the low-cost instruments for normal day-to-day applications. This has led to the 'personal' logic analyser which is low enough in cost to be used by one operator, compared with a costly high-end instruments used by the whole lab.

The analyser is itself a computer, so it is possible to simulate the functions of an analyser as a computer program. Such programs are available for running on many of the computers found in laboratories. Some of the functions can be delegated to a 'front-end' analyser, whose output is relayed to a computer for storage and display.

All analysers need a probe to physically contact the device under test and this is designed to be specific to the device – a 'personality' probe. This is so that the signals on the pins coincide with the expected signals by the analyser. The probe can include some processing power on internal i.cs (in the jargon, a 'smart' or 'intelligent' probe) or just re-route the signals to the analysers' inputs. The logic analyser has many functions. All digital signals have an on-off condition and the analyser can act like a multi-channel oscilloscope, displaying the sequences of ons and offs coming from the pins of an integrated circuit. By displaying a number of sequences on a screen it is possible to compare the time relationships of signals and discover any glitches that may be present.

What the device under examination is actually doing is determined by sequences of 1s and 0s entering and leaving it, so another function of the analyser is to display these as columns of 'words', indicating the logic state of the device. These words can be disassembled into computer instructions understandable by the operator so disassembly is often included in logic analysers' repertoire.

Thandar are tackling both high and low ends of the spectrum of analysers. The TA2000 is a low-cost instrument offering 32 channels of 25MHz or eight channels at 100MHz. It features multi-level triggering, 5ns glitch capture and glitch trigger. Three external clocks have independent thresholds. RS232, GPIB and Gentronics links are provided, as is non-volatile storage of data and set-ups. TA3000 interactively combines 8 or 16 channels or 100MHz timing with 32, 64, or 96 channels of 20MHz state analysis. Cross triggering of the timing channels by the state sequencer allow a 'snapshot' to be taken of the hardware activity at a specific point in the operation of the circuit under test. The instrument has full CP/M+ computing facilities.

This needs to be specific to the device under test and may be stored internally on a rom or download from a disc. Such facilities have the additional advantage of being able to test software or firmware, at the assembly-language or machine-code level, while it is actually running.

Thus the principal differences in logic analysers are between the numbers of channels capable of being probed at one time, and the speeds of instruments, which needs to exceed by about three times the speed of the device being tested. Other differences include the complexity of the analyser which gives it additional analysis functions, perhaps the comparison of the output pattern of a device with a stored pattern for routine checking, or communication with a computer for further data storage and analysis, or in a computer-controlled test and measurement system.

SERIAL ANALYSIS

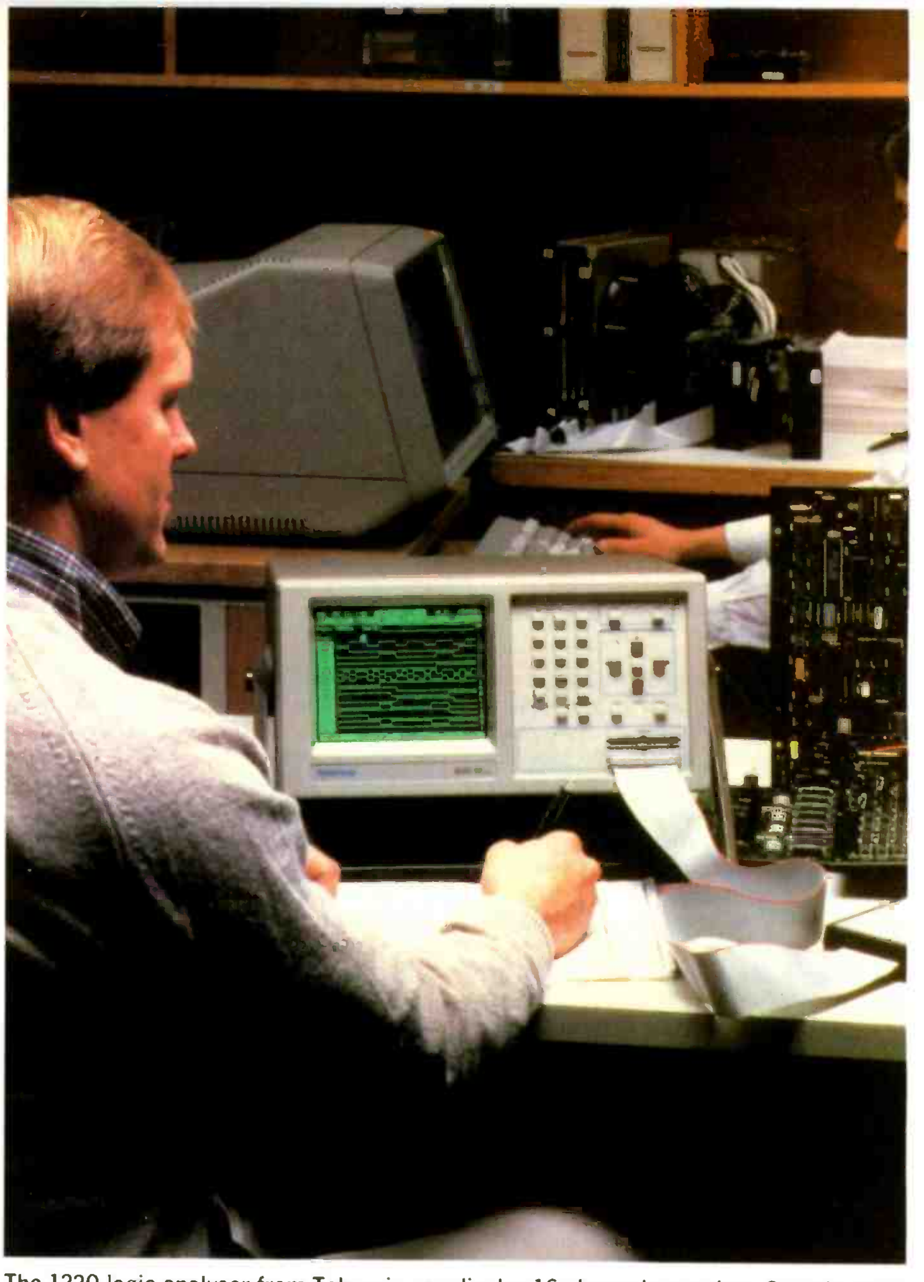
A serial logic analyser acquires serial data one bit at a time on its single channel. By using a matching decoder, and synchronization, it can change the serial data into parallel for storage and word recognition. Once the data is converted into parallel, word recognition for triggering can take place in a similar way to that in a parallel logic analyser. Two consecutive words can have a special meaning in some protocols, so the triggering operation often includes word recognition in pairs. The software in the analyser is used to recognise various aspects of data protocol; such as number of bits/character, parity selection, sync word etc. Specialized versions of serial logic analyser are called protocol analysers.

SIGNATURE ANALYSIS

The flow of data through a digital circuit means that at certain nodes a specific pattern should appear regularly, this is known as a signature. A single probe can be moved from node to node sensing the signatures. These can be compared with pre-recorded signatures to detect any malfunction in the circuit under test. Some logic analyser are dedicated to this use and are called signature analysers.

WORD GENERATION

As a further tool for testing, analysers can include the ability to generate pre-set word patterns which can be introduced into the test circuit to excite expected patterns in the circuit.



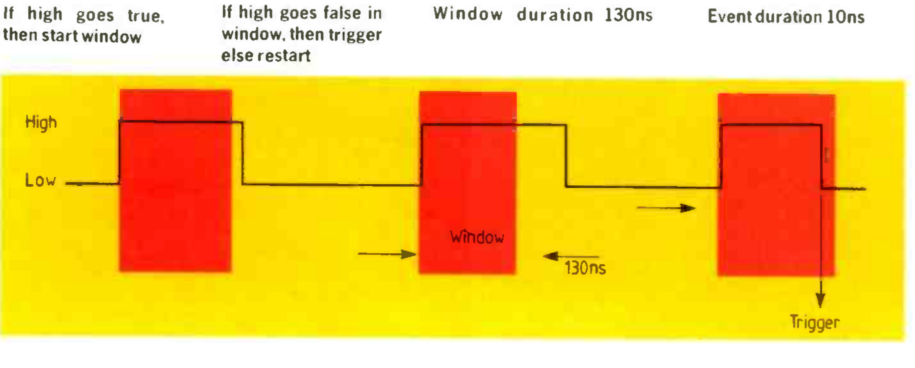
The 1220 logic analyser from Tekronix can display 16 channels at a time. Sample rates are up to 100MHz. There are many trigger options, a non-volatile set-up memory, real-time clock and glitch detection. This is one of a range of analysers intended to cover the whole field of logic analysis.

WIDTH BY DEPTH

The trend to ever higher numbers of channels for logic analysers is easily explained by the bus widths of the tested devices. A short time ago 16-bit processors were 'state-of-the-art' but now 32-bit c.p.us take that place. Falling prices and rising density of memory chips, as well as the ability to analyse larger parts of the processes running on the target system are the chief reason for the increase in memory depth. This last-mentioned feature is often requested to hide a certain fear of having to define a proper trigger sequence. Without a good trigger sequence, however excessive time may be needed to evaluate the data acquired.

Disregarding 'transitional timing' or 'transition recording' as offered by some logic analysers – memory depth becomes much more critical on timing analysis, because with increasing sample rate and resolution in time, the 'window' or length of the maximum time during which data can be recorded decreases. But in the software domain, deep memory may also be useful for the statistical evaluation of certain system activities with the purpose of program optimization, software performance analysis for example.

Fig.1. Trigger condition with verification of time intervals. The same principal can be applied to verify nominal values of handshake, set-up and hold times, and allows easy identification (detection, verification and determination) of exceptions.



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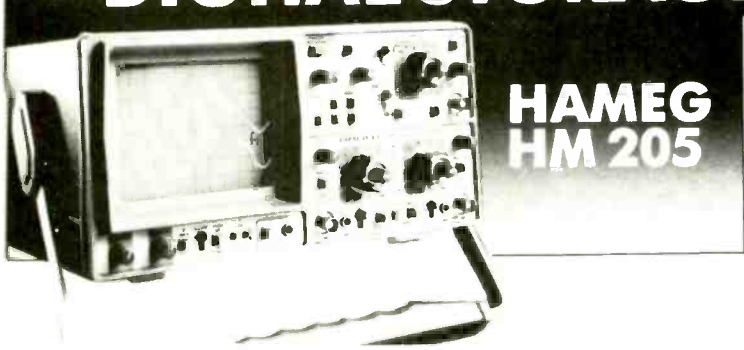

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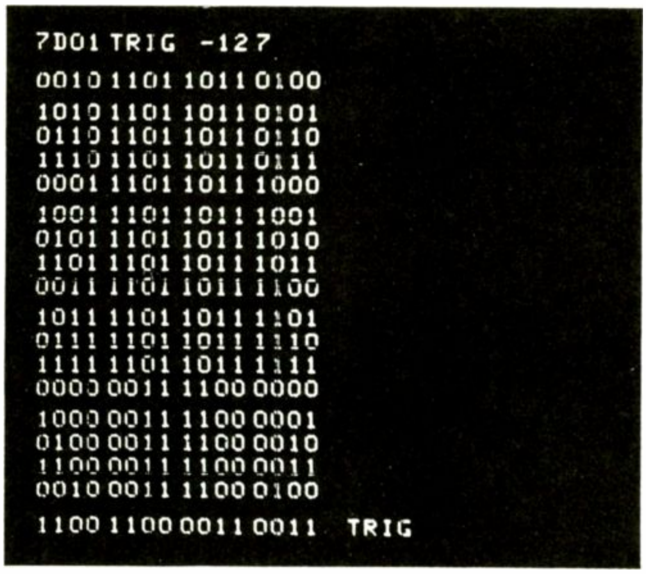

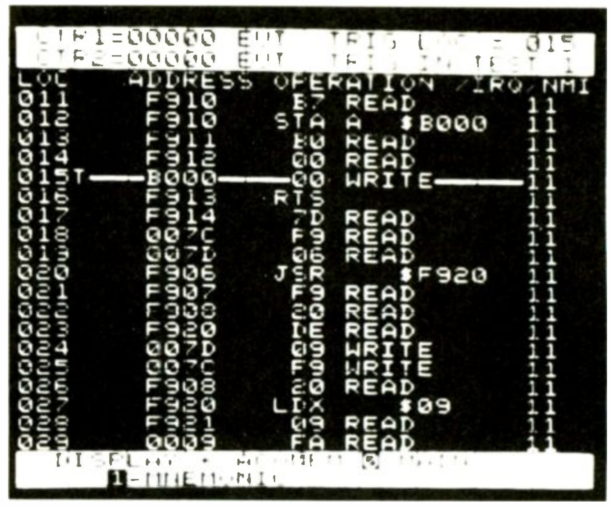

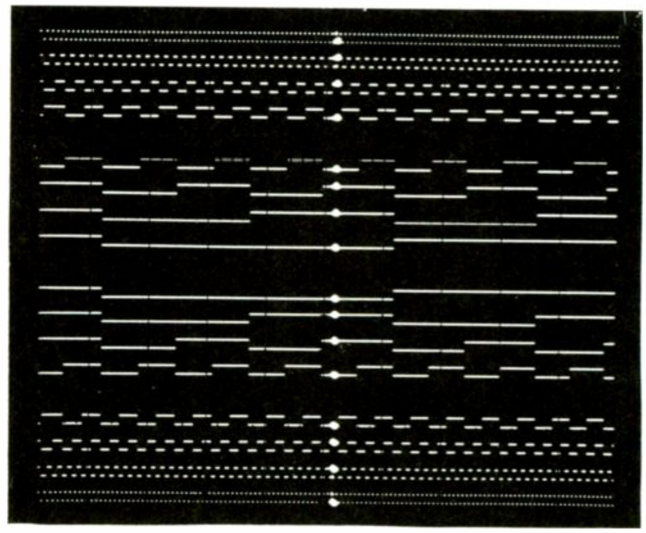

The logic analyser's screen (right) can display timing diagrams of the input channels, the trigger position can be altered so that events before or after the trigger can be viewed.

State analysis is shown above as a binary output on the screen. It can also be displayed in octal or hexadecimal words or dis-sassembled into operational code memonics for software analysis (above right).

UNIVERSAL VS DEDICATED MODULES

There are three major concepts to be considered when designing a logic analysis system as far as casting the channels into their roles of either timing or state.

1. All channels best designed equally for both modes of analysis. Hardware configuration does not change when going from external to internal clock, that is from state to timing analysis, nor does it depend on sample rate.
2. Timing and state modes are best performed by the same modules. To reach the higher sample rates required for timing analysis the memory is divided into two or more groups of channels into which data is multiplexed or interlaced. This allows the clock rate to be multiplied by the same value as the number of lost channels. This procedure may also be nested which allows the user to divide and multiply 32 channels at 12.5MHz to 16 channels at 25MHz, 8 at 50MHz, and so on.
3. Different modules for timing and state analysis require each to be designed for a specific application. This concept of an analyser constructed of different modules, known as a combined analyser, is the most common. Instruments which, in their basic configuration or with certain types of modules, support timing and state analysis equally often do not manage to do the job without dedicated modules. Often, high resolution timing and analysis requires sample rates much higher than those needed for synchronous recordings (state analysis) and difficult to realise in hardware.

The advantage of an architecture as under 1 is the ability to immediately switch between timing and state analysis of the same signals. However, it takes a large expenditure to design all channels for the high sample rates required for timing analysis, and therefore the interlace method, as described in 2, is often used as a solution in low-cost instruments. An analyser built this way can analyse only a hardware *or* software problem but never the interactions of software *and* hardware. This is one of the reasons why some manufacturers, even on high performance instruments, decide to build-in two analysers – one timing and one state analyser.

A typical analyser may have 8 or 16 channels with 100MHz sample rate and 8k memory depth designated for timing analysis, and an additional 48 or 96 channels designed primarily for state analysis with 20MHz sample rate and 4k memory depth, but may allow selection of these same channels for a timing display format. Thus co-existence of timing and state channels is technically not unusual. However, it is unusual in low-cost analysers in which timing clock rates are usually achieved only by interlacing. This concept, where hardware configuration does not depend on the currently-selected mode of operation but is determined only by its equipment, provides clearness and ease of operation. All channels are available at any time so there is no need to re-probe or to enter a new set-up and there are no unpleasant surprises such as one or other feature not being available.

ANALYSIS STARTS BEFORE ACQUISITION

A logic analyser in which different modules take care of hardware and software analysis should be designed optimally at a reasonable cost for these tasks, but in many modular instruments this option is under-exploited – for triggering on timing analysis, for example.

A good analyser also requires features for more hardware specific problems. Take the following as an example.

A pulse must not fall short of a minimum duration of 150ns, so the trigger most poll event A, a rising edge, event B, a falling edge, and the time interval between them, as shown in Fig.1.

An event duration filter can directly check whether the event is high for less than

150ns. However, such a filter is used more frequently to avoid interpretation of bit-patterns which occur as short unstable intermediate states in the data stream, as regular trigger events. Checking for 'greater than', as needed in this case, corresponds to the function of the usual trigger filter.

Checking distances, as shown in the panel example serves an entirely different purpose in software analysis, which must unambiguously identify certain locations in a program fow or data stream. Polling for A and then B is often insufficient because A and B may occur several times. However, if their distance (in samples of processor cycles) is included in the trigger condition, the desired determination can often be obtained from a two-level trigger sequence. In other words, checking the distance is the easiest way to define precise trigger conditions with little effort.

The capacity for triggering a state analyser is not so much determined by its maximum number of trigger levels but more by how few levels are required to trigger unambiguously. Sometimes, more levels will be an advantage; within a longer program run, program sections may need to be indentified but only certain activities within these sections should be recorded. To achieve this, the sections in question have to be identified by a suitable trigger sequence, while specifying which particular activities should be recorded until the next section is found. This allows a trace of all activities, none at all or selective recording of only certain activities like i/o for example. The procedure for repetitively recording only a single segment of the program from address A to address B is shown with the example of Fig.2.

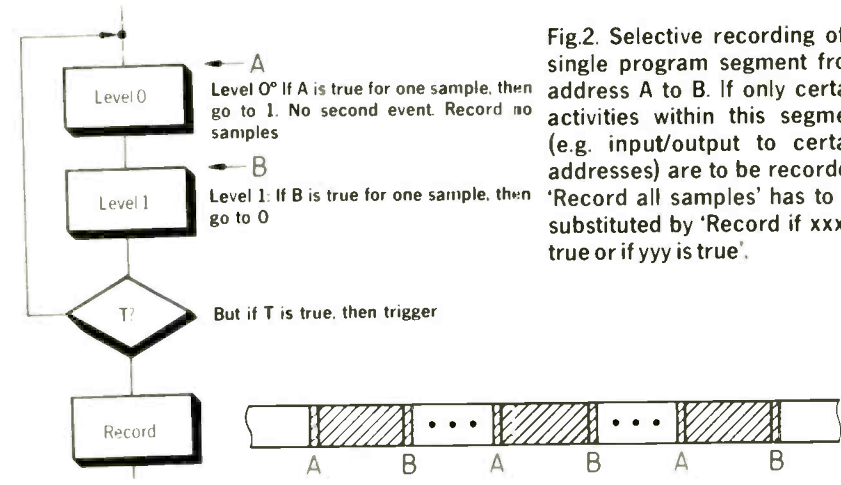

Fig.2. Selective recording of a single program segment from address A to B. If only certain activities within this segment (e.g. input/output to certain addresses) are to be recorded, 'Record all samples' has to be substituted by 'Record if xxx is true or if yyy is true'.

OPERATIONAL CONVENIENCE

Besides the purely quantitative properties such as clock rate, number of channels and memory depth, triggering and record control are among the most important functions of a logic analyser. As decisive criteria on the software side, post processing such as disassembly and, not least, the operating concept contribute much to the usefulness of an analyser. In one new instrument, all functions are selected with a 'scroll knob' within pop-up menus. The course of such entries are described with "touch – turn – release." Touching a key brings a menu to the screen, showing the possible settings for the parameter selected in the main menu at a glance. The scroll knob then moves a pointer to the desired setting within the pop-up menu. This setting is then entered into the main menu by releasing the select key.

Speed and clarity are important properties in this concept of operation. With all types of post-processing and data evaluations, the importance of processing speed is increasing with the number of channels and the depth of the memory. In one case, a 112-channel configuration has 64 bytes for evaluation, substantially more than the usual 2 to 16 bytes acquisition memory. A powerful 16-bit c.p.u. with megabytes of memory results in extremely short display up-date times, as well as horizontal and vertical scrolling of the timing diagram.

HOST COMPUTER

A computer built-in to a powerful logic analyser can obviously be used to run the owners specific data evaluation programs. Extensive possibilities, reaching far beyond logic analysis, arise if the computer is built to an industrial standard. Compatibility with the IBM-AT, for example, would give access to a comprehensive library of user software and bus-compatible hardware.

In addition to the pure processing power, this suggests further benefits for the logic analyser. Complete analyser setups, along with a data recorded by the analyser, may be stored to disc; interfaces would allow printing of screen content such as timing diagram and disassembler. And as the analysers operating software can be loaded from disc, software updates or retrofitting options are no problem.

80286 DISASSEMBLY

Logic analyser disassembler support for the 16-bit 80286 microprocessor can be used with the entire Philips high-end logic analyser line, including the PM3551A, the PM3565 and the PM3570 (115 channel/400MHz). Hardware consists of a front-end unit which ensures proper connection of the logic analyser channels to the 60-pin, pin-grid-array package of the 80286. The multi-clock state analyser architecture avoids the need for external 'personality' probe hardware. This allows small and cost-effective personality adaptors to be used. The software support consists of a prom-based disassembler package, fitted to the option board of the analyser. Up to four different packages can reside inside the instrument at all times and are available from power-up. Thus there is no need for down-loading of disassembler software from disc.

This package adds to the collection of over 40 different 8 and 16-bit processors supported by Philips' system. The analysers on which run incorporate separate analysers for logic-state and timing. They range from 35-channel state analysers to 83 channels at 20MHz timing, and eight channels of 50MHz timing to 32-channels of 400MHz timing.

LOGIC ANALYSER MANUFACTURERS

Advantest (formerly TakedaRiken) instruments available from Chase Electronics Ltd, London SW14 7LY.
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Tel: 0223 358866.

Racal-Dana Instruments Ltd, Duke Street, Windsor, Berks SL4 1SB.
Tel: 0735 368101.

Rohde & Schwartz UK Ltd, Roebuck Road, Chessington, Surrey KT9 1LP.
Tel: 01-397 8771.

Tektronix UK Ltd, Fourth Ave, Globe Park, Marlow, Bucks SL7 1YD.
Tel: 06284 6000.

Thandar Electronics Ltd, London Road, St. Ives, Huntingdon, Cambridge PE17 4HJ.
Tel: 0480 64646.

Thorn EMI Instruments Ltd, Archcliffe Road, Dover, Kent CT17 9EN.
Tel: 0304 202620.

Thurlby Electronics Ltd, New Road, St. Ives, Huntingdon, Cambridge PE17 4BG.
Tel: 0480 63570.

Zicon Instruments Ltd, 23 Meteor Close, Airport Ind. Est, Norwich.
Tel: 0603 400083.

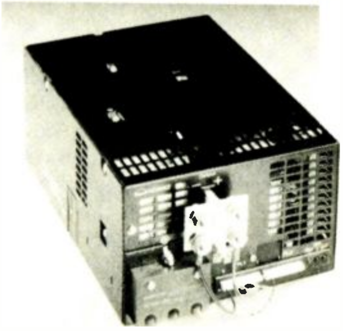
British Electronics Week

Olympia, London, 28 to 30 April 1987

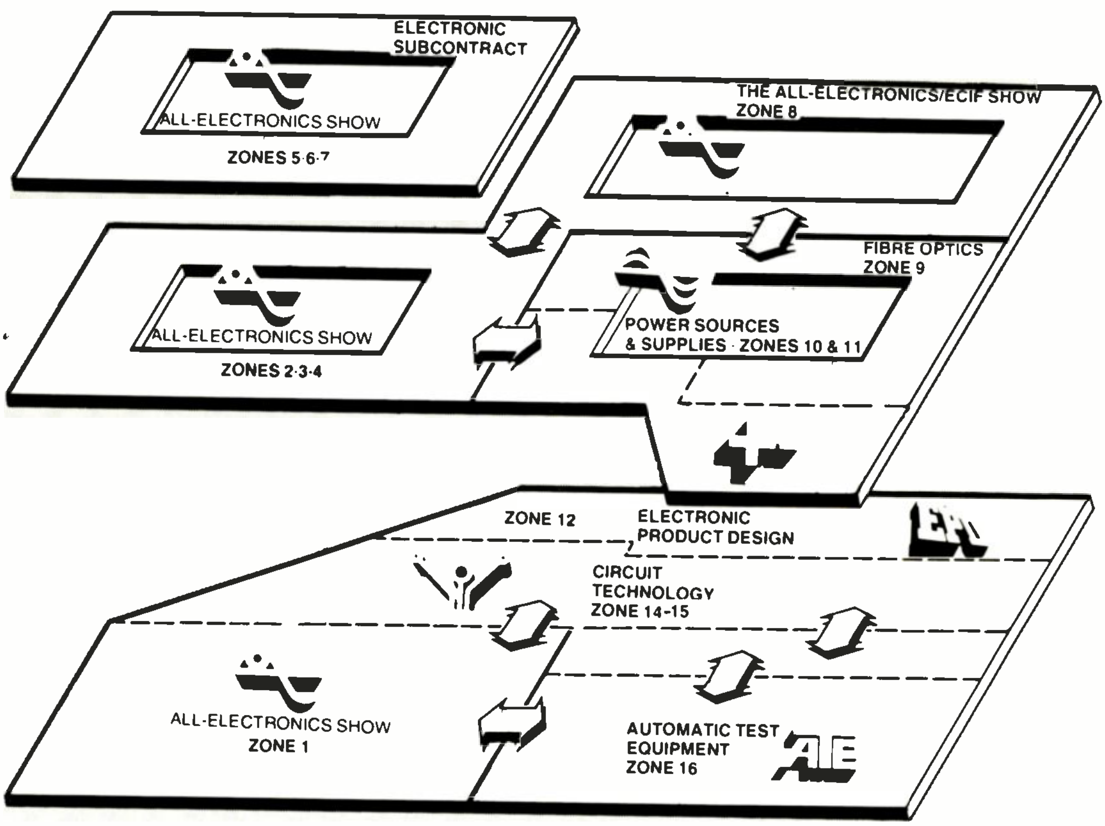
No less than seven exhibitions are combined to make up British Electronics Week. The senior event is the **12th All-electronics/ECIF Show,** for electronics components and systems. **Circuit Technology** specializes in the design and manufacture of p.c.bs. A large number of semiconductor manufacturers will be exhibiting in the **Electronics Product Design** show. **Fibre Optics** has its own show. Introduced this year are two new sections: **Power Sources and Supplies;** and the **Electronic Subcontract Show,** where some 40 providers of design and manufacturing services will be on show. The final section, zone 16 on the map, is devoted to the **Automatic Test Equipment** show.

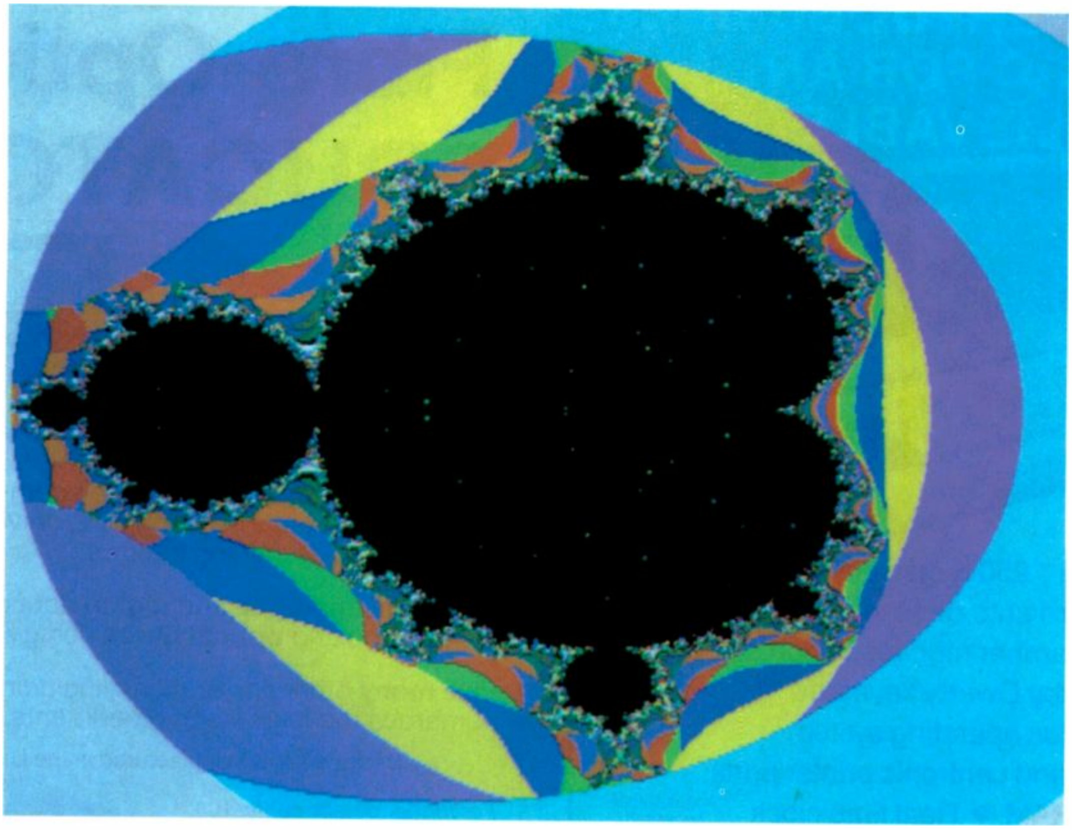
There are conferences and/or seminars being run in conjunction with the Fibre Optics and Automatic Test Equipment shows.

Olympia is on Hammersmith Road, Kensington, and has its own Underground station. The show is open between 10.00 and 18.00h except on April 30th, when it closes an hour earlier. Tickets cost £2 at the door or from the organizers; Evan Steadman Services Ltd, The Hub, Emson Close, Saffron Walden, Essex CB10 1HL. Telephone: 0799 26699.



How the shows are distributed about Olympia.





High-performance colour graphics controller

With little more than a few memory and interface i.cs this versatile display controller makes high-resolution colour graphics with up to 640 by 512 pels.

JOHN ADAMS

Bus control signals on the VSDD are intended for an 8086 or 8051 bus interface. The design shown in Fig. 6 is in two parts, the second consisting of an interface to an HD64180 processor such as is used in the SC84 computer.

VSDD can work with two independent clocks Fig. 7. The video-display clock drives high-speed logic for generating video and sychronizing signals while the video-system clock operates the system parts of the chip. Video system sections include the bus interface, video memory interface and construction processor. In a minimum system only one clock is used and that signal can be generated using an internal clock oscillator by connecting a crystal between the pins XTALIN and XTALOUT. Provision is made for the use of two external clocks as it is possible to clock the video section at a higher rate than the system, thereby achieving higher pel rates.

Two versions of the VSDD are available; the '–3' version has maximum system and video clocking rates of 10MHz and 15MHz respectively. When using separate clocks connect the system clock to XTALIN and the video clock to CKIO.

Two 640-by-4-bit line-construction buffers are built into the VSDD; one of these is loaded with data from memory while the other is outputting display data. When working in the two or four-bits-per-pel bit-mapped mode, this buffer is treated as being 640 pels long, the difference being that in the two bits per pel mode only two bits are valid, the other two being obtained from the object's descriptor table. When working in eight bits-per-pel mode the buffer is treated as being 320 pels long.

For character objects the buffer is always used in the 640-by-4 mode. Figure 8 shows how the state, i, of a character dot selects the colour. In limited mode, two colours are available whereas in full attribute mode the full range of colour is available through the values stored in the FGND and BGND fields within the object descriptor.

At the beginning of every frame period the VSDD reads the colour look-up table from memory. This table consists of sixteen 12-bit words and is initialized by the host processor writing sixteen 16-bit values to the colour look-up table area of memory. Each written word consists of four 4-bit fields. Three of the fields are values corresponding to the three primary colour intensities required. The fourth field is the colour's address in the table. During output, the four bits of data (the lower four for 8-bit mode) are used as the address pointer into the colour table. The three 4-bit values drive three of the four digital-to-analogue converters which in turn drive the RGB pins.

Seventeen analogue levels can be output by the system, the seventeenth, which is approximately one level below the lowest colour value, being output during blanking periods. External buffering to 50Ω is provided for the four analogue output signals as is a common, adjustable, reference voltage for the digital-to-analogue converters. Colour two is used as the background colour, i.e. it is displayed when a scan line contains no objects and during display of the programmable margin.

A colour defined as one unit of each of red, green and blue activates the I (insert) pin.

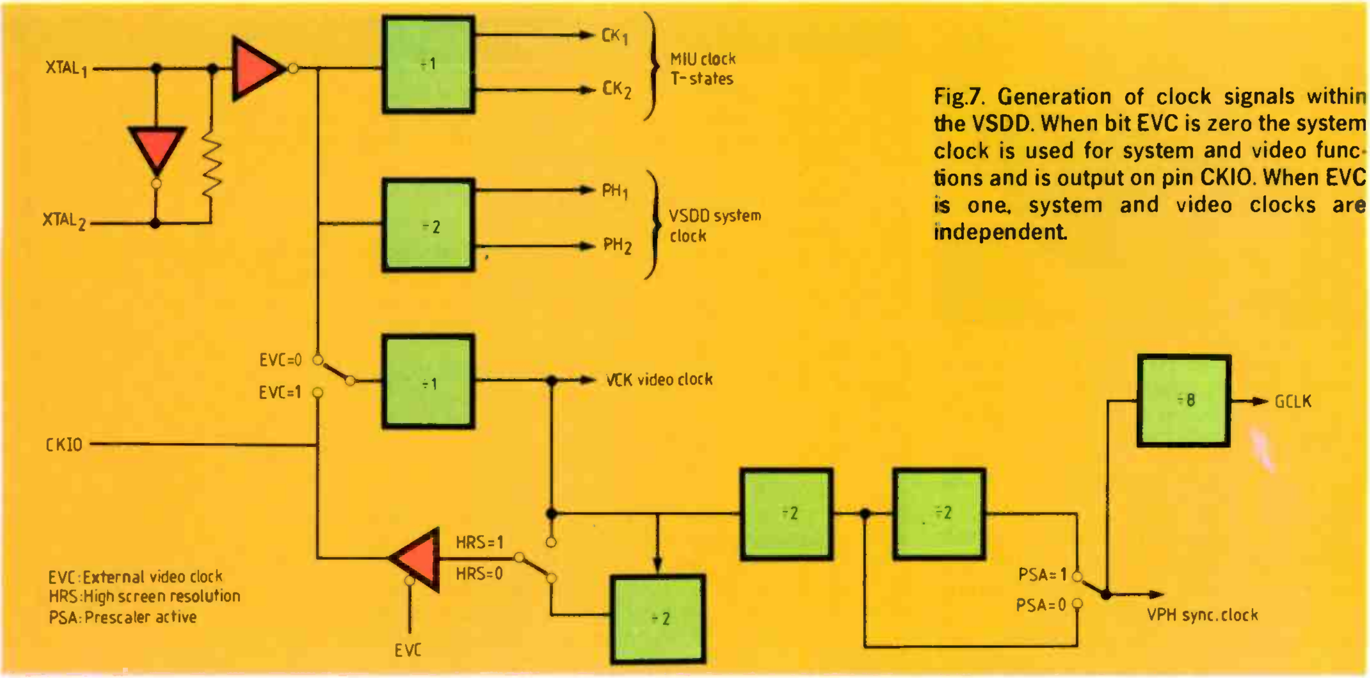
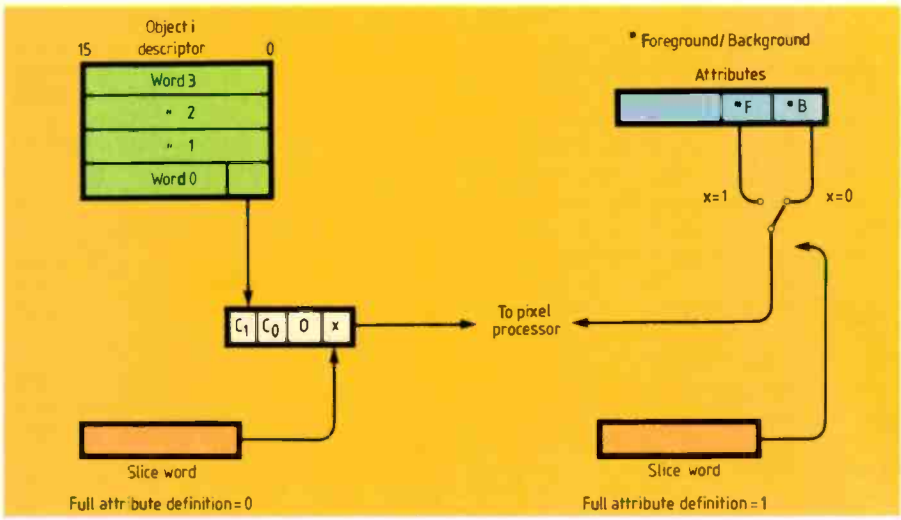


Fig.7. Generation of clock signals within the VSDD. When bit EVC is zero the system clock is used for system and video functions and is output on pin CKIO. When EVC is one, system and video clocks are independent.

Fig.8. Colour selection for the two text modes. Each bit of the slice word fetched from the character generator is expanded to a 4-bit pel code. When FAD is zero the slice word bit is directly combined with two from the object descriptor to select one of two colours across the whole object. When FAD is one the slice word bit selects between two, three or four bit words held within that character's own attribute word – giving individual foreground and background colours for individual characters.



This pin is like the other analogue pins except that it only gives out two values, those corresponding to the colour digital values 0 and 15. Fifteen is the norm but the specific colour code 111 switches it to the zero value. It is possible to program this colour as the background colour in which case the I pin can act as a 'data insert' to overlay graphic data on a conventional video display.

This mode can be very effective when the VSDD is used in slave mode, under control of the conventional system's sync. signals. Under these conditions a phase-locked loop circuit in the VSDD can be used to synchronize the crystal clock to the main system clock allowing superimposition onto an off-air image.

By programming certain control bits, the four analogue lines, RGBI, can be made to act as a four-bit digital bus sending either the four-bit input to the colour table or one of the three (software selected) colour table outputs. Direct output of the colour-table input code, i.e. the construction buffer output, is used during eight bits-per-pixel mode. In this mode the VSDD multiplexes pairs of four-bit nibbles onto the pins which can be captured by external circuitry and used to produce up to 256 colours. The mode in which the colour table digital values are output could be used where a colour separation print was required.

Positive and negative synchronizing signals are available. Separate or combined

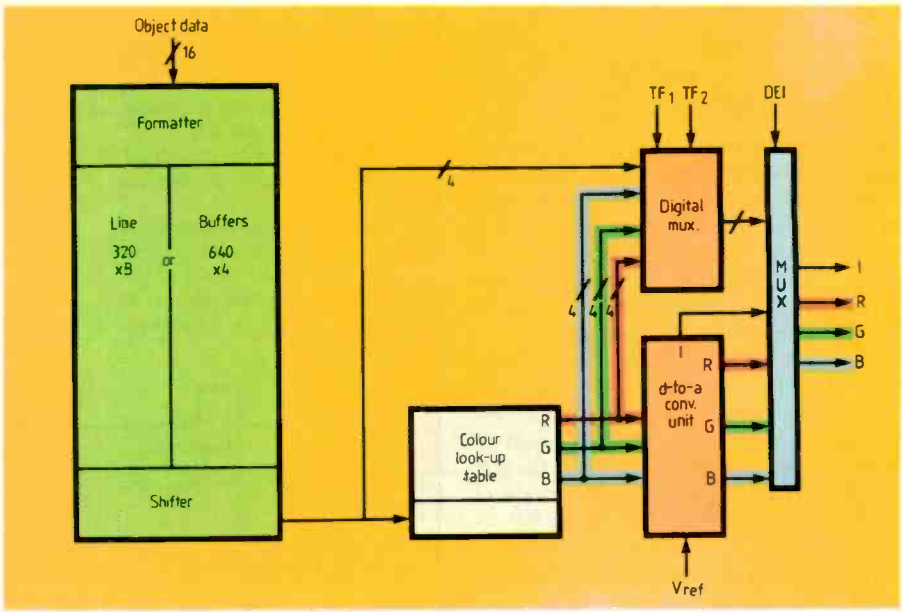
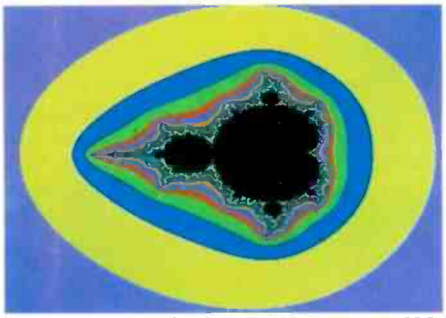


Fig.9. Pel formation within the VSDD. Control bits TF1, TF2 and DEI select the format of the data output on pins RGBI.



Listings for a 9-by-6 character generator in VSDD format and for an HD64180 program to generate the Mandelbrot plot shown in less than four minutes are available from John at 5 The Close, Radlett, Hertfordshire for three loose 18p stamps.

sync. signals may be selected by a bit in one of the control registers.

Bus buffering converts HD64180 signals to 8086 form. Signal $\overline{\text{ME}}$ is a 64180 line indicating that a memory cycle is occurring. As it goes active once the address lines are stable it can act as ALE. Paging line $\overline{\text{PAGE 5}}$ is a chip-select signal produced by the SC84 c.p.u. board using address lines $A_{16\text{-}18}$. It acts as the most-significant address line of the VSDD, A_{16}. It is possible to think of this pin as a programmable chip select. By gating line $\overline{\text{PAGE 5}}$ with the data bus enable signal E, a signal indicating that a bus transaction is taking place in memory page five is available. This signal is used to select between the eight-bit data bus and the 16-bit address lines, producing the multiplexed 8086-like bus.

The only other timing requirement is for a delayed read signal which is produced by gating the relatively early 64180 $\overline{\text{RD}}$ signal with the bus-transaction signal. Other requirements are for an active high RESET and open-collector buffering on the RDY and CTO signals, the former being used directly as the 64180 WAIT signal and the latter, once inverted, as an interrupt.

After a hardware reset the VSDD is configured in 'single' mode with analogue colour selected but with the display disabled and the sync. outputs in a high-impedance state. Access to video memory and the priority access system are disabled, the RDY pin is configured as a WAIT generator and the CKIO pin is in a high-impedance state, the system clock acting as both system and video clocks. The register window is accessible and is mapped to appear at byte locations 400-41F in the main-processor memory map. Immediately after reset is released the VSDD performs eight very fast refresh cycles in order to 'power-up' the substrate generators in external dynamic video memory and is then, 10µs after the reset, ready for use.

The first write to the VSDD should be to the first location in the register window. This write is unique in that the VSDD acts on the lower eight bits of this word as it passes it on to the video memory. Specifically the bits DOF, DF_1 and DS_2 describe the configuration of the video memory to the VSDD and the UCF bit, when clear, instructs the processor to store but not to act upon the other control words being written until the UCF bit is set.

Following this procedure is very important as the device may act oddly if the control registers are accessed by the VSDD before

VSDD REGISTERS

These register descriptions illustrate flexibility of the video display and storage i.c. Almost all functions are programmable. In the tables, the column headed Cond. describes the condition of the bit for which the function description is true. Complementing the bit makes the function false.

Video configuration register R0

Bit	Mnem.	Cond.	Function.
0	UCF	Clear	Locks out updating of all registers except VCR_0 and ATBA.
1	DEI	Set	Enables digital data o/p (rather than analogue).
2	SAB	Set	Memory access 3 clock cycles (slow).
		Clear	Memory access 2 clock cycles.
3	DEN	Set	Enables display.
4	HRS	Set	Permits lines of 321 to 640 pels.
5	DOF	Set	Selects 4bit 16K d-rams.
		Clear	Selects 1bit 16K d-rams.
6	DS_1	Set	Selects 64Kbit d-rams.
7	DS_2	Set	Selects 256K-bit d-rams.
8-12	BR	–	Blink rate in multiples of 8 frames.
13-15	DC	–	Blink duty cycle in ⅛ths of blink period.

Video configuration register R1

Bit	Mnem.	Cond.	Function.
0	PRE	Set	Selects pipeline access mode.
1	PSA	Set	Halves sync. generator clock rate.
2	RE	Set	Allows system to read from video memory.
3	FAE	Set	Converts RDY pin to FREE ACCESS indicator.
4	PCE	Set	Enable priority-access mode (used only with RDY).
5	EVC	Set	CKIO acts as input for separate video clock.
6	VP	Set	Selects European interlace vertical sync.
7	TMS	Set	Configures VSDD as slave in twin mode.
8	TMM	Set	Configures VSDD as master in twin mode.
9	SM	Set	Combined sync. signal produced at HSYNC pin.
10	MAS	Set	VSDD generates sync.
		Clear	VSDD inputs sync.
11	INL	Set	VSDD generates interlaced display.
12-15	CH	–	Char. height in display lines (0 implies 16).

Register-window base address R2

Bit	Mnem.	Cond.	Function.
0	ME	Set	Enables margin of background col. around image.
1,2	TF	–	Selects red, green, blue or pel code digital o/p (DEI set).
3	PLL	Set	PLL o/p only active during hor. sync.
4-15	RWBA	–	Upper 12 bits of reg. window word address.

Data-window base address R3

Bit	Mnem.	Cond.	Function.
3-9	SB	–	Upper 7 bits of 10bit coordinate of r.h. display edge. By specifying SB, no time is wasted in constructing non-displayable data.
11-15	DWBA	–	Upper 5 bits of data-window word address in host memory.

Data-length mask R4

Bits 11-15 of this register are DLM and form the upper five bits of a mask used to qualify which bits of a processor address must match those in the DWBA for the address to be accepted as being in the data window. For example, 11100 represents a 16Kbyte window 11000 a 32Kbyte window and 10000 a 64Kbyte window.

Data-segment base address R5

Bank bits 7 and 8, whose mnemonic is BNK, form the word address of the data window in VSDD ram. Character objects must be in bank zero. Bits 11-15 are the next 5 bits of the data-window word address in VSDD and have the mnemonic DSBA.

Priority-access quantity R6

The number of priority accesses permitted per scan line is defined by bits 0-3 of this register. Their mnemonic is PAQ.

Object-descriptor table base R7

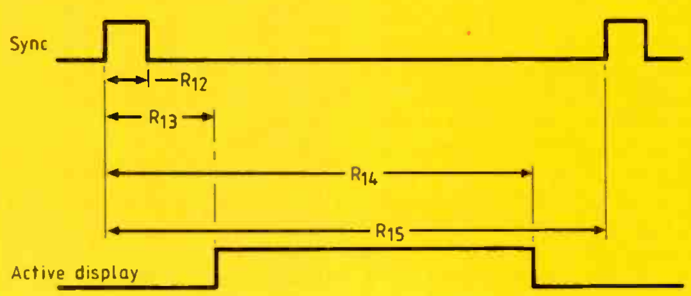
Bits 6-15, ODTBA, are the upper 10 bits of the object-descriptor word address in ram bank zero.

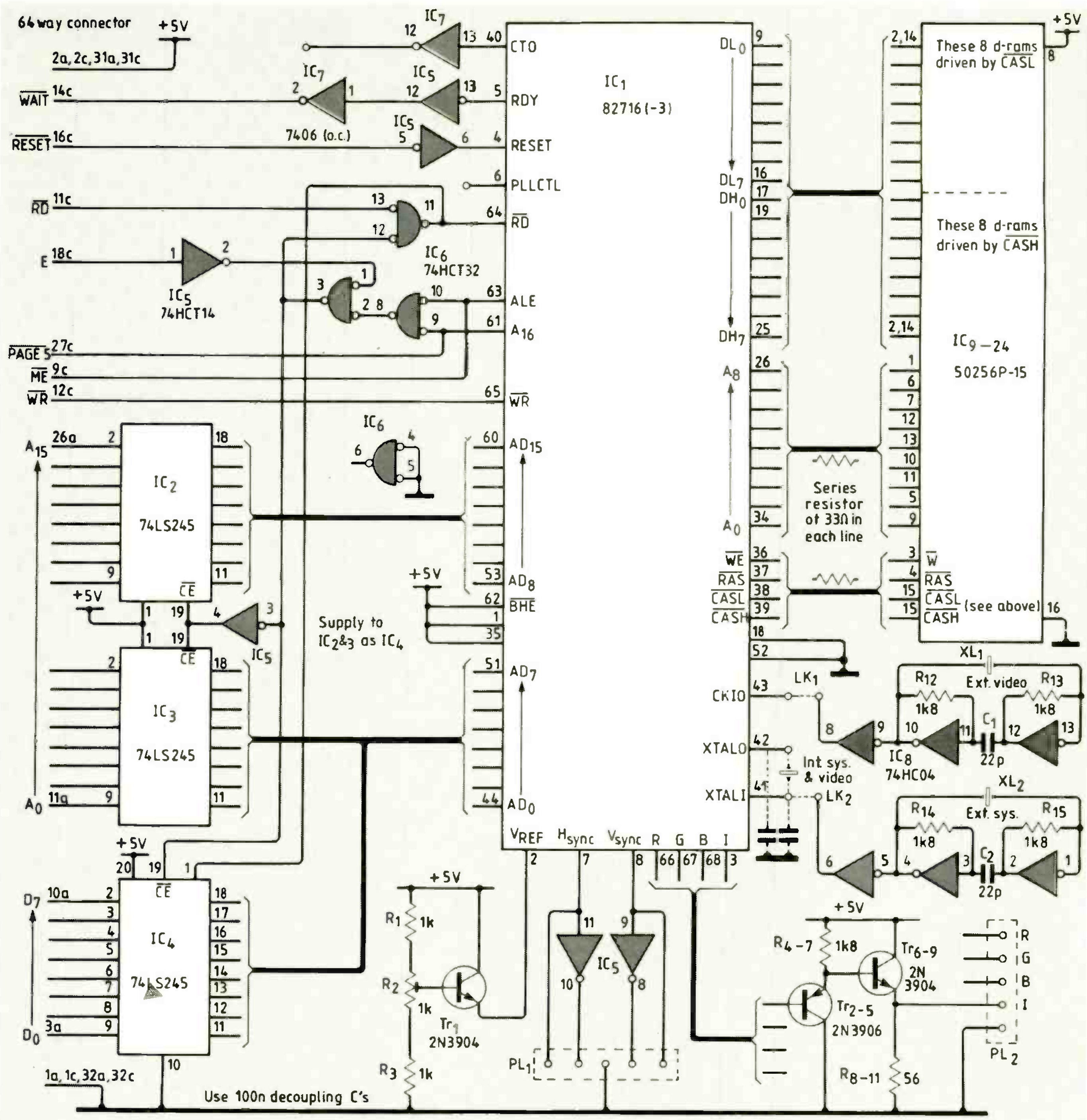
Access-table base address R8

The word address of the access table in ram bank zero is formed by bits 0-15 of this register. These have the mnemonic ATBA.

Colour-table base address R9

Bits 0-15 have the mnemonic CTBA and define the word address of the colour table in ram bank zero.





Character-generator base address R10
Here, bit groups 0-3 and 4-7 form the upper 4 bits of character generators two and one respectively. These groups are CGBA2 and CGBA1.

Access-table address counter R11
Bits 0-15 are a pointer to the next line's access word and are maintained by the VSDD.

Timing constants R12-15
In each of these registers, the lower 10 bits represent a vertical parameter measured in scan lines and the upper 6 bits form a matching horizontal parameter measured in GCLK clock cycles. In each case the value written is the intended value +1.

Object descriptors
Word 0

Bit	Mnem.	Cond.	Function
0-1	CO-1	–	Used to complete 2-bit/pixel and plain Ascii colour codes.
2	TDE	Set	Colour 0 is redefined to mean 'transparent'.
3	HCR	–	When FAD is set, HCR selects extra colour capability on text.
4	BLA	Set	Inhibits object display.
5	OBL	Set	Object blinks.
6	FAD	Set	Full-attribute mode (character only).
7	PSE	Set	Enable proportional character display (character only).
6-7	–	–	Upper 2 (i.e. bank) bits of object base address (bit-map only).

Two versions of the VSDD are available, one for maximum system and video clocking rates of 10 and 15MHz respectively and the other for clocks of up to 14.5 and 25MHz respectively. When using separate clocks, connect the system clock to XTALIN and the video clock to CKIO.

being initialized. The resulting mayhem may put the computer into a permanent wait state, causing loss of all computer data, or cause random output of display synchronizing signals with the risk of damage to the display itself.

There are two prime reasons for this unpredictable activity. Firstly, one of the control words specifies the address in processor memory at which the register window will be mapped. If the VSDD acts on this parameter before the entire register window has been updated then the remaining regis-

8	CRS	Set	When FAD is set, CRS allows use of conceal/reveal. When FAO is clear, CRS selects which character generator is used (character only).
9-10	R0-1	–	Resolution: used in conjunction with HRS (in VCR0) as in table below.
11	CBS	Set	Character mode.
		Clear	Bit-map mode.
12-15	–	–	Character starting dot row for display (allows smooth scrolling).

Word 1

Bits 0-9 are a two's complement number representing position of the leftmost pel of the object relative to the leftmost display pel. Their mnemonic is X. If HRS is zero, X is in pels and the object may be scrolled left or right in the range –512 to +511 pels in one pel steps. When HRS is one, X is in pairs of pels and the object may be scrolled left or right in the range –1024 to +1023 pels in two pixels steps.

Remaining bits 10-15, whose mnemonic is W, describe width of the object in units of 64 video-memory bits, i.e.

Mode	Width units (pels)
2 bit/pel	32
4 bit/pel	16
8 bit/pel	8
Normal	8
Full attrib	8*

*provided that W is always a multiple of three.

Word 2

All 16 bits of this register are used to describe the object-base word address in video memory. Bank bits from Word 0 are appended when in bit-map mode. For these bits, the mnemonic is O.

Word 3

Here, bits 0-15 are used to maintain data on current scanning status of the object.

Character modes

In both character modes, pairs of sequential characters are stored in sequential words of video memory with the first character in the word's lower byte. When FAD is zero, this pattern repeats. When FAD is one, the next two words after each character word contain the attributes for the two characters. Within those words, the bits have these meanings.

Bit	Mnem.	Cond.	Function.
0-2	BC	–	Background colour.
3	UL	–	Extra background colour if HCR is set. If HCR is clear, UL indicates which half of a double-height character is being displayed at this position (0 implies lower half).
4-6	FC	–	Foreground colour.
7	DH	–	Extra foreground colour if HCR set, otherwise double height.
8	UND	Set	Enables underline attribute.
9	BLI	Set	Blinks foreground between foreground and background characters.
10	INV	Set	Swaps foreground and background colours.
11	MSK	Set	Forces foreground colour to be the background colour; used in conjunction with HRS.
12	DW	Set	Causes the character to be displayed at double width and next character to be ignored.
13	TBG	Set	Causes background to be transparent.
14	TFG	Set	Causes foreground (i.e. the character itself) to be transparent.
15	CGB	–	Selects between two banks of character generators.

Character generators

Characters n dots high require n×256 words of video memory. Each block of 256 words represents a given dot row for each of 256 characters. In each word the least-significant bit is the first pel displayed.

When using uniform spacing, bits higher than the specified character width are ignored. When using proportional spacing (PSE=1), individual characters may be programmed to be any even number of pels wide between 2 and 14 using the top three bits of the word; 000 implies two-bit width, 001 implies four bits, 101 implies 12 bits and 110 and 111 both imply 14-bit width.

When using plain Ascii (FAD=0) the CRS bit selects which character generator is used for the entire object, limiting the number of possible generated characters to 256. When using full attribute mode, the CGB bit selects the character generator used for each character and hence 512 different characters may be generated.

Colour look-up table

Structure of each of the 16 words in the colour look-up table is as follows.

Bit	Function.
0-3	Colour address.
4-7	Blue value.
8-11	Green value.
12-15	Red value

The order in which the words appear is irrelevant. At the beginning of each display frame the table is read into a 16-by-12-bit ram within the VSDD using the colour address rather than the table position to locate the values read in the correct ram locations. This look-up table is then made from the internal memory (for speed).

Note that plain Ascii characters only use colours 0, 4, 8 and 12 for background and colours 1, 5, 9 and 13 for foreground colours. Colour codes for these characters are constructed as C1 C0 00 x where C1 and C0 come from the object descriptor and x is fixed as zero for background and one for foreground. In full-colour attribute mode, only the first eight colours are available when the double-height attribute is in use.

SPECIAL OFFER

A limited number of VSDD display controllers is being made available to EWW readers at a special fully-inclusive price of £39.86 ; the normal one-off price is around £64.

These 12MHz devices in p.l.c.c. form with the full part number S82716-3, can be obtained by sending a cheque made payable to Thame Components to Jacqueline Cole, Thame Components Ltd, Thame Park Road, Thame, Oxon OX9 3XD. The G82716-3 in a pin-grid-array package is also available at £45.80 fully inclusive. This offer is limited to one device per reader.

Combe Martin Electronics of King Street, Combe Martin, North Devon EX34 0AD is in the process of making a Eurocard p.c.b. for this design which is to cost £18, fully inclusive. This board has two 41612 connector positions, one at either end. One of these is wired for the backplane of John's 64180-based SC84 computer and the board can be wired to suit other backplanes.

Cards for the SC84 now include a 64180 processor with 256Kbyte memory, a monochrome v.d.u. controller, a floppy-disc interface with i/o, a hard disc interface, a half-megabyte silicon disc and a p.s.u. Boards for these designs and the original Z80 card are still available at the original prices. All software including SC84's CP/M-compatible operating system is available from John Adams.

ter writes will be to where the register window was, not is. Secondly, one control word is the base address of an object descriptor table, every fourth word of which may be used as scratch memory by the VSDD. If the VSDD acts on this parameter before it is correctly set – possibly as a result of the remapping of the register window as described above – then random memory will be corrupted by the VSDD.

As the register bank is stored at the bottom of the video memory and dynamic memory has the tendency to 'power-up' with blocks of all zeros, this will direct the VSDD to treat the very area being used for the register window as the scratch area. As chance would have it, one of the four control words which will be altered by the VSDD's scratch activities is the base address of the object descriptor table and so, once corrupted the object tables are relocated by the corruption and the mayhem continues.

When writing to the registers it is important to remember that most parameters are only updated at the end of each display frame.

A sample of the data which should be written to this window is shown separately. Once these sixteen words are written to the device, the first word should be rewritten with UCF and DEN set. This will ensure that no spurious operation occurs until all registers are initialized. This data is for a system using a single 10MHz clock which is to produce a non-interlaced near-standard CCIR 626 display. Such data can be used directly with standard monitors or with modified colour televisions.

John Adams, M.Sc. is with Graseby Ionics in Watford. An example of VSDD initialization values can be obtained by sending a s.a.e. marked VSDD to E&WW's editorial offices in Quadrant House, The Quadrant, Sutton, Surrey SM2 5AS.

Voltage or current?

J.W. enlarges on amplification, which is neither pure nor simple

JOULES WATT

Of course, to get a job of work done in a reasonable time, *power* (in the physical sense) is required. Some might say it helps if power is available in the other sense too, but then the situation gets a bit messy because politics becomes involved, and it might be best to repudiate that sort of power for the moment.

Yet, if we return to amplifiers in our sense of using watts of power, it appears that this signal power is only one of the quantities that arises. In addition, engineers talk about *voltage* amplification or *current* gain. The confusion does not stop there, as you might very well come across someone talking about *transconductance* amplification. And the transistor itself is said to be a shortened name for *transresistance* amplifier.

Like most things, nothing is pure and simple and voltage amplifiers often appear to amplify signals as well as voltage. Conductance is the reciprocal of resistance; is a transconductance amplifier a kind of reciprocal transresistance amplifier? I would answer no, but in earlier articles carried by *Wireless World*, Cathode Ray would have argued, I'm sure, that each was the electrical *dual* of the other. One might ask if there is any real difference in practice between amplifiers, as surely it is true that you put a signal into them and get a bigger one out?

As in many attempts to build a picture of what does occur in practice, it is best to take the ideal, or as some might say, the extreme example for each amplifier concept. At the same time, we realise that real life will probably offer a mixture of these results, with some merging into the others as the parameters change. So, as an engineer directs his or her thoughts along these lines, often the situation might be indeterminate. Nevertheless, the answer to the question is that there are different amplifiers and it is useful to examine the pure or ideal cases.

IDEAL SIGNAL SOURCES

From the beginning of the subject, people have separated from the a.c. signal paths[1] the d.c. bias arrangements that supply the power to drive amplifier circuits. Engineers and designers tend to draw a.c. equivalent circuits in which the d.c. supplies have mysteriously disappeared. To make up the 'loss' of the power supply by crossing off the d.c. sources, the active devices (the transistors and formerly valves) are redrawn as fictitious a.c. generators of voltage and current to account for the signal power observed. We all know that this signal power actually comes from the conversion of some of the d.c. bias power in the real amplifier circuits, but everyone goes along with the deception, because it gives correct results and is so useful. This *equivalent generator* method makes the analysis of the signal performance of the circuit a much easier task. It also simplifies the d.c. design calculations, which can be carried out separately. The design and performance of the whole amplifier is the sum of these two separate solutions, because nearly all circuits are designed for linear operation and the Law of Superposition applies.

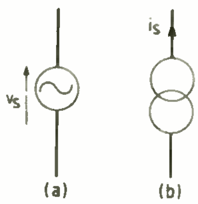


Fig.1. The voltage generator shown in (a) supplies a terminal voltage v_s. In the general case this is an instantaneous alternating quality. Nevertheless, a "direction" is assigned, which is important to avoid errors in, for example, the application of Kirchhoff's Voltage or Mesh Law. Likewise the current generator in (b) has an instantaneous direction, thereby assisting in getting signal phase correct, or in applying the current, or Node Law.

A particular active device might look like an ideal voltage generator when operating. Or another device might approach the ideal current generator. One traditional set of symbols for these generators is shown in Fig. 1(a) and 1(b). The symbols have the peculiar properties of possessing, in the voltage generator case, a zero internal resistance and, in the current generator case, infinite internal resistance. Of course, no real life generators, equivalent or otherwise, have such extremes of internal resistance, but those with low resistances approximate most conveniently to voltage sources – those with high values to current sources.

What makes the generators in amplifier equivalent circuits special is that they are *controlled generators*[2]. A voltage across a separate pair of terminals, or alternatively a current in the separate circuit, can control the voltage or current generated elsewhere via a *transfer parameter* which determines how sensitive the cross control is allowed to be.

A little thought shows that there are four possibilities. Figure 2(a), (b), (c) and (d) illustrates these possibilities and Table 1 lists the properties. The parameters μ, r_m, g_m and α are often written as partial derivatives, where the input terminal quantities act as independent variables and the output quantities follow as dependent variables.

Thus $\mu = \dfrac{\partial V_o}{\partial V_i}$, $r_m = \dfrac{\partial V_o}{\partial I_i}$

and so on.

AMPLIFIERS

Figure 2 shows the ideal or extreme versions of what can be defined as the four possible types of electronic amplifier. In type (a), the first departure from the ideal is the existence

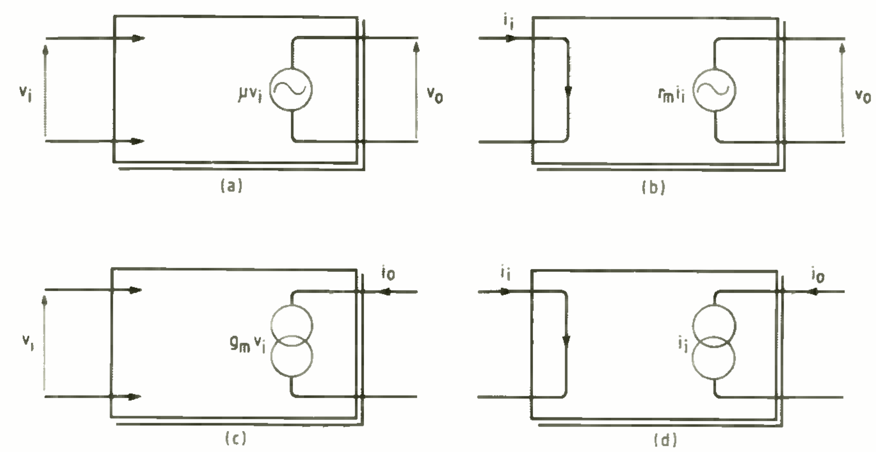


Fig.2. The ideal voltage amplifier (a), is a controlled voltage generator operated by an input voltage v_i across the open circuit. The ideal transresistance case (b) has the voltage generator operated by an input current flowing in a short circuit. Similar definitions apply to the transconductance (c), and current (d) amplifiers.

TABLE 1

Circuit	Type of generator	Transfer parameter	r_i	r_o
Fig.2(a)	voltage generator, voltage controlled	μ, voltage transfer ratio (dimensionless)	∞	
Fig.2(b)	voltage generator, current controlled	r_m, transfer resistance (ohms)		
Fig.2(c)	current generator, voltage controlled	g_m, transfer conductance (siemens)	∞	∞
Fig.2(d)	current generator, current controlled	α, current transfer ratio (dimensionless)		∞

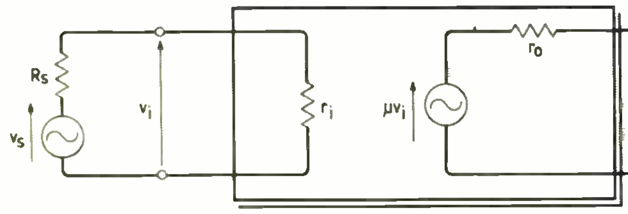


Fig.3. A 'real' voltage amplifier offers a finite input resistance r_i and output resistance r_o. The designer has to keep a weather eye on these, or the gain might be much less than expected – if the external load and source resistances are not suitable.

of finite input and output resistances. Figure 2(a) is then modified as shown in Fig.3. You might recognize this much more familiar block with its input resistance r_i, output resistance r_o, together with source signal generator (with its own internal resistance, R_s), and the load resistor, R_L.

This familiar voltage amplifier equivalent circuit enables a quick analysis to be carried out for its voltage amplification. This is defined as the ratio of the output voltage to the input voltage, and is found by noting the input and output voltage dividers (R_s working with r_i and r_o in conjunction with R_L) together with the transfer parameter μ. But one not so obvious question, and one that is not often answered very well in the books, immediately arises. *Which* voltage amplification are we talking about? Is it v_o/v_s or v_o/v_i, because these ratios will be different in general. I have plumped for defining the ratio v_o/v_s as A_v – the *external* voltage amplification, and V_o/V_i as A_v – the *internal* voltage amplification.

The main point, though, is to see how to arrange the design for closest approach to ideality. Clear requirements for this include the conditions $r_i \gg R_s$ and $r_o \ll R_L$. If the first condition obtains, then the external and internal amplifications, as I have defined them, become equal. If the second condition is true also, then the loss of voltage at the output potential divider disappears so that the overall gain is the absolute maximum value μ. The best voltage amplifiers must therefore have a very high input resistance, a low output resistance and a constant voltage ratio transfer function, i.e. they approximate to the conditions of Fig.2(a), in particular, it is no use connecting, say, a pH meter probe whose R_s might be $\approx 10^{10}$ ohms to a bipolar transistor amplifier whose r_i is usually about 1.5 kΩ. You won't see anything on the meter...

TRANSISTORS

Field-effect transistors yield a good approximation at the input to the conditions for amplification. They have a rather high output resistance, similar indeed to the characteristics of the pentode valve stage – for those readers who can still remember them. For example, they would be appropriate for the pH probe requirement. Bipolar transistors were conceived as current driven devices, operating more or less exclusively in the common-base circuit. This circuit yields a very low input resistance looking into the emitter and a very high resistance looking back into the collector at the output. The equivalent circuit in Fig.4 shows that Fig. 2(d) is appropriate.

This would indicate that the common-base transistor circuit makes a good current amplifier. Unfortunately, the current "gain" α is less than 1, even though only slightly. This means a current *loss* occurs, which is a little embarrassing.

Like all good stories, there is often a messy – if not confusing part. Ours is the mode of operation that gave the transistor its name. It is the current amplifier just described that was appropriate at the time, although the actual current gain itself – or lack of it, was of secondary importance. The significant action was that the input current flowing in the low r_i could be transferred to flow (via the effect of the current-gain factor α) in a different circuit mesh containing the high resistance, r_o. So the device became known as a 'transfer resistor' or transistor for short because of this action. But this is not the same argument as that for the example illustrated in Fig. 2(b), which is a true transresistance amplifier, possessing a transfer resistance parameter, r_m. The output resistances and the type of controlled generator differ in the two cases. This could be very confusing as the same term (transfer resistor) is used in both.

SIGNAL CONVERTERS

A voltage amplifier has a gain which is dimensionless. Of course, nearly all the tiny voltages from transducers and sensors designed to respond to the enormous range of physical variations we run around detecting in the work, home and natural environment these days, need boosting to reach working levels. Some signals are produced as tiny currents and simple current amplifiers can be used to boost these via the amplifier's dimensionless gain ratio, together with appropriate consideration of the input and output current dividers and, as in voltage amplifiers, care whether we are using the *external* or *internal* current gain.

The possibility of converting one kind of signal to another would also be very useful. The 'amplifier' then operates not only to give gain, but also *signal conditioning*. This is another way of looking at transresistance and transconductance amplifiers, namely, as current-to-voltage and voltage-to-current converters. As seen earlier, the gain parameters describing either of these amplifiers are not dimensionless, and are therefore not ratios. The quantities are *rates* and measure either the rate at which the output current changes for input voltage variations, or how the output voltage varies for input current changes.

Finally on this point, the actual transfer rates or ratios may themselves vary — in other words, they may not be constants or even simple parameters[3] any more. Tone controls in audio amplifiers carry out this kind of function. (In this case the transfer ratios or rates are functions of frequency.) Another simple application of 'doctoring' the rates or ratios in this way is to make them depend on the logarithm of the signal quality. (This time they become functions of amplitude). In this operation, direct decibel-scale outputs can be obtained[4]. This kind of functional designing-in broadens the concept of signal conditioning even more. In this last example, the amplifiers are no longer operating in the linear mode, which now therefore requires more careful thought.

So there is more in the simple idea of amplification than meets the eye. The subject could be amplified (!) further and if your appetite has been whetted, then an hour or two with a good book[5] will expand on the design principles of particular applications. I have said nothing about negative feedback. It is well known that the use of the various methods of connecting feedback into the input terminals and of deriving the fraction sampled at the output, has a strong effect on the input and output impedance levels of the amplifier.

Current amplifiers and transconductance circuits are really inherent power amplifiers. Plenty of amperes are required to dissipate the watts required to drive most output transducers such as loudspeakers, or electric motors for that matter. But although *power* amplification was where we came in, it must now become another story – and is a subject strewn with even more pitfalls.

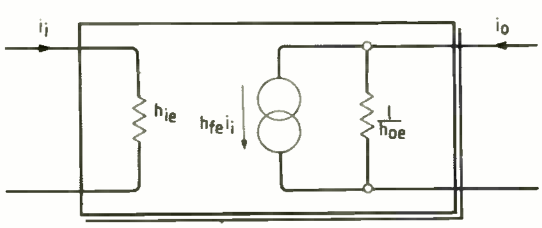


Fig.4. If h_{ie} is small and $1/h_{oe}$ large (at least compared to the source and load that is connected to the respective terminals), then this block approximates to the ideal current amplifier and fits the common-emitter transistor well.

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Measuring low frequencies

Long measurement intervals in very-low-frequency measurement can be avoided by the use of a look-up table residing in rom.

H.G. DE MATTOS-SHIPLEY

A digital meter measuring the frequency of an h.f. signal is theoretically simple. One simply counts the number of signal cycles during a convenient time interval to obtain a measure of the signal's frequency. The same principle could be applied to low-frequency signals, but because everything happens so slowly, counting the cycles can be a slow business. It takes 100 seconds to tell the difference between 49.99 Hz and 50.00 Hz, and that does not take into account the possibility of rounding errors, which can arise if the time interval starts or stops at an impropitious moment.

It is, of course, possible to use a frequency-multiplying circuit, using a divider in the feedback circuit of a phase-lock loop to obtain a higher-frequency input signal. Even then, there is the problem of the time it takes for the loop to lock, not to mention tracking problems if the low-frequency signal suddenly changes frequency.

Of course, with a low-frequency signal there is nothing to prevent one measuring its period. Since that period is inversely proportional to the frequency, the latter can be calculated and the answer is available within one or two cycles of the input waveform. The meter described in this article does operate by measuring the period of the incoming waveform. What is of interest is the manner in which the frequency is obtained therefrom.

Obtaining the reciprocal of a number can be obtained by going through the mathematics, either in software if a computer is available for the task or even in hardware, although the latter requires a fairly complicated design. Another method is to use look-up tables stored in rom.

Look-up tables have the advantage that you can provide more than one "frequency" for each cycle period. A frequency meter can be used, for example, as a car speedometer taking its input from a suitable transducer. With a multiple look-up table, at the flick of a switch, the speed is available in miles/h or km/h or ft/s or even knots. It merely requires a few address bits to a rom to be changed and a different "calculation" results.

Of course, if a separate entry were provided in the look-up table for every possible time period likely to be encountered, the table could become uncomfortably large. Using a 16-bit counter for measuring the time period would require 65,536 entries for each item of frequency information to be recovered. This, however, is not necessary.

The look-up table can be arranged so as to contain not merely frequency information, but period information as well. Having measured the period of an input waveform, one can then scan the period information until one finds in the look-up table the largest period not greater than the period measured. Stored with that value will be the corresponding frequency.

This method has the advantage that the frequencies for which there are entries in the look-up table need not be equally spaced. The meter can be arranged to have different resolutions at different points of its scale. A meter for measuring the mains frequency could have (say) a resolution of 0.01 Hz in the region round 50 Hz (or 60 Hz or both) while having a resolution dropping to only 1 Hz below 40 Hz or above 70 Hz.

Further, the meter can operate quickly, for there is no reason why the look-up table scanning should not proceed while the period is being measured. This is a simple matter. One simply arranges the entries in the look-up table in order of size of period.

The meter then operates as follows. At the start of an input signal cycle, a timing counter is zeroed, as is a counter used as a pointer into the look-up table. The timing counter is then incremented at regular intervals to measure the length of the period.

As this counter is incremented, its value is compared with the first timing period obtained from the look-up table. This first value corresponds to the period representing the transition between the highest frequency (which would correspond also to frequency overflow) and the next highest frequency. If the values are equal, then the look-up table pointer is incremented to point to the next transition period.

The process is continued until the end of the input cycle. Since the look-up table pointer points to that part of the look-up table corresponding to the detected frequency, it can be used to extract from the look-up table the frequency information which is to be the output.

The only other requirements of a practical circuit are suitable input signal conditioning, data steering to take into account the liking of cheap roms (that is to say eproms) to deal in data which is eight bits wide, and some means of detecting frequency underflow.

The principles of operation have been outlined, but the circuit can be varied to suit particular requirements.

In this circuit, I have assumed a maximum of 256 different period transitions. The circuit will accordingly only output 256 different frequencies, but these can of course be distributed in such manner as is desired. Again, it is merely a case of programming the eprom with the appropriate data. For each frequency, up to 16 bits of output information may be required. What form this data takes is arbitrary: It could be binary code, b.c.d. code or even direct output for seven-segment devices. If b.c.d. coding is used, the output data could contain code to blank the less significant digits of the display to indicate the resolution of the meter in the area of the frequency detected.

There is also provision for four different sets of transition periods and corresponding output data to be available. This is implemented by switching two bits of the eprom's address data. A mains frequency meter can have its area of maximum resolution switchable between 50 Hz and 60 Hz, with two more "spreads" available.

In the circuit shown, the input signal period is measured using a 16-bit counter driven at 1 MHz (Counter 1). This will measure a maximum period of 65.535 ms, corresponding to a minimum measurable frequency of about 15.26 Hz.

Exactly how the 16-bit counter is constructed does not matter. Synchronous counters clocking on the rising edge of the input signal can be used with signal A, while asynchronous counters clocking on the falling edge of the input signal would use signal B. Likewise, signals C and D are used for active high and active low "clear" or "reset" signals. (Resetting should be asynchronous.)

The clock is derived from a 2MHz oscillator of standard design (Oscillator 1), and the flip-flop FF_1 provides the two phase signals A and B.

No signal conditioning circuitry is shown, but will be present if necessary. On the falling edge of the input signal, flip-flop FF_2 is reset. On the next rising edge of signal A, this is detected and stored in flip-flop FF_3 (which also resets FF_2). Flip-flop FF_4 provides signals E and F, indicating that the falling edge of the input signal has been detected, but this is information is delayed for one cycle of signals A and B.

If the start of an input cycle has not been detected, and the timing counter has not overflowed (detected by flip-flop FF_5), then the circuit undertakes the following tasks. At the start of Phase A, the timing counter (Counter 1) is incremented. Meanwhile the least significant byte of the current timing transition period is fetched from the eprom and is tested for equality with the least significant byte of the timing counter. At the end of Phase A (which is the beginning of Phase B), the results of this comparison are latched in FF_6.

Multiplexer 1 is an octal 2-to-1 multiplexer, which may be constructed in any convenient manner. Signals A and B are both available, which means that quad And-Or gates could be used. CF_1 is an octal comparator which produces an active low of the

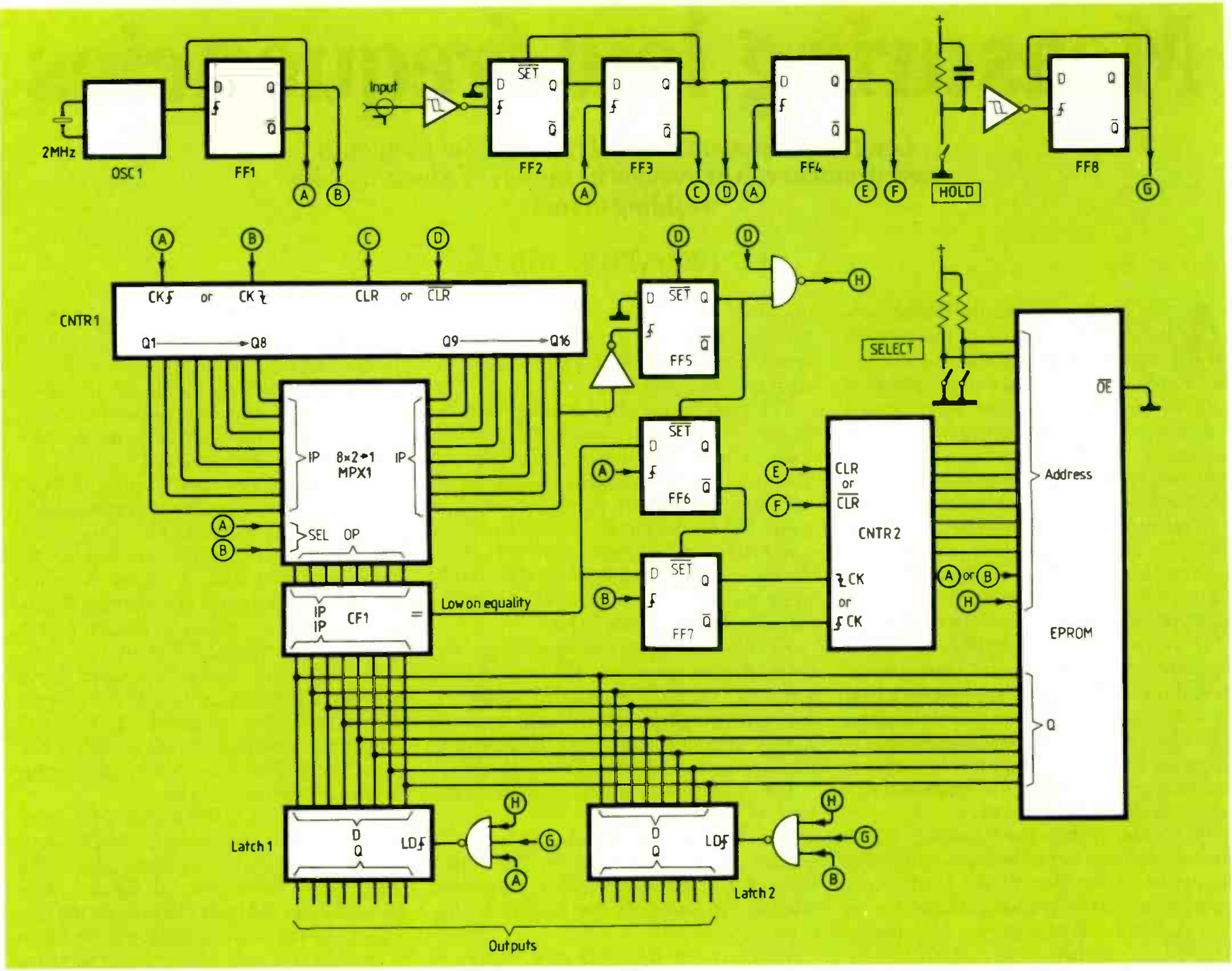


Fig. 1. Complete theoretical circuit diagram of low-frequency meter. Device types are not specific and circuit functions can be carried out by available i.cs.

output when the two inputs are equal.

During Phase B, the most significant byte of the current transition timing period is fetched from the eprom and is now compared with the most significant byte of the counter. At the end of Phase B, the result of this comparison is latched into FF_7.

The SET input of FF_6 and FF_7 are used to ensure that the output of FF_7 will only go low if both comparisons led to the relevant bytes being found to be equal and then only if the counter has not overflowed (detected by FF_5).

The output of FF_7 is used to increment the look-up table pointer counter, Counter 2. Again this could be constructed using synchronous or asynchronous counters with an active high or active low "clear" input. The "clear" input should be asynchronous.

As has been described, the end of an input cycle (and hence the start of the next) is detected by FF_2, FF_3 and FF_4. Various things now happen. Signal C or D is used to reset Counter 1. Meanwhile Latch 1 and Latch 2 are loaded with the recovered output data, and when all that has been accomplished, signal E and F is used to reset Counter 2.

The choice of latches is essentially arbitrary. In the circuit described, the latches are loaded either on the LD input being taken low (as with the LE input of a 4511 c-mos latch/decoder/driver) or on the rising edge of the LD input (as with a 74C374 or 74HC374 octal D-type flip-flop). An active-high load input latch could be used if the appropriate Nand gates are replaced by And gates, or the outputs of the Nand gates are inverted.

If the timing counter overflows, this is detected by FF_5 since if the input had been disconnected (thereby stopping the flow of input signal cycle starts), the output information would not otherwise be updated. With no signal applied some "frequency underflow" indication is needed. Accordingly, after FF_5 detects counter overflow, signal H is generated to cause the output information to be latched on the appropriate phases of signals A and B. When the next input cycle start is detected, then FF_5 is reset, and normal operation resumes.

Finally, flip-flop FF_8 is used to provide a "hold display" facility. Since the data output changes with each cycle of the input waveform, a display output may be difficult to read if it is jittering between adjacent values. The output signal G of FF_8 is used to prevent the output latches being updated, thereby freezing the display.

The Eprom is permanently enabled, and is shown with its data output driving CF1 and the two latches directly. If any of these devices are (say) LS t.t.l. rather than c-mos input devices then some buffering may be required.

Further, although this circuit has been described as a frequency meter, the output information is essentially arbitrary – what is put into the eproms comes out.

With the circuit shown, the signal H used as an address bit must distinguish between data corresponding to transition periods (H low) and output information (H high). The address bit corresponding to signal A or B will distinguish between the bytes that go to make up the transition period data (H low) or the output data (H high).

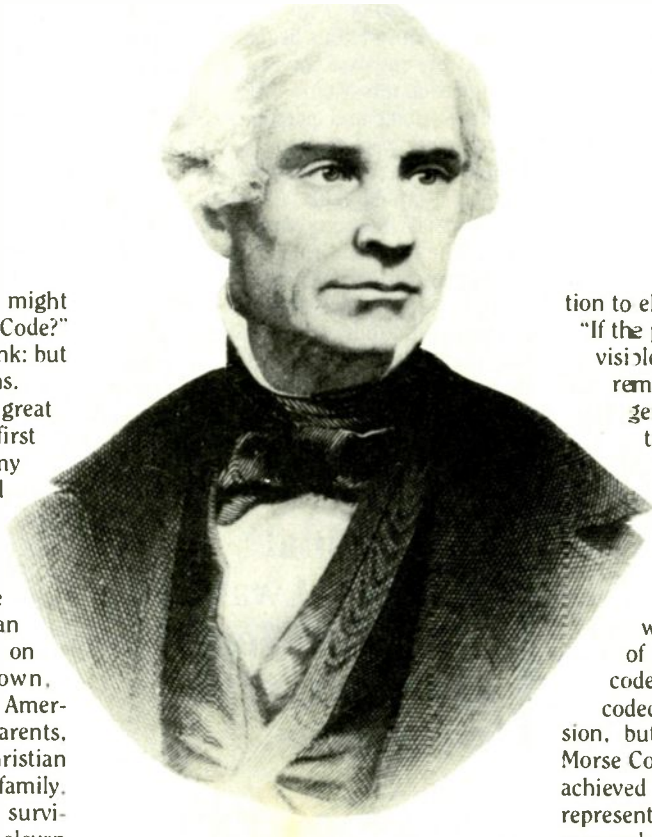
With two "select function" address bits and an 8-bit counter for Counter 2, the eprom is of 4K-byte size. Like the rest of the circuit this may be varied.

The only critical point about the information stored in the eprom relates to the transition period data. This must be organized to be output in increasing order as Counter 2 counts up, because CF_1 only detects equality and, if it misses a comparison, then Counter 2 will not be incremented.

Further, in order to ensure that Counter 2 does count, FF_7 must be set between transition periods. This can be achieved if all adjacent transition periods differ by two or more counts of Count 1. Otherwise, the circuit must be re-arranged with the output of FF_7 being used as a "clock enable" input to Counter 2, the clock being derived from signal A or B.

Pioneers

5. Samuel Finley Breese Morse (1791–1872) – the American Leonardo



Institution of Electrical Engineers.

A good Trivial Pursuit question might be, "Who invented the Morse Code?" Not very taxing, you might think: but the answer is less obvious than it seems.

Morse was an artist, painting his great love. He was a founder and the first President of the US National Academy of Design. When he took up a second career as an engineer-inventor he left his art unwillingly and grieved over the loss for years.

Samuel Finley Breese Morse – the American Leonardo, according to an enthusiastic biographer – was born on 27th April, 1791 in Charlestown, Massachusetts, a sixth-generation American. Named after his mother's parents, taking their surnames as his Christian names, he was called Finley by his family. He and two brothers were the only survivors through birth and infancy of eleven children. Later he fathered eight of his own.

Whilst a student at Yale his reputation as an artist began to grow, especially for his ivory miniatures. But his father dissuaded him from art as a career and, for a time, Morse became a clerk in a bookshop.

His talent was not to be restrained, though. On 13th July 1811, aged 20, and with his parents blessing, he sailed for England where he studied art for the next four years, mainly at the Royal Academy in London. Among his works were at least three of outstanding merit. One, 'The Dying Hercules', was exhibited at the Royal Academy; another, a statuette of Hercules, won a gold medal from the Society of Arts.

On his return home his hopes of reviving the splendour of the fifteenth century crashed. Though admired, his historical paintings were not bought and for income he turned to portraiture, seemingly the only form of painting Americans would buy. At this he excelled.

His personality brought him social respect; his art scratched him a living, though at times meagre. Best known of his works are probably two portraits of Lafayette, painted in Washington in 1825, and the slightly earlier 'The Old House of Representatives' which includes 86 portraits.

"If the presence of electricity can be made visible... I see no reason why intelligence may not be transmitted instantaneously."

Even in those early years Morse appears to have been something of an experimenter. For a portrait of his wife and children he ground the pigments in milk. Another time he used beer!

The mid-1820s brought change for Morse. In four short years his wife, father and mother all died. In 1829 he again sailed for Europe and spent the next three years mostly in France and Italy.

On the return voyage in 1832 a fellow passenger drew the dinner-time conversation to electricity. Soon Morse was hooked. "If the presence of electricity can be made visible in any part of the circuit," he remarked, "I see no reason why intelligence may not be transmitted instantaneously by electricity." By the end of the voyage his notebook was crammed with sketches and ideas. The next dozen years transformed his life – and the world.

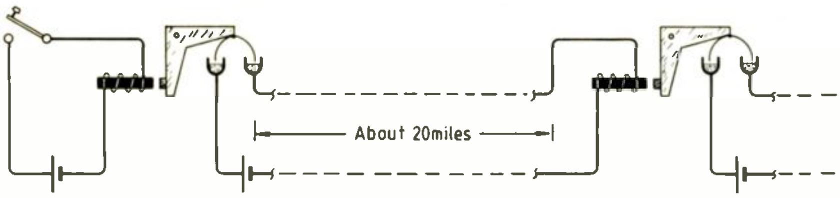
He devised a system in which words were represented by groups of numbers and he began work on a code book. Each numeral was further coded into dots and dashes for transmission, but this was not the now famous Morse Code. Speedy transmission was to be achieved with lead 'types' which had teeth representing the dots and dashes of the numerals. Assembled on a bar, they were pulled across contacts so that the teeth switched a battery in and out of a two-wire circuit. From the beginning he wanted a receiver that would give a permanent record of the message. The earliest model had an electromagnet which moved a pencil to mark the dots and dashes on to paper tape driven along by clockwork.

Evidently Morse's proposals owed little to the rush of European ideas for magnetic needle telegraphs. His thoughts were his own, and for years he found it difficult to believe that anyone had considered electric telegraphy before him.

After landing at New York he tinkered with telegraphy until necessity forced itself upon him. He had children to support, paintings to finish, and very little money.

By the end of 1835 he was at the University of the City of New York (now New York University) as professor of painting and sculpture (later as professor of literature of the arts of design). Apart from teaching and painting, both of which brought in a little money and took most of his time, he was once again working on the telegraph.

A friend who saw this early telegraph was Leonard D. Gale, a professor of science, and in him Morse found a partner. In particular



Morse relay system, as published in 1867. An electromagnet closed a mercury switch which activated the next battery and a further 20 miles or so of wire.

he learned from Gale of Henry's achievements with electromagnetism. Henry had pointed the way to telegraphy in 1831 when he signalled through more than a mile of wire to cause an electromagnet to strike a bell – the first electric bell!

Gale's contributions included recognizing the need for a large number of turns of fine wire (hundreds instead of tens) at the receiving electromagnet, and a multiple-cell rather than single-cell battery at the transmitter (so as to give a much higher voltage). This knowledge Gale had learned from Henry, and with such help Morse increased his range from a meagre 40 feet to a respectable 10 miles. On a number of occasions later Henry gave direct advice and encouragement.

Meanwhile the US Government had begun to consider whether some form of telegraph system would be of use to America. Amongst others, Morse responded with his proposals on 27th September, 1837. In October he began his application for a patent, which was granted on 20th June, 1840. His bid for a British patent was foiled by objections from Cooke and Wheatstone who had already patented their own telegraph system.

A third man, Alfred Vail, who had been a student only a year before, joined the partnership in September 1837, bringing much-needed financial backing as well as great mechanical skill. In Morse's own words, the original equipment was made up of "an old picture or canvas frame fastened to a table, the wheels of an old wooden clock moved by a weight to carry the paper forward" and "three wooden drums". It was so crude he was reluctant to have it seen.

Morse and Vail set to work to improve it. The lead types at the transmitter were soon replaced by a key and keyboard. At the receiver, pencils, fountain pens and embossers were tried, and the number-coded words and code book were thrown out in favour of a dots-and-dashes code for each letter. It is likely that this 'Morse' code, which underwent a number of changes, was actually designed by Alfred Vail. Morse who was very protective of his own inventions, did not refute the suggestion.

F.O.J. Smith, a fourth partner, joined in March 1838. As a lawyer his job was to steer the telegraph through the labyrinths of Washington. Here Morse made a dreadful mistake. Smith has been described by many adjectives of which perhaps the gentlest is unscrupulous. In his attempts to further the telegraph, of which he was now part owner, he is said to have abused his position as a congressman. Much later he harried Morse for a share of 400 000 francs which European countries had given to Morse as an honorary gratuity. Morse was at times close to despair.

In 1838, with the improved equipment, public demonstrations began. The dots and dashes were embossed on to paper and gave a transmission rate of ten words per minute.

Morse's long and personal struggle for government recognition was finally rewarded in 1843 when Congress, by a narrow margin, granted $30 000 (£6000) for a 40-mile trial line from Washington to Baltimore. The long and frustrating delays had once again brought Morse to the brink of financial ruin, with even Vail's family, who had provided funds, refusing more support. The years from 1837 to 1844 were hard, Morse preferring poverty and hunger to debt. It was his tenacity in the face of rejection which brought him eventual success.

The original equipment was so crude that Morse was reluctant to have it seen.

The twin 40-mile lengths of iron wire were tested before laying. Then, with a specially designed 'plough', the wires were encased in hot lead and speedily buried. When it was discovered that the line no longer worked (the insulation having been damaged by the heat) all was discreetly recovered (Government money was involved) and the line strung up on chestnut poles using glass doorknobs as insulators.

As the two-wire line reached out from Washington it was regularly checked by sending messages both ways. At last on 24th May 1844, soon after his 53rd birthday, Morse opened his telegraph with the famous first message, "What hath God wrought!"

That year's Democratic Convention in Baltimore brought further publicity. The vote for the presidential nomination ran to nine ballots. The result of each was telegraphed immediately to Washington where Morse had cunningly established his office in the Chamber of the Supreme Court. As the excitement grew politicians flocked to Morse's room in such numbers that the Senate was adjourned. The Morse telegraph had arrived.

By 1845 the line had been extended to New York and Boston, using one wire and an earth return. The paper embossers were eventually replaced by inkers. In turn these gave way to the sounder, perfected by Vail after it was realized that operators could recognise messages from the clicks of the receivers.

Rarely can anything so novel have caught on so quickly. After only four years there were 6000 miles of wire in use in America and after eight years the figure was over 16 000 miles, about 70% of the world total. Morse had hoped that the Government would take up and run the telegraph as a national asset but this was not to be. Instead licences were granted and private companies set up. The first big merger took place in 1851 and produced the Mississippi Valley Printing Telegraph Company, better known later as Western Union.

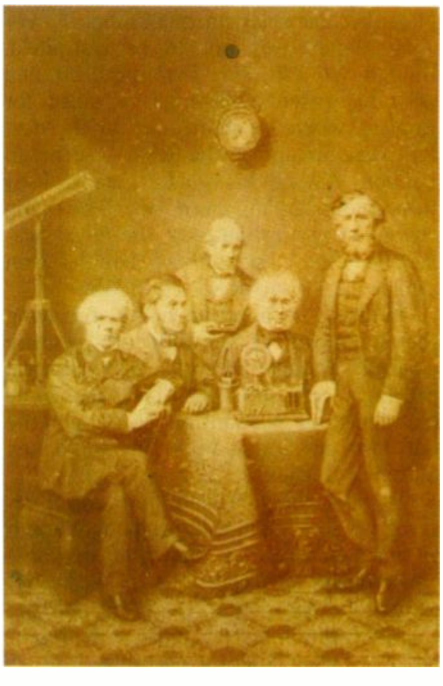
At 57, after 23 years as a widower, Morse remarried. Later, as he grew rich from the exploitation of his system he became a philanthropist and again supported the furtherance of art, though his own skills were never really recovered. In 1836 he had tried his hand at politics when he ran for mayor of New York. Aged 63, he had another go, this time attempting to become a Democratic Congressman. Again he was defeated.

As the Morse telegraph spread, only memories remained of the early system over which the artist had laboured in New York. Gone were the lead types, code book, pencil or embosser and buried line. In their place was a simple system of Morse key, overhead wire, and sounder. Gone too was a public naivety which prompted one Washingtonian to ask the cost of sending a parcel to Baltimore by telegraph.

Tony Atherton works at the Independent Broadcasting Authority's engineering training college in Devon. His book, From Compass to Computer, A History of Electrical and Electronics Engineering, was published by Macmillan in 1984.

Next in this series of pioneers of electrical communication will be William Thomson (Lord Kelvin).

The distinguished group below comes from a photograph in the collection of Mr Peter Mallett.



Editorial Feature List

JUNE 1987

Batteries. Recent developments in battery design mean that an investigation into the new types available is needed. We discuss design and applications and characterize the types on the market.

JULY 1987

Computer-aided design. There is a great deal of hardware and software dedicated to the design of electronic equipment, from printed circuit boards to integrated circuits. We examine what is now available.

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Building blocks for active op-amp compensation

Actively compensated op-amps offer significant improvement to the h.f. performance of active filters. Here Professor Soliman surveys first-order circuits using two op-amps to formulate a systematic design procedure.

AHMED M. SOLIMAN

The characteristics of most active filters using operational amplifiers change significantly at high frequencies due to h.f. roll-off of the op-amp gain. Several actively compensated finite-gain amplifiers and integrators have recently been introduced in the literature (see bibliographic references) that offer significant improvements in the h.f. performance of filters employing them This article is a wide-ranging survey of actively compensated finite-gain amplifiers and integrators.

To formulate a systematic procedure for the realization of the compensated amplifiers and integrators, five first-order buildings blocks are considered together with their transfer functions. Most of the actively compensated amplifiers and integrators are generated using one of these building blocks. The actively compensated amplifiers and integrators considered in this paper are limited to those employing two op-amps only.

GENERALIZED FIRST-ORDER BUILDING BLOCK

Figure 1(a) represents the generalized first-order building block employing a single op-amp, for which the basic equation is

$$\frac{V_o}{A}=aV_i+bV_o \qquad (1)$$

where a and b are real coefficients having magnitudes ≤ 1. Let the open-loop gain of the op-amp be represented by the single-pole model:

$$A(s)\approx\frac{\omega_t}{s}$$

where ω_t is the gain-bandwidth product of the op-amp. Substituting this into (1), the transfer function of the generalized block can be shown to be

$$\frac{V_o}{V_i}=-\frac{a}{b}\cdot\frac{1}{1-\dfrac{s}{b\omega_t}}$$

and the d.c. gain is $= -a/b$. For the stability of the block, coefficient b must be negative. For a non-inverting block coefficient a must be positive, and for an inverting one it must be negative.

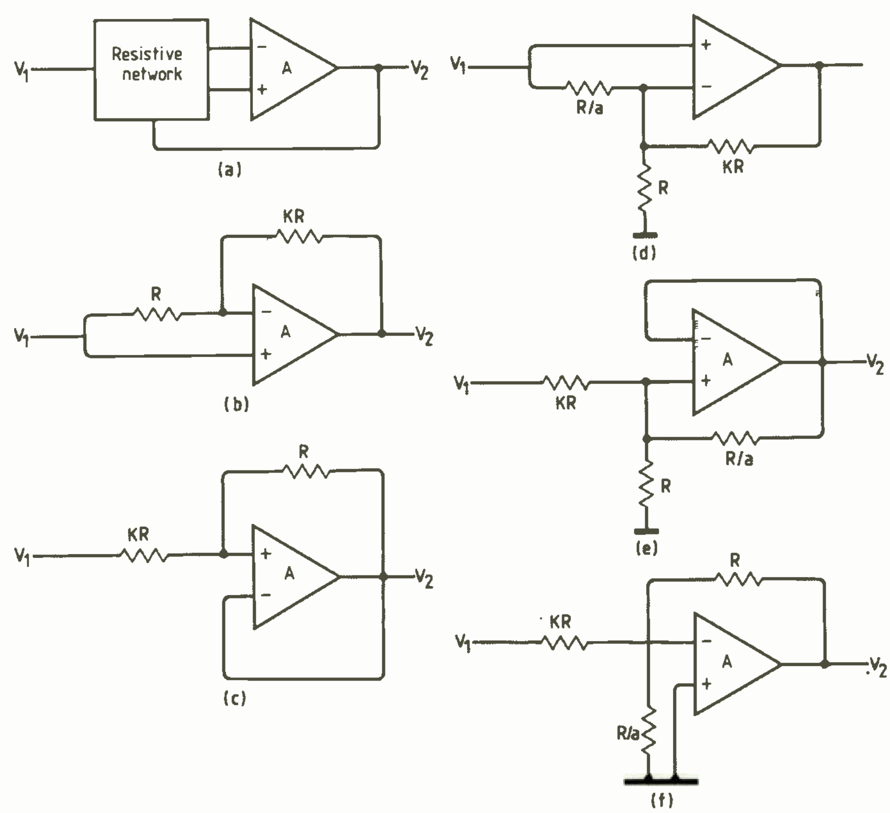

Fig.1. Generalized first-order building block (BB) employing a single op-amp (a) and two equivalent non-inverting first-order blocks BB1 (b,c) with unity d.c. gain. BB2 (d) has a d.c. gain >1 and BB3 (e) has a d.c. gain <1, while the fourth BB4 (f) is an inverting block.

In the next section, five building blocks are given, where it is assumed that the single-pole model is used to represent op-amp gain characteristics.

BUILDING BLOCK 1

The transfer function of the first building block, Fig.1(b) is

$$\frac{V_2}{V_1}=\frac{1}{1+\dfrac{K+1}{\omega_t}s}$$

and an equivalent building block is shown at (c). These two equivalent blocks have been employed widely in the field of active compensation. The first application is in the phase-compensated three-port v.c.v.s. network[1] shown in Fig.2, whose general compensated expression for v_o is

$$V_o=[(K_1+1)V_p-K_1V_n]E(s)$$

where $$E(s)=\frac{1+sT}{1+sT_1+s^2TT_1},\quad T=\frac{K+1}{\omega_t}\ \text{and}\ T_1=\frac{K_1+1}{\omega_{t1}}.$$

To reduce the phase error to a negligible limit it is necessary that $T = T_1$, so that if matched op-amps are used, the design equation for phase compensation simplifies to $K = K_1$. This compensation technique has been applied to realise compensated all-pass filters, and experimentals results were given in ref. 1.

Actively-compensated three-port v.c.v.s. using BB1, Fig.2, with a non-inverting d.c. gain K_1+1 and an inverting d.c. gain $-K_1$, yields a negligible phase error assuming matched op-amps are used and $K=K_1$. Fig.3 is a variable-phase inverting integrator using BB1. In the improved Kerwin-Huelsman-Newcomb biquad filter using BB1, Fig.4, resistor KR in BB1 should be tuned to $K=3$ for phase correction around the loop. In the variable-phase non-inverting amplifier using BB3, Fig.6, resistor KR in BB3 controls the d.c. gain of the v.c.v.s. which equals to $K+1$. Resistor R/a controls phase. If matched op-amps are used, the condition for phase compensation is $a=K+1$. The phase-compensated three-port v.c.v.s. network of Fig.7 uses either BB2 or BB3.

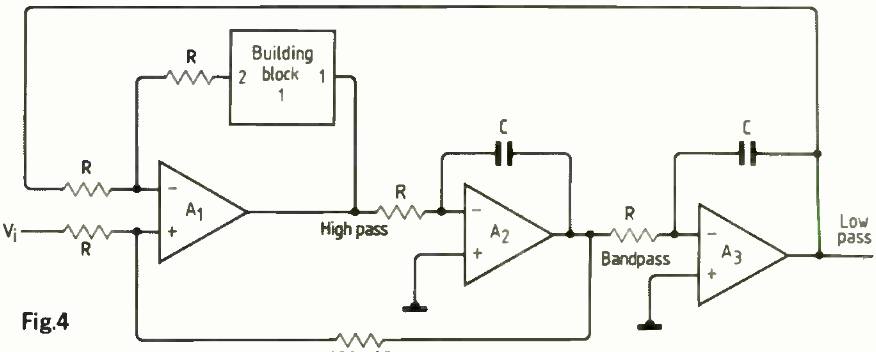

Fig.4

The second application is in the variable phase-inverting integrator[2] shown in Fig. 3. If matched op-amps are used, the integrator phase is controlled by the parameter K and is approximately

$$\phi \approx K\frac{\omega}{\omega_t} \qquad \omega \ll \omega_t.$$

Many applications for this phase-lead inverting integrator in realizing two-integrator loop filters suitable for high Q and high frequency are given in reference 3.

The three-port v.c.v.s. of Fig. 2 can also be adjusted to realize a phase-lead three-port v.c.v.s. which has an important application in the phase correction of the Kerwin-Huelsman-Newcomb KHN filter. Fig.4 represents the improved KHN biquad filter. Fig.5 shows the improvement in the performance of the filter with BB1 included and adjusted so that $K=3$ to provide the necessary phase lead of $2\omega/\omega_t$ to cancel the phase lag of the two integrators (ref.4).

Building blocks 2 and 3 are generalizations of each of the first blocks. Block 2 has very limited application; on the other hand block 3 has many useful applications, as given next.

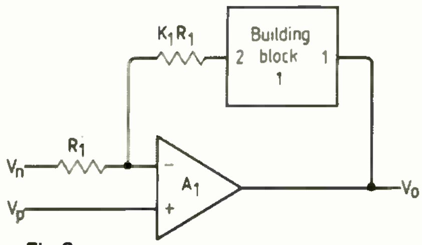

Fig.2

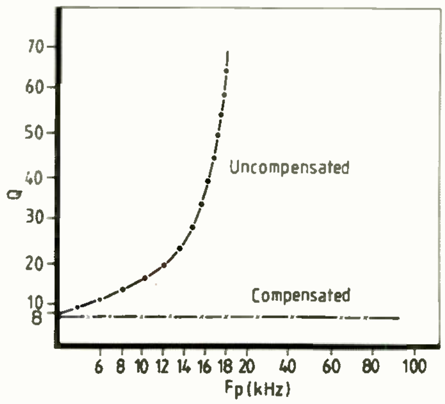

Fig.5. Graph shows measured Q versus f_p at $Q_o=8$ of the KHN filter (from ref.4).

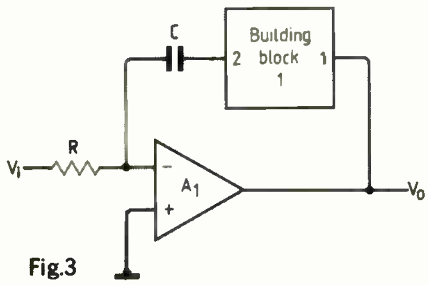

Fig.3

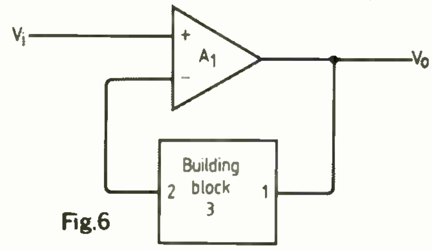

Fig.6

BUILDING BLOCK 3

An important application of BB3 is in the variable-phase non-inverting amplifier[5] shown in Fig.6. If matched op-amps are used, the phase for this amplifier is

$$\phi \approx K\left[\frac{a}{K+1}-1\right]\frac{\omega}{\omega_t} \qquad \omega \ll \omega_t. \qquad (2)$$

Figure 7 is a generalization of Fig.2 using blocks 2 or 3 (see ref.6). The phase-lead inverting integrator[7] shown in Fig.8, introduced in 1980, has excess phase given in eqn 2. Its application in the Tow-Thomas (TT) biquad and the KHN biquad is shown in Figs 9 and 10 respectively where parameters K and a for BB3 are adjusted so that $K = 1$ and $a = 8$ to yield the phase lead of $3\omega_o/\omega_t$, which is the necessary amount for phase correction at ω_o.

Another application for BB3 is in the realization of the variable-phase non-inverting integrator[7] shown in Fig.11, where the phase for this grounded-capacitor integrator has the form given by (2). An improved two-integrator loop filter using this integrator has parameters adjusted so that $K = 1$ and $a = 4$, Fig.12.

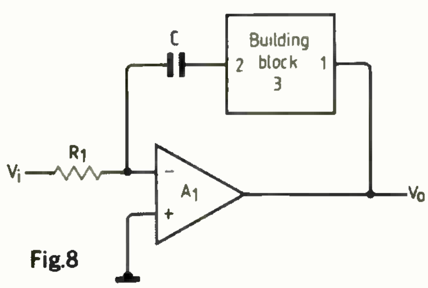

Fig.8

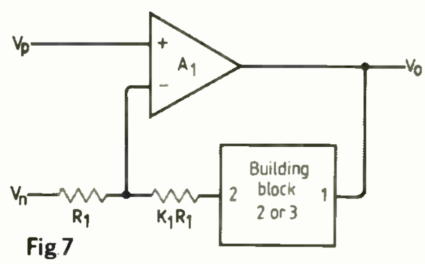

Fig.7

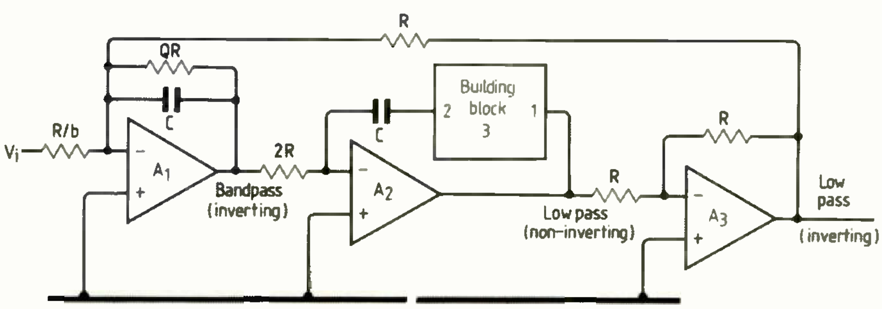

Fig.9

BUILDING BLOCK 4

The inverting building block of Fig.1(f) has the transfer function

$$\frac{V_2}{V_1}=-\frac{1}{K+\frac{[K(a+1)+1]s}{\omega_t}}$$

Figure 13 represents the variable-phase inverting amplifier[8] using block 4, in which the phase is

$$\Phi\approx\left[a+1+\frac{1}{K}-K\right]\frac{\omega}{\omega_t},\quad \omega\ll\omega_t.$$

Block 4 can also be used to realise a phase-compenstated three-port v.c.v.s. as shown in Fig.14. And finally, an improved TT biquad using block 4 is given in Fig.15.

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Professor Soliman is head of the electrical engineering department of the United Emirates University, Al-Ain, United Arab Republic.

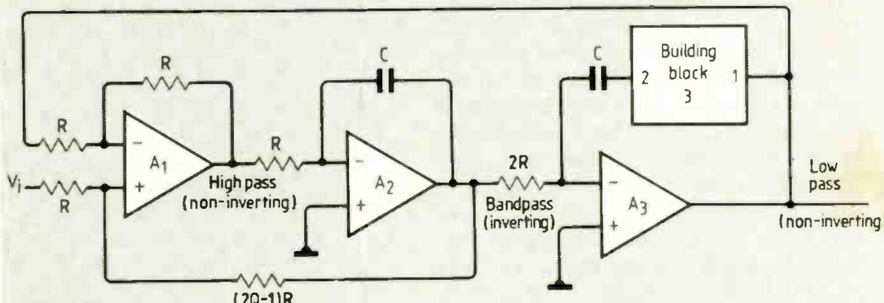

Fig.10.

Improved Kerwin-Heulsman-Newcomb biquad (above) and high frequency using BB3, with a=8 as in Fig.9, and K=1 (Fig.10). Grounded-C variable-phase non-inverting integrator using BB3 is shown left (Fig.11), while Fig.12 (below) is the improved two-integrator loop filter. The non-inverting integrator is adjusted to provide a phase lead at resonance equal to ω_o/ω_t. In this case the design values for the BB3 parameters are K=1, a=4. In the variable-phase inverting amplifier using BB4, Fig.13, the design value for a that provides phase compensation is $K-1-K^{-1}$, assuming matched op-amps are used.

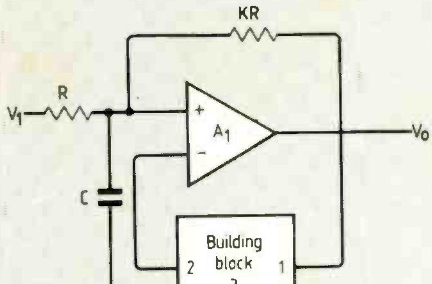

Fig.11.

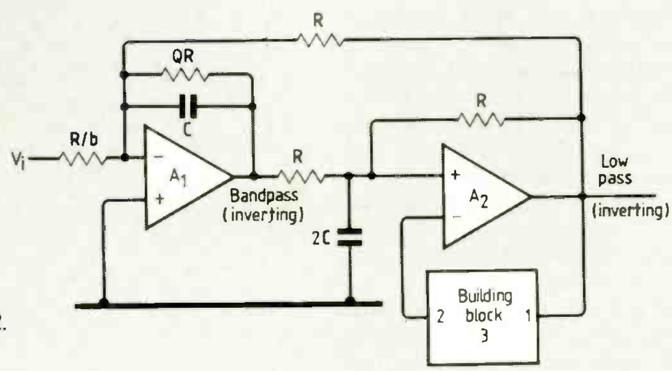

Fig.12.

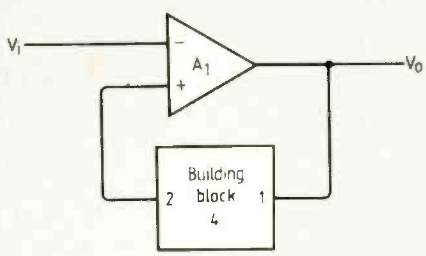

Fig.13.

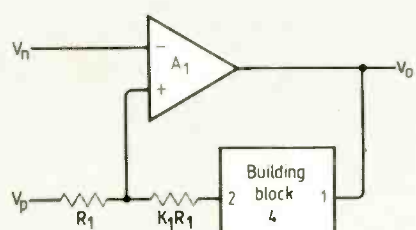

Fig.14.

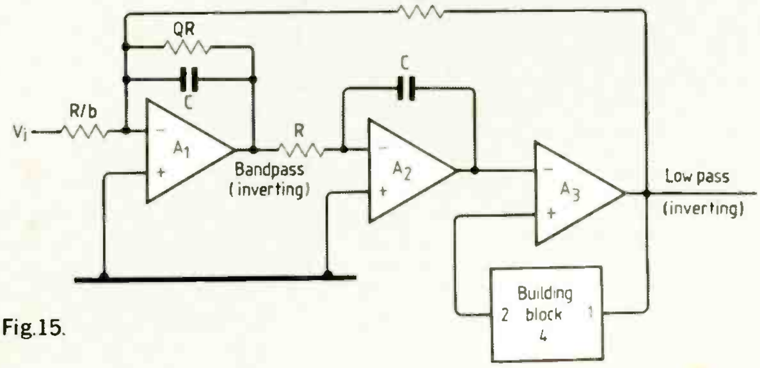

Fig.15.

In Fig.14, the condition for phase compensation is $K^2(K_1+1)=K(a+1)+1$, the non-inverting d.c. gain $P=KK_1$ and the magnitude of the inverting d.c. gain $N=K(K_1+1)$. Improved TT biquad filter, Fig.15, is suitable for high Q and high frequency using BB4. Assuming matched op-amps are used and taking K=1 in BB4, the condition for phase correction around the loop is a=1.

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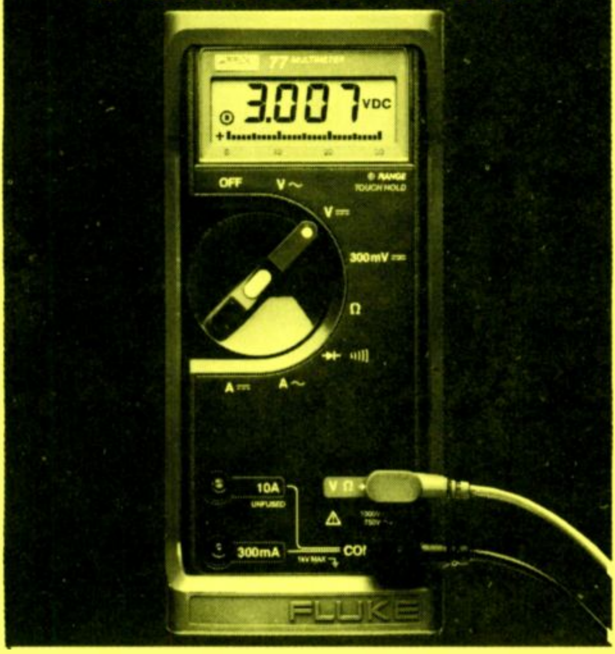

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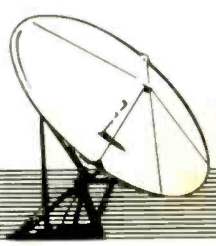

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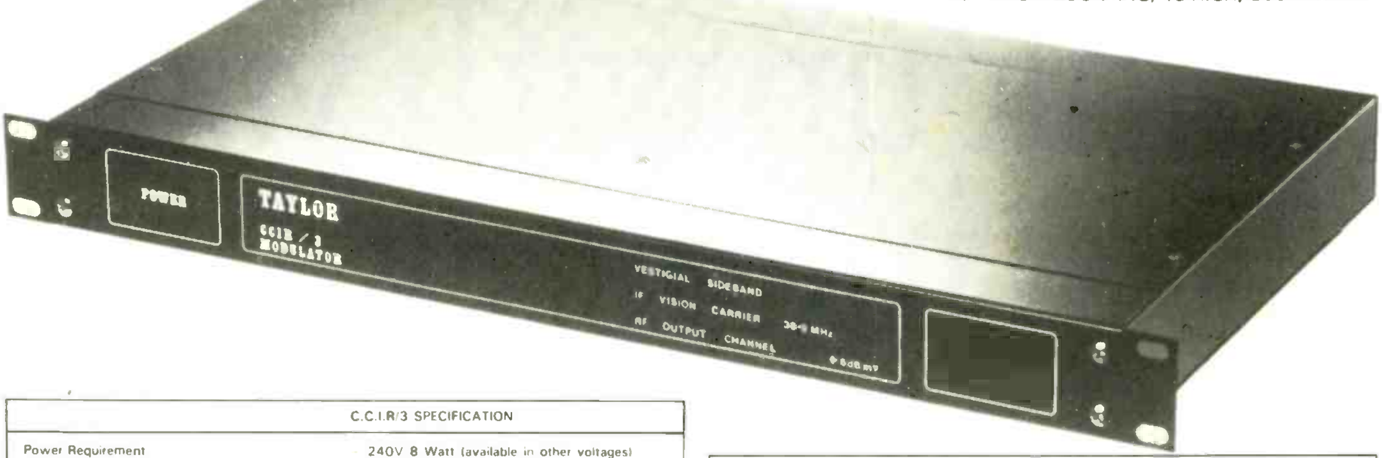

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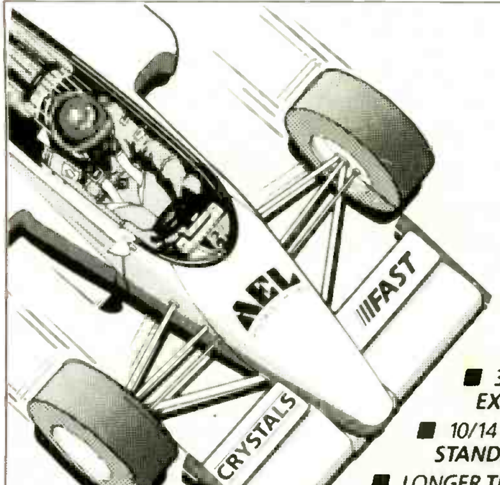

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Band III mobile radio

August is the date chosen for the London launch of a national private mobile radio network. The licence has been granted to Band Three Radio Ltd, a consortium consisting of Pye, Racal, Securicor and Digital Mobile Comminications. Band III is the frequency band vacated when the 405-line tv services ceased operation.

Mobile radio requirements are continuously expanding and there has been congestion on the permitted channels. The new allocation will add some 400 further channels to the existing 1300 private mobile radio and 600 cellular radio channels.

The Band Three network is intended to cover the whole country, with 60% of the population covered by mid-1988.

The system will incorporate long-distance trunking of shared circuits and frequencies. It will offer call queueing so that it will return an engaged tone. Privacy of conversations is ensured by varying the allocated channel from call to call. The system will have the capacity for 60 000 subscribers when fully operational. This compares with over 350 000 mobile radios currently in use outside the emergency services, and 130 000 cellular subscribers.

Users will be offered a choice of service from local to national coverage. The costs will be around 60% of those for cellular radio and will be more predictable because there is no use of the telephone network; although it will be possible to link with a PSTN call. Band Three Ltd will set up and run the network. Service providers will supply equipment and give access to the end users.

Advanced robotics centre

A government proposal to found an advanced robotics research centre has been met with enthusiasm by a number of institutions wishing to host the centre. The DTI has invited five applicants to make firm proposals. These are The Turing Institute, Glasgow, Harwell (UKAEA) Laboratory, Salford University, RSRE, Malvern combined with the Royal Armament Research and Development Establishment, Chertsey, and ERA Technology Ltd. The aim of the centre is to consolidate the UK's position in the field by developing a greater awareness of the market potential of robotics. Cooperation between industry and educational establishments will help to avoid wasteful duplication of effort and assist the formulation of collaboration projects. It is intended that the centre should combine the efforts of over 20 industrial partners.

The centre will be dedicated to the development, evaluation and integration of robotics technologies among which are: manipulators, including artificial limbs; sensors; navigation systems and mobility; and systems, software and control, including artificial intelligence. A particular emphasis will be placed on the development of robots for use in hostile environments.

Software ghost in the machine

One of the 1987 British Design Awards has gone to Direct Technology Ltd, of Isleworth, Middlesex, for a system that can copy the actions of an operator of a personal computer and then copy them. It's called a 'software robot' or ghost operator. 'Automator mi' is a program that is incorporated into the personal computer's systems disc so that it is always available.

One of the most frequent uses is to access a mainframe computer from the p.c. to obtain information from a database. This can be a tedious and error-prone operation; requiring the user to enter long strings of characters to call up the mainframe, set the transmission standards, enter passcodes and the like. Any error or a busy or faulty telephone link requires the whole operation to be repeated. The 'robot' can do the whole job automatically, repeating the operation or trying alternative numbers until the connection is made. In addition, because it can store the link drivers to a number of mainframes, it can even enable a link between incompatible mainframes through a p.c. running the program.

The robot can be set into action in a number of ways. An operator can press a pre-set key; it can respond to an incoming message; or it can operate automatically at a specific preset time. Thus it can be used to transfer files during the night or access a mainframe at a specific time each week. It can automatically reject unwanted electronic mail from blacklisted sources. Priorities can be built in so that it will interrupt a program already running if a more important task is detected. It can also be used to train operators by offering easy-to-use guides to running a program and telling the operator what they have done wrong.

The software comes in two parts, a "teaching" package to programme the robot and the normal user software.

Software design tool

The second of the two Design Awards for software goes to Yard Software Systems, of Chippenham, Wilts. It is designed specifically for the production of software used to run complex control systems, such as air-traffic control, or reactor systems where applications are critical. Lifespan, as it is called, was developed in Glasgow by Yard. It runs on a DEC Vax computer and imposes an organized environment on the development of the constituent modules that go into a complex control program. Each labelled module is 'signed out' to an engineer and carries its own history, such as version number, date, nature of modification, whether it has passed quality control, and its relationship to other modules. The modules are also provided with security checks so that only authorized users can use or change them. It keeps an 'overview' of the project and can provide progress reports.

More than 40 Lifespan systems are in operation, including exports to Switzerland and Holland. The system is under continuous development and has recently been extended to incorporate computer-aided design, and facilities leading towards integrated manfucturing control.

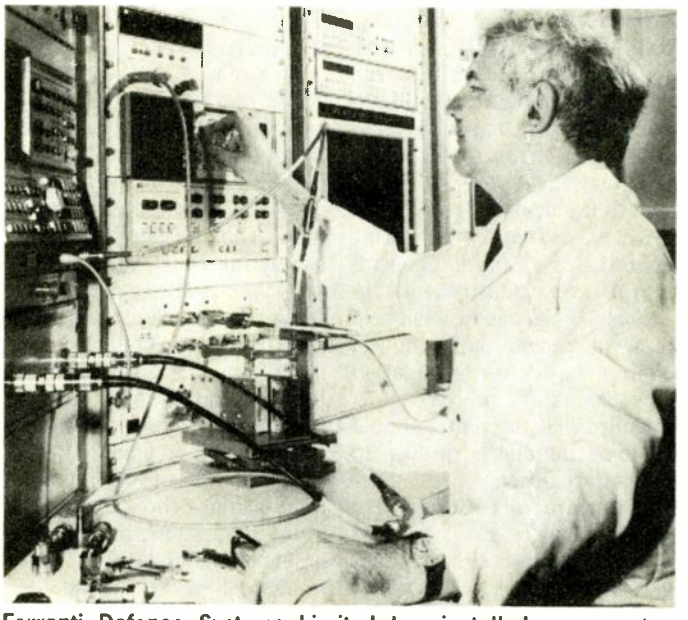
Don Yeates, Datasolve education director and Janet Larcher of The Spastics Society demonstrate a 'touch-painting' computer to Adam King, a pupil at the Society's Thomas Delarue School, Tonbridge, during the February launch of Datasolve's Award Scheme to further development of new technologies to help cerebral palsy children.

Electronics for peace

Electronics for Peace is an organization set up to unite those engineers in electronics and computing who did not want their resources used in a military context. The organization has now expanded by setting up a company, Exchange Resources, which will act as an employment agency, connecting engineers with like-minded companies and also as a business consultancy, offering business-to-business contacts, organisational and project help. Career and ethical counselling for individuals can be provided along with staff/management awareness seminars. Further details from Tony Wilson, a founder of Electronics for Peace, at EfP Ltd, 28 Milsom Street, Bath, BA1 1DP.

Electronic mail protocols

The X400 system of message-handling protocols has "moved from the laboratory to the world of commercial reality" says a report that follows demonstrations of equipment at the Hanover computer exhibition CeBIT '87. Two national telecommunications administrations, BT and Deutches Bundespost, combined with twelve manufacturers of electronic mail computers to demonstrate how their proprietary services and equipment communicated with each other. They were using the trial message-handling services being run by both authorities. BT has been running engineering trials since October and expects to launch a full commercial service in "late spring". The X400 protocol was developed by BT's subsidiary, Dialcom, in the USA. The system is available under franchise in 15 countries and can offer access to a world-wide business network. It can be used to link computers and terminals, telex, teletex and facsimile machines.



Ferranti Defence Systems Limited has installed a computer-controlled microwave test system for the measurement and calibration of microwave and hybrid r.f. radar components. The test system is the result of a three-year joint development project with Hewlett-Packard, representing one of the most sophisticated automatic test installations to be commissioned by Hewlett-Packard.

Electronic drums

A new range of electronic drum-kits with a number of new technical features was launched in Europe by Simmons Electronics Ltd at Musikmesse – the International musical instruments trade fair held at Frankfurt, West Germany.

The drum kits, in the SDX range, have been developed by Simmons with British Technology Group (BTG) support in the form of joint-venture funding for the project.

SDX embodies a number of significant advances and incorporates an 8Mbyte random-access memory controlled by a semi-custom integrated circuit so as to make optimum use of memory capacity to store the output signals. Up to 16 different voices are available on the top-of-the-range model. One facility enables the performer to manipulate digital samples of real drum and cymbal sounds. Sample resolution is 16-bit at 44.1 kHz, the processing format for compact disc digital audio.

An electronic drum-kit consists of a number of pads with electrical sensors instead of the drumheads of a traditional kit. Signals from the pads activate electronic signal generators which provide the audible output via conventional power amplifiers and loudspeakers. Advantage of electronic drum-kits include the ability to create remarkable effects and 'silent' practice using headphones. Hitherto the pads in electronic drum-kits have used piezoelectric transducers to sensor how hard the pad has been struck. The SDX range uses a resistor pattern printed on to a surface inside the drum pad so that the output sound depends on the position of the striking point within the pad as well as the force with which the drumstick hits the pad, as is the case with a traditional acoustic drumhead. The technique derives from pads designed for computer graphics applications. Each voice can be manipulated electronically by the performer using five programmable envelope generators for detailed control of sample playback frequency (to pitch the sound), filter cut-off frequency, noise amount, amplitude and output mix. Pitching is achieved by a second semicustom gate array, while a third array deals with rapid digital-to-analogue conversion.

The company, started by David Simmons and two colleagues, produced the world's first electronic drum kit. It has expanded rapidly in five years and has become the market leader in these instruments, despite competition from Japanese and European manufacturers.

In brief

Decisions on the exact nature and application of an h.f. planning system have effectively been postponed for some years until a proposed future WARC. In the meantime, h.f. broadcasting is to continue under the existing Article 17 regime. Recommendations of the 1987 WARC – held last February and March and reported elsewhere in this issue – will be put to the ITU's Administrative Council in June but a decision when to convene the proposed WARC will rest with the 1989 Plenipotentiary Conference.

The IBA are completing engineering test transmissions for their radio teletext service using the Telerate data system, these have been broadcast on the IBA LBC 97.3MHz transmitter in London. The sytem uses techniques developed in the USA and works rather like tv teletext, needing an adaptor to feed the data into a display terminal or computer. The service will offer up-to-date financial information. A similar service is to be offered on the Capital Radio transmitter (95.8MHz) run by Telemet (UK) Ltd.

The system can be used in parallel with the forthcoming Radio Data Service.

IEE and IEEIE lectures and meetings

12–15 May 1987
Automan: 4th European Automated Manufacturing systems exhibition and conference. NEC, Birmingham.

17–20 May 1987
CES – Consumer Electronics and Technology Show. Earls Court, London. Organised by Montbuild Ltd. Tel: 01-486 1951.

19–21 May 1987
Sound-Comm 87: Exhibition of the Association of Sound and Communication Engineers. Business Design Centre (formerly Royal Agricultural Hall), Liverpool Road, Islington, London N1. Batiste Exhibitions. Tel: 01-340 3291.

16–18 June 1987
Scottish Technology Week: including the Scottish Electronics Technology Show and Conference; the Scottish Factory Efficiency Show and Conference and OEM Scotland show and conference. Scottish Exhibition Centre, Glasgow.
Cahners Exhibitions. Tel: 01-891 5051.

18–20 June 1987
Television measurements: Third international IERE conference. Montreux, Switzerland. IERE. Tel: 01-388 3071.

22–26 June 1987
Laser 87 Opto-electronics, microwaves. 8th International congress and exhibition. Munich Trade Fair Centre, F.R. Germany. MMA, Messegelande, Postfach 12 10 09, D-8000 Munchen, FRG.

26–30 June 1987
BKSTS 87. 10th international film and tv technology conference and Exhibition. Metropole Hotel, Brighton. BKSTS. Tel: 01-242 8400.

7 July 1987
World final of the **Micromouse competition.** Maze-solving, self propelled computers will be running around the IEE, Savoy Place, London E1 at 17.30h. Further details, and rules and entry forms, from Andrew Wilson at the Institution. Tel: 01-240 1871 Ext. 260.

LANGREX SUPPLIES LTD

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SEMICONDUCTORS

AA119	0.10
AAY30	0.17
AAZ13	0.30
AAZ15	0.30
AAZ17	0.30
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AC125	0.35
AC126	0.35
AC127	0.40
AC128	0.35
AC141	0.35
AC141K	0.45
AC142	0.40
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AC176	0.35
AC187	0.35
AC188	0.35
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ACY19	1.80
ACY20	1.55
ACY21	1.55
ACY39	4.00
AD149	1.00
AD161	0.50
AD162	0.60
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ADZ12	12.50
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AF115	3.50
AF116	3.50
AF117	4.00
AF139	0.55
AF186	0.75
AF239	0.65
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AFZ12	5.00
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ASY27	3.00
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ASZ16	2.00
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E86C	8.25
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EY88	1.75
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G55/1K	12.00
G180/2M	17.50
G240/2D	12.00
G400/1K	17.50
GN4	9.00
GN4A	9.00
GS16	16.00
GTIC	25.00

GU50	20.00
GU51	20.00
GXU1	15.35
GXU2	30.00
GXU3	25.40
GXU4	44.50
GXU50	20.00
GY501	3.00
GZ32	4.00
GZ33	4.75
GZ34	4.00
GZ37	4.75
KT61	5.00
KT66	15.00
KT77 Gold Lion	12.00
KT88 Gold Lion	20.00
KTW61	2.50
KTW62	2.50
KTW63	2.50
M8079	12.34
M8080	8.25
M8081	9.82
M8082	9.69
M8083	10.25
M8091	10.43
M8096	6.80
M8097	8.10
M8098	8.15
M8099	8.00
M8100	10.30
M8136	11.75
M8137	12.25
M8140	6.00
M8141	6.50
M8142	8.75
M8144	7.50
M8149	6.50
M8161	9.35
M8162	11.75
M8163	8.25
M8190	5.00
M8195	10.85
M8196	7.50
M8204	7.05
M8212	11.37
M8223	6.00
M8224	6.30
M8225	4.50
M8248	14.03
MD2001	115.00
MU14	2.50
MX119	55.00
MX123	86.00
MX145	61.50
MX151	18.30
MX152	150.00
MX161	175.00
MX163	19.50
MX164	26.40
MX166	164.00
MX168	57.00
N78	15.00
OA2	3.25
OA3	2.50
OA4	6.00
OB3	2.50
OC2	4.35

OC3	2.50
OD3	2.50
OZ4	3.50
PC86	2.50
PC88	2.50
PC95	1.75
PC97	1.75
PC900	1.75
PCC84	1.75
PCC85	1.50
PCC88	2.00
PCC89	1.75
PCC189	2.50
PCC805	1.60
PCC806	1.60
PCE82	2.00
PCF80	1.50
PCF82	1.50
PCF86	2.50
PCF87	2.50
PCF200	3.25
PCF201	3.25
PCF801	2.50
PCF802	1.75
PCF805	1.70
PCF806	1.70
PCF808	1.70
PCL82	2.00
PCL83	3.00
PCL84	2.00
PCL85	2.50
PCL86	2.50
PCL805/85	2.50
PD500	6.00
PE06-40N	45.00
PFL200	2.50
PL36	2.50
PL81	1.75
PL81A	2.00
PL82	1.50
PL83	2.50
PL84	2.00
PL504	2.50
PL508	5.50
PL509	6.00
PL519	6.00
PL801	1.50
PL802	6.00
PY33	2.50
PY81	1.50
PY82	1.50
PY83	1.25
PY88	2.00
PY500A	4.00
PY800	1.50
PY801	1.50
QE51	82.50
QQV02-6	38.00
QQV03-10	26.25
QQV03-20A	48.38
QQV06-40A	46.00
QQV07-50	76.65
QQZ06-40A	62.20
QU37	12.50
QV03-12	6.80

QV04-7	3.50
QV08-100	197.40
QY3-65	63.24
QY3-125	78.48
QY4-250	74.00
QY4-400	87.20
QY5-500	208.00
QY5-3000A	566.80
QZ06-20	46.00
R10	6.00
R17	3.00
R18	3.00
R19	9.24
R20	2.50
RG3-1250	59.50
RG3-250A	32.68
RG4-1250	61.60
RG4-3000	99.45
RR3-250	40.00
RR3-1250	45.75
SI30	6.00
SI30P	6.00
STV280-40	14.00
STV280-80	21.00
SU41	5.00
SU42	10.00
TD03-10	35.00
TD03-10F	35.00
TT15	50.00
TT21	37.50
TT22	37.50
TT100	60.00
TY2-125	78.75
TY4-400	88.20
TY4-500	124.26
TY5-500	272.50
TY6-800	231.00
TY6-5000A	632.20
TY6-5000B	395.00
TY6-5000W	523.00
TY7-6000A	632.00
TY7-6000W	579.00
TZ40	25.00
U18/20	3.50
U19	13.75
U25	2.50
U26	2.50
U37	12.00
UABC80	1.25
UAF42	2.50
UB41	3.00
UBC41	2.50
UBF89	1.50
UCC84	1.75
UCC85	1.85
UCF80	2.00
UCH42	2.50
UCH81	2.50
UCL82	1.75
UCL83	2.75
UF41	2.00
UF42	2.10

UF80	1.75
UF85	1.75
UF89	2.00
UL41	5.00
UL84	1.75
UM80	2.00
UY41	4.00
UY85	1.75
VLS631	15.00
XG1-2500	100.00
XG5-500	30.00
XG2-6400	185.00
XR1-1600A	53.75
XR1-3200	110.00
XR1-3200A	
XR1-6400	165.00
YD1120	395.00
YD1240	588.00
Z803U	25.00
Z759	27.59
ZM1001	8.00
ZM1020	9.00
ZM1021	9.00
ZM1022	9.00
ZM1023	9.00
ZM1040	19.36
ZM1041	16.66
ZM1042	17.77
1B3GT	3.00
1B24	25.00
1B35A	48.00
1B63	64.00
1R5	1.75
1S5	1.75
1T4	1.75
2A515	11.50
2C39A	60.00
2C43	70.00
2D21	3.25
2E26	8.25
2J42	98.00
2J55	265.00
2J70A	383.00
2J70B	336.00
2K25	125.00
3400Z	115.00
3500Z	100.00
3A5	3.00
3B24	11.00
3B28	15.35
3B29	20.05
3B240M	17.50
3B241M	17.50
3C23	25.00
3C24	12.00
3CX100A	47.00
3E29	45.00
3S4	2.00
3V4	1.75
4-65A	60.00
4-125A	60.00
4-250A	80.00
4-400A	87.00
4B32	20.00

4C35	120.00
4CX250B	58.00
4CX350A	105.00
4X150A	60.00
4X150D	56.00
5HE12	65.00
5B254M	35.00
5B255M	35.00
5C22	160.00
5H80E	2500.00
5R4GY	5.50
5U4G	3.00
5U4GB	2.50
5V4G	2.50
5Y3GT	2.50
5Z3	4.00
5Z4G	2.50
5Z4GT	2.50
6-30L2	1.75
6AB4	1.75
6AB7	3.00
6AC7	3.00
6AF4A	4.25
6AG7	3.00
6AH6	5.00
6AK5	5.90
6AK6	2.50
6AL5	1.50
6AM4	4.00
6AM5	9.69
6AM6	6.02
6AN5	4.75
6AN8A	3.50
6AQ5	3.25
6AS6	8.66
6AS7G	8.75
6AT6	1.25
6AU5GT	5.00
6AU6	2.50
6AV5GA	4.50
6AV6	1.50
6AX5GT	3.00
6B7	3.25
6B8	3.25
6BA6	1.50
6BA7	5.00
6BA8A	4.00
6BC4	4.00
6BE6	1.50
6BH6	2.50
6BJ6	2.25
6BK4	4.50
6BL6	125.00
6BL7GT	4.50
6BM6	115.00
6BN6	2.00
6BQ7A	3.50
6BR7	6.00
6BR8A	3.50
6BS7	6.00
6BW6	6.00
6BW7	1.50
6BX7GT	5.00
6BZ6	2.75
6C4	1.25
6CB6A	2.50
6CD6GA	5.00
6CG7	2.50
6CH6	13.00

6CL6	13.75
6CW4	8.00
6D2	1.50
6DK6	3.00
6DQ6B	4.75
6EA8	3.00
6EB8	2.50
6EW6	2.25
6F6	3.00
6F23	1.60
6F28	1.60
6F33	13.50
6H1	14.00
6H3N	2.75
6H6	3.00
6J4	5.50
6J6	8.93
6J7	4.75
6JL6C	7.50
6K6GT	2.75
6K7	3.00
6K8	3.00
6KD6	8.00
6L6G	5.00
6L6GA	3.50
6L6GC (GL)	5.75
6L6GT	3.00
6L7	2.50
6N2P	2.50
6N3P	2.50
6N7	3.00
6P25	4.00
6Q7	3.75
6K7	3.25
6RHH8 6KN8	10.00
6SA7	3.00
6SC7	2.75
6SF7	2.50
6SH7	3.00
6SJ7	3.25
6SK7	3.50
6SL7GT	3.00
6SN7GT	3.00
6SQ7	3.40
6SR7	4.00
6SS7	2.75
6U5G	3.50
6U8A	2.25
6V6GT	4.25
6X4	3.00
6X5GT	1.75
7B7	2.50
7C3	4.00
7C6	2.50
7H7	4.00
7R7	4.25
7S7	3.50
7Y4	2.25
7Z4	2.00
12AH8	5.00
12AT6	1.50
12AT7	1.75
12AU6	2.50
12AU7	1.75
12AV6	2.50
12AW7	3.50
12AX7	1.75

12AY7A	4.00
12B4A	3.50
12BA6	2.50
12BE6	2.50
12BH7	2.75
12BY7	3.00
12E1/TT	28.00
12E14	65.00
12E1	20.00
13E1	170.00
19H5	47.50
24B9	67.25
30C15	2.00
30C17	2.00
30C18	2.00
30F5	1.60
30FL1/2	1.38
30FL12	1.80
30FL14	2.00
30L1	1.50
30L15	2.00
30L17	2.00
30P4	2.50
30P19	2.50
30PL1	3.00
30PL14	1.80
30PL15	1.80
35W4	1.00
50C5	1.50
75B1	6.05
75C1	4.50
85A1	7.50
85A2	6.45
90AG	20.00
90AV	20.00
90C1	6.00
90CG	14.54
90CV	15.45
92AG	20.00
92AV	20.00
95A1	8.45
150B2	6.50
150B3	8.35
150C2	3.25
150C4	6.00
211	35.00
723AB	125.00
803	25.00
805	45.00
807	3.75
811A	18.33
812A	47.50
813 valve	65.00
833A	193.16
866A	35.00
872A	20.00
922	6.00
931A	18.50
1624	4.00
1625	3.50
2050	7.50
4212E	300.00
4212H	300.00
5544	110.00
5545	150.00
5551A	120.00
5552A	165.00
5642	9.00
5654	3.00

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

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

BASES

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

CRTs

2AP1	8.50
2BP1	9.00
3BP1	20.00
3DP1	5.00
3LG1	10.00
3FP7	6.00
3GP1	6.00
3JP1	8.00
3JP2	8.00
3JP7	10.00
3KP1	15.00
3RP1	35.00
3WP1	20.00
5ADP1	55.00
6CP1	10.00

5CP1A	10.00
5P15A	15.00
SUP7	25.00
DG7-5	63.32
DG7-31	58.07
DG7-32	58.07
DG7-36	65.00
DH3-91	56.83
DH7-11	113.12
VCR138	12.00
VCR138A	12.50
VCR139A	8.00
VCR517B	10.00
VCR517C	10.00

CRT sockets
Prices on application

IC sockets
Texas
low profile

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

INTEGRATED CIRCUITS

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

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

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

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

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

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

TAA570	1.75
TAA630S	1.75
TAA700	3.00
TBA480Q	1.50
TBA520Q	1.50
TBA530	1.50
TBA550Q	1.75
TBA560Q	1.75
TBA673	1.75
TBA700	1.50
TBA700Q	1.75
TBA750Q	1.50
TBA800	1.00
TBA920	1.75
TBA990Q	1.50
TCA270Q	1.00
TCA760A	1.25

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TELECOMMS TOPICS

Alcatel wins 2.4Gbit/s opto

Alcatel CIT has been awarded a contract by the Belgium Telephone and Telegraph Administration for a 2.4Gbit/s optical transmission system. It will provide a 50km link between the cities of Brussels, Mechelen and Antwerp and is believed to be the first in the world to operate at such a high speed. Having 16 times the capacity of the most widely used 140Mbit/s systems, it will ease the strain on the heavily used route between Brussels and Antwerp.

Alcatel CIT is the French public telecommunications subsidiary of Alcatel NV, the company formed at the end of last year to bring together, under the management of CGE, the telecommunications activities of ITT worldwide and all the activities of French companies Alcatel CIT, Alcatel Electronique and Cables de Lyon.

Philips for private ISDN in China

Philips Sopho-S PABXs are to be used to establish a private ISDN network in China under a £500,000 contract with the Beijing Application Information Institute of Technology (BAITT). The network will link up all the government research organizations in the main cities of each province in China.

The first phase of the project involves eight Sopho-S systems having a total of 2,800 lines. A further 14 sets of systems are expected to be ordered for the second phase.

Discussions between Philips and the Chinese began in 1984, the order for optical fibre and transmission equipment for the Beijing ISDN trial being placed with AT&T and Philips Telecommunications (APT) in early 1986. Following evaluation of PABXs from suppliers, the Chinese then visited Europe, mainly Holland and Belgium. The purpose of this visit was to choose a long-term partner and to gain an understanding of the supplier company and product.

APT is the joint venture between AT&T of the USA and Philips Telecommunications Industries, with headquarters in The Netherlands.

Packets for Irish Distilleries

Irisih Distilleries, one of the countries largest companies, has set up a packet-switched network to link its headquarters with seven remote locations. These sites are engaged in a range of activities ranging from distilling to distribution of finished products. Links are through a combination of leased lines and the Eirpac packet switched service based on X.25.

All locations have the back-up necessary to maintain network integrity through the public switched telephone network (PSTN). The network management system automatically monitors the state of the lines and controls the network as well as providing management information. It is based on a Motorola 6740 distributed communications processor and an IXP network management system. All eight sites are equipped with either 6001 or 6002 statistical multiplers or 625 PADs (packet assembler/disassembler) and a total of 13 2345 modems under a contract worth £100,000.

British Telecom looks towards Pacific

British Telecom marked the recent opening of its new San Francisco office with a teleconferencing link-up to London. When speaking over the satellite link to customers in San Francisco, BT chief executive Iain Vallance stressed BT's committment to its overseas customers in its aim of becoming the world's best telecommunications company. He went on to add that BT opened its first office in the USA in New York in mid-1984 and that this office is "...the next step in our plans to establish offices in key business areas throughout North America." He pointed out that San Francisco, as well as serving the West Coast, also looks westwards towards the Pacific countries such as Japan, Singapore, and Hong Kong, all of which have tremendous potential in the telecommunications marketplace.

At the office opening Anthony J. Booth, managing director of British Telecom International (BTI), said that "Transatlantic digital satellite and cable technologies will soon be extended to the West Coast. With a single, direct satellite hop between the western seaboard and the UK now a reality, the additional West Coast satellite earth stations coming on stream shortly, and with the advent in 1988 of the optical-fibre TAT-8 service and growing availability of optical-fibre cables on US domestic routes, the West Coast is entering a whole new era of low-cost, efficient communications with Europe."

Dictaphone shows the Connexions

At a press conference mainly devoted to voice recorders and dictating systems, Dictaphone gave a preview of its Connexions communications terminal. According to the company's sales director, Les Goff, "This is a preview of the next barrier that Dictaphone will break in the business communications market. How long it will be to the UK launch we cannot say at present but we are not embargoing information about it – it is too important for that."

In addition to incorporating those functions expected in a feature phone, it incorporates call logging, personal electronic calendar with reminder alarm for appointments, electronic mail facilities to and from other computers plus, as one would expect from Dictaphone, a dictating machine recording onto an integral cassette tape.

Goff went on to say that "this is the kind of integration to which the end user must be led. No-one can expect users to demand technology which has not yet been previewed to them. They are not inventors – we are. There has to be a four-way integration of voice and data, communication and recording. He continued by stressing the need to integrate these functions to meet user needs. "Or more simply, we have telephones on their way now which allow you to see who you're talking to. What more natural need than to record the voice and the vision parts, along with the text of the document or computer file you are dicussing? That development at Dictaphone is a little further off than our Connexions unit but not much further."

CICI goes for Gold

Telecom Gold, British Telecom's electronic mail service, has been chosen by the Confederation of Information Communication Industries (CICI) to provide electronic communications tailored specifically to the needs of the information industry.

CICI decided that, in order to improve communications to its members and to increase the industry's awareness of electronic information services, it should establish an online network, CICInet.

Members will be invited to register for a Gold mailbox within the CICInet closed user group so as to access an online version of CICI's newsletter and diary of events. A private noticeboard will also be available to give users the opportunity to exchange ideas with other members and to ask them for information.

CICI is essentially a confederation of associations, public bodies and leading companies in the information industry. Members include the BBC, the British Library, the British Council and the Publishers Association. The larger bodies within CICI will be encouraged to become corporate members of Telecom Gold. They can then have an unlimited number of mailboxes for one corporate registration fee, while still benefitting from all the extra CICInet services.

Mercury Link 7500 – the new Easylink

For the past year the Easylink service has been managed on behalf of Cable and Wireless Easylink Ltd by Mercury Communications Ltd. The relaunch of the service as Mercury Link 7500 enables it to be integrated in marketing terms within the developing portfolio of business communications services being offered under the Mercury banner.

The first of a programme of service enhancements is the 'personal telex number' for users of the Mercury Link 7500 telex access service. All users are allocated their own number which will be quoted on all outgoing telex messages and may be used as a regular telex address for all return messages.

Cable pressure monitors for British Telecom

British Telecom has placed an order for Condic 100 systems designed to continuously monitor telephone cable pressurization. The order, worth £250,000, was placed with Vaisala (UK) Ltd., the British subsidiary of a Finnish meteorological and industrial measurement company. The first network, comprising 3-4 central monitoring points and 11 sub-stations, will be installed in North Wales this year.

Many telephone cable systems are pressurized with compressed air to protect the inner cores from damage by water. Currently the normal BT procedure for locating a leak involves the repair team checking the cable pressure at a number of manholes along a cable run. They can then establish the pressure profile along the cable and thus find the leak.

The new system is said to represent an important increase in technical sophistication over existing methods and will lead to the more rapid location of leaks in the cable pressurization systems. It employs independently addressable sensors which are interrogated via telephone lines. The system's computer collects the data and reassembles it into groups each of which relate to a single cable. Cable pressure values can be presented in various forms and the system can generate out-of-tolerance alarms.

The system can also, if necessary, be equipped with additional sensors to monitor water level in manholes, humidity in cable connection cabinets and the status of alarms in exchange buildings.

Direct link to USA

Mercury Communications Ltd, together with FTC Communications Inc. are offering high-quality, dedicated, private, leased voice service between the US and UK. The voice service will be provided using 32Kbit/s a.d.p.c.m. digital transmission techniques.

The channel will be provided on a full 24 hour availability at what are claimed to be extremely competitive tariffs. The FTCC tariff for the US terminal is 1500 US dollars per month and the Mercury tariff for the UK one is 1350 pounds. FTCC's previous published tariff only covered the higher speeds from 56/64 Kbit/s through to 2.048 Mbit/s.

PC to fax service from Lydiastar

Lydiastar Telecommunications, providers of a personal computer-to-telex message delivery service is launching a PC-to-facsimile delivery service. The new service, which the company believes will be the first of its kind in the world, will be added to the existing telex service at no extra charge.

As with Lydiastar's existing telex service, the new fax capability will offer a number of other user benefits including simplicity and the flexibility to allow access by most types of communicating PC.

By taking advantage of differences in international messages transmission costs, it is claimed that the new service will offer customers savings of 20 per cent against conventional fax-to-fax transmission costs.

Philips Radio/ E.F. Johnson agreement

Philips Radio Communications Systems Ltd. (PRCS) of Cambridge and E.F.Johnson Company, Waseca, Minnesota, USA have reached a collaborative working relationship.

The joint agreement permits the latter to distribute certain Philips mobile radio communications products in the United States as well as allowing Philips to distribute certain Johnson products in various other countries around the world. In addition, the agreement allows for the potential exchange of technology and combined R & D activities.

According to Ian McKenzie, managing director of PRCS "With the recent establishment of PRCS as the Philips corporate centre for international mobile radio activities, it is only natural that we, more actively, participate in the US market. Our business is international in scope and we are very pleased to establish this new relationship with the E.F. Johnson Company which has considerable mutual benefit for both organisations.

Dowty cooperates with Dorset police

Dowty Information Systems has signed an exclusive agreement with Dorset Police under which it will undertake further development and market Dorset Police's new command, control and management information system.

Dowty already has 12 years experience of developing and marketing emergency services command and control systems and has installed eighteen systems worldwide. The £2 million Dorset Police system comprises two DEC 8300s to run the system, 18 DEC Micro PSP11/23 terminal concentrators at various locations around the Force, and 109 v.d.us and keyboards, customized for police use, and a DEC VAX 11/750 for training and development. It has been specifically designed "to meet the needs of the Force until the mid-1990s" according to Brian Weight, Dorset's Chief Constable. "It puts the Dorset Police light years ahead of any other force in the British Isles."

Review of Telecommunications Standards

Prof. Bryan Carsberg, Director General of Telecommunications, has published the findings of the Report of the Telecommunications Standards Review Committee together with a covering statement.

The Committee was formed because of the concern that apparatus approvals were taking too long and were too expensive. Its task was to determine what improvements could be achieved by simplifying standards.

Because of the complexities involved, the Committee was unable to reach full agreement on all the issues considered. Minority reports were submitted by TEMA, the Telecommunications and Engineering and Manufacturing Association; Mercury Communications Ltd; Hull Telephone Department; and British Telecom.

Prof. Carsberg emphasized that although the integrity of the network must be maintained, the system should also allow suppliers rapid access to their markets. He said that he could see considerable possibilities for suppliers to commission their own test reports through approved test laboratories, and to submit findings to BABT (the British Approvals Board for Telecommunications). He would be looking to BABT to play an enhanced role both in setting standards and establishing technical policies.

Telecomms Topics was written by Adrian Morant.

MATURE, FRIENDLY EPROM PROGRAMMER

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GANG-OF-EIGHT is a successful product, because of its performance and unbeatable price. Since the launch we have taken careful note of comments made by engineers who have called us. This gave us a wish-list of extra features and revisions to work by. The result is an improved G8 which should suit you even better — it is just what you asked for.

25 and 27 Series to 512K

G8 will handle 2516, 2532 and 2564 EPROMS, as well as all 27 series from 2716 to 27512.

FAST and SLOW Programming Method

You can use a FAST, intelligent algorithm to program larger EPROMS, which speeds up the programming operation by a factor of five, at least. G8 will also program the old-fashioned way, with 50ms pulses.

Voltage Selection

There are three different voltages selectable (by switches) and these are each resettable (by potentiometers) over a wide range. The factory-setting is 25 volts, 21 volts and 12.5 volts.

Liquid Crystal Display

G8 shows the EPROM type, the Program-Method and the Program-Voltage and changes the display when you reset the switches. You always know what is happening with G8.

Two Key operation

G8 has only two keys — START and RESET — simple to operate, yet it does all the useful things you need. Before every programming cycle it checks that you have not programmed any of the EPROMS already, reporting any which match the master. Then G8 tells you if any are not blank, so that you can erase them. Only if the EPROMS pass these tests does G8 start programming (but G8 will try to program unerased EPROMS, if you ignore the ERASE message and press START again — something else you asked for).

Checksum Facility

G8 will calculate and display a 6-digit checksum of your master EPROM, when you press START and RESET at the same time. This helps you to identify EPROMS which are unlabelled, and provides a simple check on the integrity of your data.

Tuneful, too

G8 provides audible feedback, to avoid the necessity for constant monitoring — that is, it makes noises so you don't need to watch it: rising and falling arpeggios as the program starts and finishes; occasional tones to remind you that your EPROMS are ready. Data is audible when uploading and downloading.

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G8 normally comes in a plastic case, which is light and durable. However, some of you want your G8 in a steel case, and this option is available now.

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G8 was intended as a fast, low-cost production copier, but frequent enquiries made us think again and design a version which could be used for development purposes, capable of uploading and downloading in a variety of serial formats: INTELHEX, MOTOROLA S, TEKHEX, ASCII-HEX and BINARY. Links on your serial cable select the format.

Quick delivery

We know you don't want to wait, so we keep lots of Gang-of-Eight programmers in stock. If you are in a real hurry telephone us — we will save your time and arrange the fastest delivery possible.

No Risk Trial: Refund Guaranteed

Without any questions asked, you get your money back if you do not get along with your G8, provided you return the product within 14 days.
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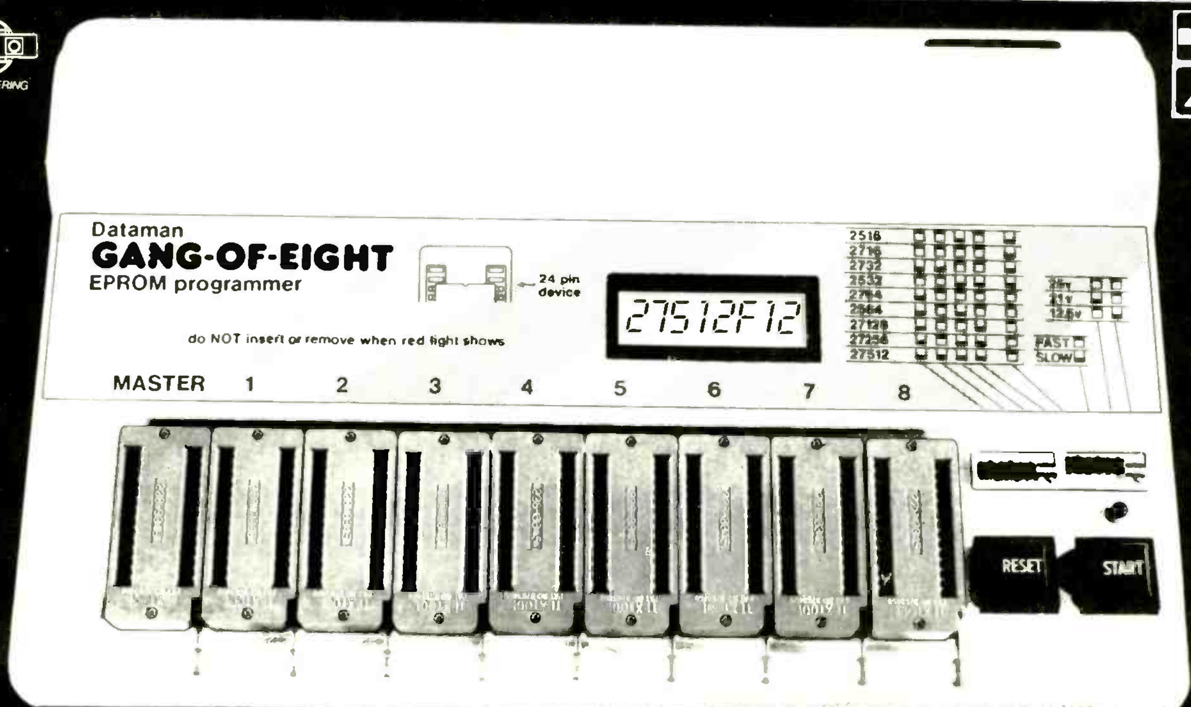

ENTER 26 ON REPLY CARD

A comparison of power mos and bipolar power transistors

It is very likely that in the near future power mos will gradually replace power bipolar devices in many applications.

SUE CAIN AND RAY AMBROSE

Table 1 lists the principal differences between mos and bipolar transistors. In addition to their inherent high switching speed resulting from the lack of minority carrier injection during operation, mos with its insulated gates requires negligible input gate-drive current. Other advantages are related to the negative temperature coefficient of the current, which prevents the formation of thermal instabilities and makes the paralleling of devices much more reliable. In contrast, bipolar transistors require ballasting or careful device matching to prevent thermal runway.

Only in high-voltage cases is mos on-resistance higher than in bipolar transistors: this leads to slightly larger steady-state power dissipation and could offset the advantages. The prospects for mos appear bright in many high-frequency applications, where switching losses become very high for bipolar devices.

PERFORMANCE COMPARISON

A comparison of the switching speeds of power mos and bipolar devices gives an indication of the energy consumption during transitions and their different values of $V_{DS(ON)}$ and $V_{CE(SAT)}$ related to energy consumption during the on state.

The two devices used in the comparison are

SGSP565	:	SGS MOS: 400V; 6A $R_{DS(ON)} = 1\Omega$
SGSD00036	:	SGS; 400V; 6A (very fast switching)

$V_{DD}/V_{CC} = 200V$

$I_L = 5A$ (average value)

Since the input losses were neglected the bipolar devices have an advantage in this comparison.

Figure 1 shows E_{TOT} (the energy losses per cycle) as a function of the operation frequency for different values of the duty cycle. For a bipolar device, the energy used during the on phase has only a slight influence with frequency variation. Mos, however, is influenced by these variations and as a result two curves, relative to the same duty cycle, are obtained. The intersecting points of these curves can be considered as a guideline to the use of devices.

In other words, if both the duty cycle and the power to be switched are fixed, there is a frequency value above which the dissipated energy per cycle for a mos transistor is less than for a bipolar device. This means the higher the frequency the more advantageous it is to use a mos.

Under relatively low frequency conditions the value of the duty cycle (d) is fundamental in determining the advantages of both bipolar and mos technologies. From the graph in Fig.2, the best working conditions for both devices can be seen. A mos is most suited to high-frequency conditions (> 100kHz) for any given value of d. Maximum frequency limitations are of a thermal nature only and depend on the die size.

For the mos under consideration, the maximum power dissipated is 100W when $R_{th\ case} = 1°C/W$ and $T_{jmax} = 150°C$. By plotting the power dissipated as a function of the frequency, when d = 50%, the actual limits of the two technologies can be seen (Fig.3).

THERMAL STABILITY

The greater thermal stability of mos with respect to bipolar devices is essentially due to the different responses that the two devices exhibit when they are subjected to external power pulses.

In a bipolar device, an external power pulse results in an increase in the junction temperature (T_j) which causes V_{BE} to decrease and h_{FE} to increase. Both cause the collector current to increase and this, consequently, further increases T_j. This positive feedback is compensated only by the base widening effect at high currents (that is a higher recombination of the minority carriers). At high voltages, the base widening effect is not present, so that any hot spots lead to thermal runaway. These effects, if not controlled, could seriously damage a bipolar device.

A power pulse in a mos device would cause an increase in temperature of the device and a decrease in the threshold voltage.

$$V_{GS(th)} = V_{GS(th)(25°C)} \times [1 - \alpha(T_j - 25°C)]$$

where alpha is a positive coefficient of temperature ($\alpha = 2.10^{-3}\ C^{-1}$). This is a positive feedback, similar to a decrease of

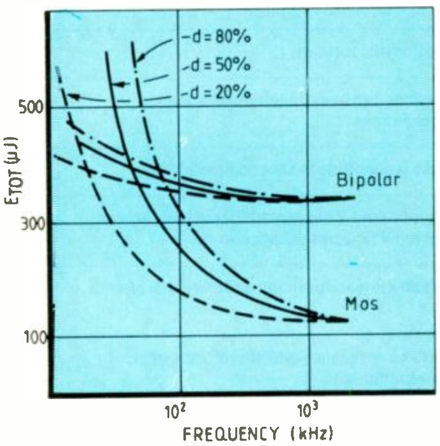

Fig.1. E_{TOT} versus frequency (kHz)

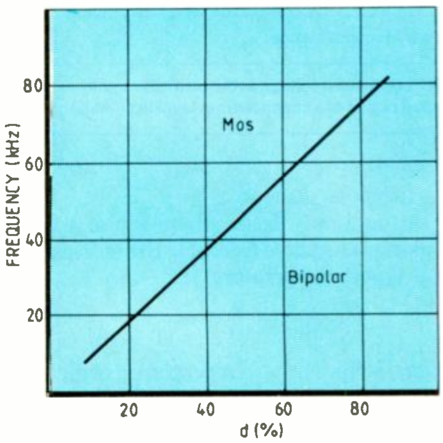

Fig.2. Best working conditions for power mos and bipolar devices

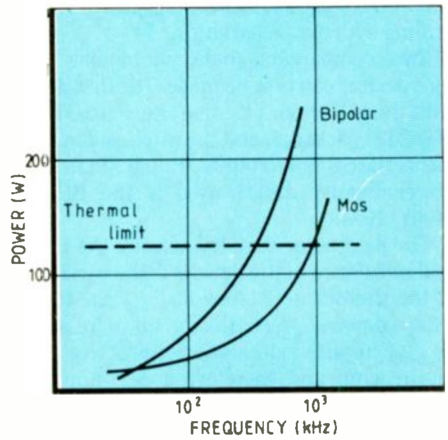

Fig.3. Thermal limits of bipolar and power mos devices

Table 1 – Comparison of MOS and bipolar power transistors

MOS	BIPOLAR
Majority-carrier device	Minority-carrier device
No charge-storage effects	Charge stored in the base and collector
High switching speed: less temperature sensitive than bipolar devices	Low switching speed: temperature sensitive
Drift current (fast process)	Diffusion current (slow process)
Voltage driven	Current driven
Purely capacitive input impedance: no d.c. current required	Low input impedance: d.c. current required
Simple drive circuitry	Complex drive circuitry (resulting from high base-current requirements)
Predominantly negative temperature coefficient of drain current	Positive temperature coefficient of collector current
No thermal runaway	Thermal runaway
Devices can be paralleled with some precautions	Devices cannot be easily paralleled because of V_{BE} matching problems and local current concentration
Less susceptible to second breakdown	Susceptible to second breakdown
Square-law I-V characteristics at low current: linear I-V features at high current	Exponential I-V characteristics
Greater linear operation and fewer harmonics	More intermodulation and cross-modulation products
High-on resistance and, therefore, larger conduction loss	Low on-resistance (low saturation voltage) because of conductivity modulation of high resistivity drift region
Drain current proportional to channel width	Collector current approximately proportional to emitter stripe length and area
Low transconductance	High transconductance
High breakdown voltage as the result of a lightly doped region of a channel-drain blocking junction	High breakdown voltage as the result of a lightly doped region of a base collector blocking junction.

V_{BE} in bipolar devices.

But in a mos device, there is also a very important negative feedback: the increase of $R_{DS(on)}$ with temperature.

$$R_{DS(on)(T)} = R_{DS(on)(25°C)} \times [1 + \alpha (T_{-25°C})]$$

where alpha is the temperature coefficient ($\alpha = 8.10^{-3}\,°C^{-1}$). The effect of an increase in $R_{DS(on)}$ is greater than the variation in $V_{CS(th)}$. As a result, mos devices are thermally stable and the difference in behaviour of the two devices is even more exaggerated when dealing with paralleled chips.

Two comparisons between bipolar and mos devices can now be made. The first deals with the behaviour of single chips in SOT-93 (TO-218) packages, and the mos used in this test is the SGSP475 (400V, 12A, 0.55Ω). The power bipolar device used is the BUV48 (400V, 10A).

The parameter used to measure the thermal unbalance of the devices is the variation of the thermal resistance $R_{thj\text{-}case}$ due to an external power pulse. In fact, an increase of $R_{thj\text{-}case}$ implies a decrease of the active area of the chip and therefore a non-uniform spreading of the heat, with a creation of hot spots and thermal and electrical unbalancing. The devices have been tested under several conditions, with respect to the power dissipation and the voltage across them (V_{DS} for SGSP471, V_{CE} for BUV48). Results are shown in Fig.4 and Fig.5). SGSP475 shows optimum thermal stability under all conditions, while bipolars, with V_{CE} = 45V and P>45W, show a degrading of the thermal performances.

The second thermal comparison was made between mos and bipolar devices in multiple chips mounted in a parallel configuration.

The mos device under test was SGS30MA050D1 : four mos chips paralleled in a TO-240 package with I_{DMAX} = 30A, V_{DSS} = 500V and $R_{DS(on)}$ = 0.250Ω. The bipolar device was SGS40TA045D : four bipolar chips paralleled in a TO-240 package with I_C = 40A and V_{CEO} = 450V. The results are shown in Fig.6 and reveal a much better thermal stability for the mos than for the bipolar device.

Sue Cain is Product Marketing Engineer with BA Electronics, with responsibility for SGS. She has been with BA Electronics for 18 months, having joined from R.R. Electronics where she worked for five years. Ray Ambrose is UK Marketing Manager of SGS. He has been at the company for five years and joined from Mostek, where he was European Marketing Manager.

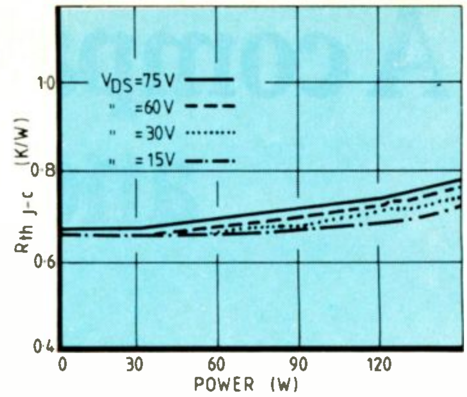

Fig.4. Variation of $R_{thj\text{-}case}$ vs. P (power mos) SGS475 SOT-93

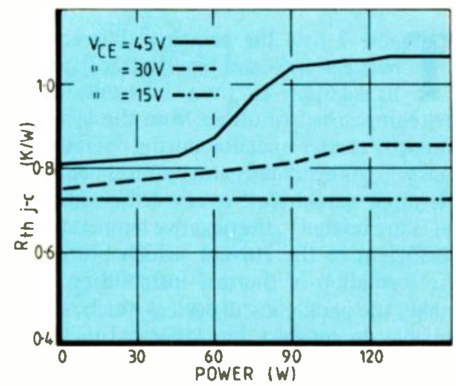

Fig.5. Variation of $R_{thj\text{-}case}$ vs. P (bipolar) BUV48 SOT-93

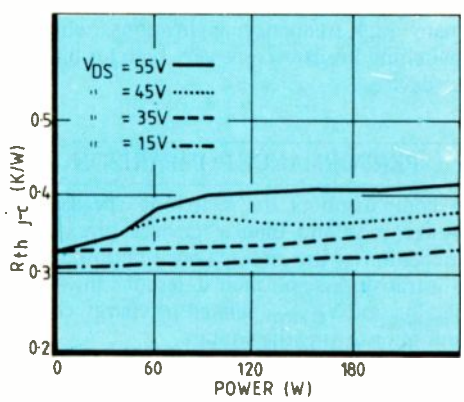

Fig.6. Variation of $R_{thj\text{-}case}$ vs. P (power mos) SGS30MA050D TO-240

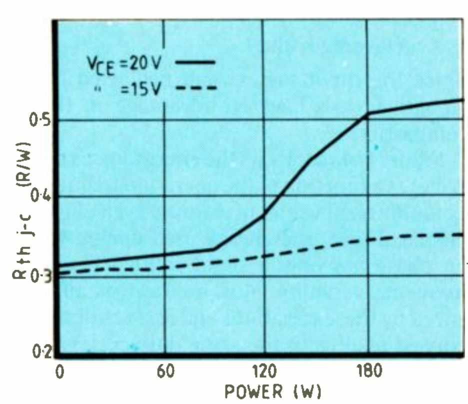

Fig.7. Variation of $R_{thj\text{-}case}$ vs. P (bipolar) SGS400TA045D TO-240

FEEDBACK

Roberts Radio

We are currently considering publishing the history of our company, Roberts Radio Company Limited.

The company was formed in 1932 at 7 Hills Place, London W1 and shortly after moved to 41 Rathbone Place, London W1, prior to moving to Molesey in 1940. We would be pleased to hear from any of your readers who may have historical information of any kind on Roberts Radio. We are particularly interested in any photographs, product information and former employees who may have memories of the early days.

I would be most grateful if anyone who has any such information or material available would contact me at the address below.

R. Roberts
Managing Director
Roberts Radio Company Ltd
Molesey Avenue
West Molesey, Surrey KT8 0RL
Telephone: 01-979 7474

Where does the bus stop?

There's plenty of information on terminating unidirectional digital buses but I cannot find anything on terminating or loading bidirectional buses.

It probably doesn't make any difference whether the load is placed on the middle of the bus or shared at each end but is there an argument for placing the loading at the most important receiving end? Any advice on this matter would be greatly appreciated.

L.J. Silver
Belmont
Surrey

S5/8

I would like to thank Mr Hardie for his suggestion and invitation (March).

On his suggestion, I telephoned the sales department of Amstrad, and enquired as to what serial interface was used with their latest computer. The predictable answer was: RS232. Had they considered using S5/8? The salesperson had not heard of it. Amstrad declined to comment on their marketing policy, so I was unable to get the "forthright answer" referred to by Mr Hardie, but from the appearance of the product, I would suggest that Amstrad manufacture up to a standard, rather than down to a price.

I think that this illustrates one point that I made earlier, namely that there is little point in proposing this standard in isolation from the rest of the world. We can argue the technical niceties *ad nauseam*, but the real problem with British Standards lies not with technical matters, but with politics. Surely a system can be devised where a much wider canvassing of users is undertaken, to find out (a) if a new standard is required at all, and (b) what features it should employ well *before* any technical work is begun. Such users should include major importers of affected equipment.

Until such a radical change is introduced, I must regretfully decline Mr Hardie's kind invitation to participate.

Les Hayward
Eastpoint Ltd
Corfe Castle
Dorset

Andrew Hardie is incorrect when he says in his letter (March 87) that the pull-up resistor at the end of a cable driven by an open-collector driver is not a proper terminator. In fact it is, because the wave is only travelling in one direction, towards the pull-up. The driven end is, however, not properly terminated, but this only matters if there is a reflection from the other end of the cable, which there won't be because it is properly terminated.

In the case of a floppy disc drive the termination may not be perfect because the impedance of the interface ribbon cable is usually fairly arbitrary, and as Mr Hardie says, various pull-up values are used in the drives.

Alun Morris
Cambridge

Planck

Ove Tedenstig (Feedback, February 1987) represents the equation

$$H = 2\pi m_e r_e c(a-1)$$

as demonstrating a "deep relation" between h and α.

Not so, I fear.

$$E = h\upsilon_e = \frac{hc}{\lambda_e} = m_e c^2$$

where λ_e = equivalent wavelength of electron and υ_e = eqivalent frequency of electron

$$\therefore \quad m_e = \frac{hc}{c^2\lambda_e} = \frac{h}{c\lambda_e}$$

Substituting in Tedenstig's equation

$$h = \frac{2\pi h r_e}{\lambda_e}(a-1)$$

– in other words, h has been craftly hidden in the r.h.s. For h may be substituted, with equal validity, the price of kippers or the mass of a distant galaxy.

Removing h

$$\frac{2\pi r_e(a-1)}{\lambda_e} = 1$$

an expression relating the circumference of a resting electron to its equivalent wavelength.

T.H. Brindlea
Isle of Luing
Oban, Argyll

Mathematics

I was delighted to read Messrs Coleman and Ridley's (March) confirmation that if one removes every vestige of energy from a system (a catastrophic procedure) one ends up with nothing (0) which is what the "proof" is all about and lay behind what I said. I did use inverted commas round the word.

The stage (a + b) = b is an entirely fresh start following the nothing (0) which is left after several catastrophes, this being the essential part of *my* logic, missed by Mr Ridley, hence his long rigmarole. No proof can have a fresh start in the middle of it – it becomes a presumptive statement as I said.

I suggest, Mr Ridley, that one should be sure of the logic before attempting to discredit anything. That is in line with my second point, and I return your compliment in thanking you for demonstrating it so clearly.

Mathematicians may claim that maths are a dynamic logic, but in the final analysis maths are no more than a universal analogy to the physical systems from or into which they may be translated. No driving energy, dead system. No constitutional energy, no system at all. Thus maths are not a dynamic logic, and must be supported by one, as I said.

As a schoolboy, I was also taught the fallacy of the so-called "proof", and thus the fallacies which *can* lie behind mathematics: I would expect the process to be normal – it should be, to keep maths pushers under control.

Thank you, gentlemen. I now suggest that you both look more carefully into the logic of removing energy, more especially in the Einsteinian context as outlined in my letter, because that is the precise procedure which modern science has followed, leading to the claimed warping of space and time, which is a technological impossibility even for Brits, however clever they may think they are.

James A. MacHarg
Wooler
Northumberland

Notwithstanding Mr Ridley's comments in the March issue of *E&WW*, perhaps Mr MacHarg needed only to select a different approach in order to demonstrate "the lack of value of mathematics..." (January 1987 issue).

If one takes, as first axiom, that mathematics is a form of communication and, as second, that all communications can be represented as Markov processes, then the subject becomes entirely out of probability. This is also to say that the "active dynamic logic" of which he speaks is entirely that of words. Such an approach should appeal to specialists in the field of communications since an adequate definition of probability is "average frequency of occurrence". In other words, all mathematics is expressible as average frequencies. But what of the associated arithmetic?

Conventionally, number theory is based on sets of objects and Peano's postulates. However, if one takes a single bacterial cell (representing a primitive object), places it in nutrient medium on a microscope slide, and keeps it under observation for twenty minutes or so, then it will normally *divide*. Clearly, this violates Peano's first postulate

FEEDBACK

that "one is a positive integer". With the right conditions, the cells will continue to divide. This violates the postulate that "no positive integer has one as its successor". Only replication, not multiplication or addition, is found in nature. Why, then do we humans make computers in which 1 + 1 = 0, carry 1? Can we really expect to understand the physical universe on this basis?

B.E.P. Clement
Crickhowell
Powys

Wide-area binary paging

Mr Kirby's article gave a very interesting introduction to practical wide-area radiopaging. Some amplification of his comparison of the two codes (POCSAG and Golay) might be helpful.

Firstly, there is a body called the Consultative Committee for International Radio (CCIR) appointed by the United Nations to create world-wide standards in radio matters. The experts of CCIR, drawn from all over the world, considered various radiopaging codes (including POCSAG, Golay and NEC). In 1982 they adopted the POCSAG code as their first world standard paging code. The POCSAG code has been renamed the "CCIR Radio-Paging Code No.1" (here called RPC1). The Post Office Code Standardisation Advisory Group (POCSAG) which developed the code is discontinued and any future development of RPC1 will be within the CCIR. In 1986 Golay was proposed as a second standard but not adopted.

In the CCIR studies it was noted that initially, by using conventional "hard-decision" decoding, RPC1 pagers offered 2-bit error correction in the address codeword and 1-bit correction in message codewords. However, it was also noted that the code could be used with a variety of error correction algorithms, e.g. by using "soft-decision" decoding up to 5 random errors or a single error burst up to 11 bits long can be corrected in any (address or message) codeword. At 512 bit/s the potential maximum signal drop-out tolerance of RPC1 thus is 21 ms (compare Kirby, Table 2). Clearly the potential of RPC1 was under-utilized, largely because of lack of available low-voltage, miniature processing power.

An important point is that RPC1 pagers are made by a growing number of competing manufacturers. Consequently there is considerable drive to achieve a competitive edge by employing more of the potential of the code. Already RPC1 pagers using hard-decision decoding have advanced beyond the initial error correction algorithms and performance mentioned in Mr. Kirby's article. Improvements in low-power processing technology will allow this advancement to continue rapidly towards the full potential of the code. Whilst the other codes studied by CCIR also possess potential greater than their current implementation, they are proprietary and so lack the multiplicity of competitive developments which are being applied to RPC1.

This point illustrates a major advantage of a standard over a proprietary code. New standard-code pagers, from whatever source, can be deployed immediately alongside existing standard pagers. Users can always be given access to the very latest technology, and have a variety of styles and prices of pager to select from.

RPC1 (or POCSAG) was designed to be very flexible and work alongside other code formats. British Telecoms Radiopaging used three codes, including RPC1 and Golay, for several years on its channels. BT now are turning over completely to RPC1 because of its many advantages. Regarding voice on the same channel, RPC1 certainly could be used since each batch lasts 1.06 second at 512 bit/s (or 453 ms at 1200 bit/s), which is a neglible delay for voice. However, there is little call now for speech paging because of the much greater air-time efficiency of digital message paging compared to speech. Additionally digital message paging is not affected by poor quality speech or loud noises, does not demand immediate attention and each message can be read many times, and is discreet.

Another advantage of RPC1 is that for alpha-numeric messages the 7-bit alphabet used is the international standard CCITT No.5 (also known as ASCII or ISO 7-bit). RPC1 alpha-message paging offers the potential of being connected directly to any brief-case or other processor since all such machines inherently cater for this alphabet. In contrast, the Golay code uses a special 6-bit limited-facility alphabet, not inherent in any common processor.

References

CCIR Recommendation 584, titled "Standard Codes and Formats for International Radio Paging"

"The Book of the CCIR Radiopaging Code No.1" available from Multitone Communications Systems Ltd. and some other radio-pager manufacturers, or BT Radiopaging.

R.H. Tridgell
Formerly chairman of POCSAG and BT delegate to CCIR
Welwyn Garden City
Hertfordshire

Magnetism

I am fascinated by P.J. Ratcliffe's experiments with high-flux pulsed magnetic fields (Feb.1987). He says his stream of projectiles simulate "magnetohydrostatic phonomena". Surely the phenomena are magnetohydrodynamic effects caused by the motion of flux of a fluid medium, an ether wind or current.

I am even more fascinated by Lee Coe's letter (Jan. 1987). If the relative velocity of an electromagnetic wave in the linear accelerator is increased by a magnetic flux flowing in the same direction as the wave, a reversal of the direction of flow of the magnetic flux would surely cause an equivalent reduction of the wave's velocity relative to the accelerator. This would seem to indicate that the magnetic flux is a flow of the wave's medium, a Newtonian ether wind.

It is possible to make a simple mechanical model to simulate the Newtonian actions and reactions of two magnets or Amperian magnetic shells by suspending two electric fans facing each other. When the two atmospheric winds flow through both fans in the same direction, the two fans attract each other at a distance. When one fan is turned through 180 degrees so that the two winds flow in opposite directions, the fans repel each other at a distance. These actions are effects caused by pressures due to fluxes of the surrounding fluid medium moving at a finite velocity, not by two central forces attracting or repelling each other instantaneously at a distance.

A tissue paper streamer glued to the end of a plastic knitting needle simulates a magnetic needle, and traces the direction and strength of the lines of atmospheric flux or Faraday's lines of magnetic force in the vicinity of the simulated magnets. Each simulated line of magnetic force is, as Faraday insisted in para. 3117 of his *Experimental Researches* "... a closed circuit, passing in some part of its course through the magnet...". Faraday's first explicit rejection of magnetic poles as centres of instantaneous attraction or repulsion at a distance, and the source of Maxwell's equation of magnetic continuity, div B = 0. In Maxwell's Newtonian mathematical model of an electromagnetic medium in space, B is an element of the medium's magnetic flux or ether wind flowing in closed circuits at a finite velocity.

In Lorentz's non-Newtonian mathematical model of the electron, two stationary electrons mutually repel each other with a Coulomb force acting instantaneously at a distance, and when set in motion begin to mutually attract each other with an Ampere force which depends on their absolute velocity, an action strictly forbidden by the law of the conservation of energy. The energy of any system of central forces depends only on their relative position.

The mutual effect of the central forces acting between two fans, or the Sun and the Earth, is caused by an action which depends on their relative position, not on their velocity. In other words, on their mutual potential energy, or atmospheric or gravitational pressure, never on their kinetic energy. Maxwell's quantity M is the mutual potential energy of two circuits, a system of central forces, and depends only on the relative position of the central forces. In Lorentz's model, M, if it exists at all, depends on the absolute velocities of the electron's central forces.

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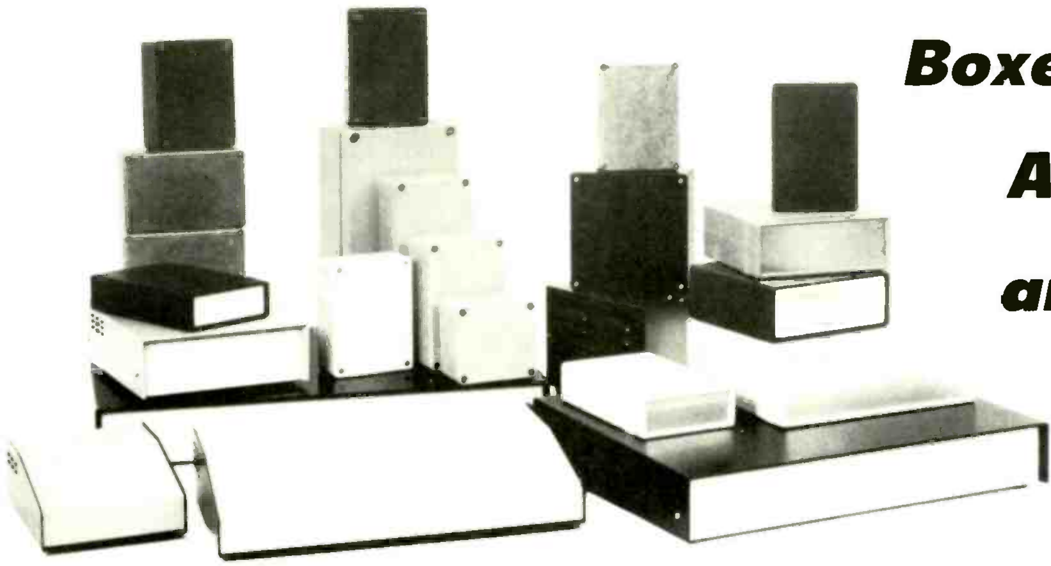

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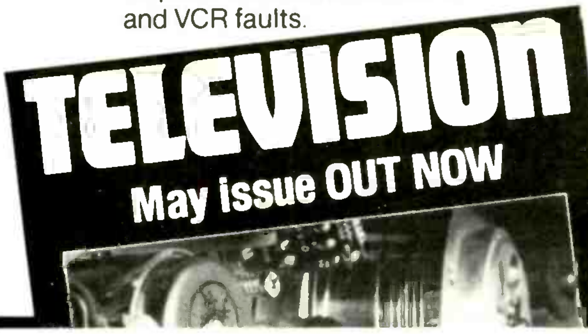

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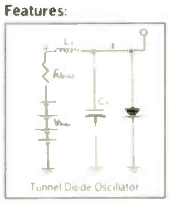

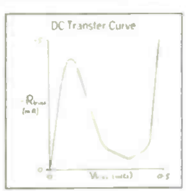

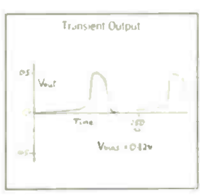

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APPLICATIONS SUMMARY

Radio navigation system

Design, testing and implementation of a Loran navigation system using a 16bit Transputer are described in two notes from Inmos.

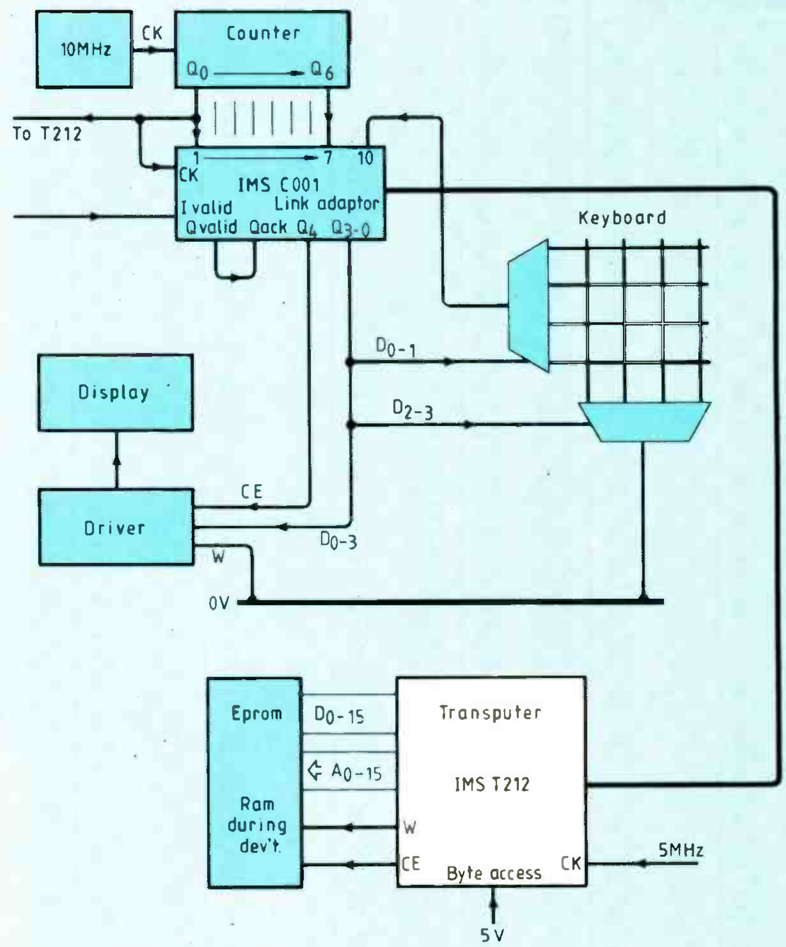
Because the Transputer is capable of servicing a repetitive event every 10μs, it can receive Loran C 100kHz transmissions directly without demodulation, saving a lot of hardware. Using averaging, the system described in the notes can give a resolution of around 300m.

Circuit diagrams are not given but each module is well described. Software too is only outlined. Elements of the design are a high-gain narrow-band amplifier to capture the incoming signal, a counter to measure phase, a Transputer to perform signal processing and trigonometric calculation, a keyboard and a display. Since the incoming signal is only short bursts of r.f., energy-storing LC circuits are avoided. The processor also provides system control signals.

At 100kHz, the events must be trapped at a 10μs cycle rate. The Inmos Transputer has an inherent response time to external stimulii of 1-3μs and has an internal resolution of 1μs. Theoretically, it could resolve r.f. information to an accuracy of 3μs, which at the speed of light would give a resolution of around 1km in a navigation system. In practice, this figure can be reduced to 300m using averaging techniques.

During the implementation phase of the project, several improvements were made over the design described in Technical Note 0. First, the external 10MHz counter was found to be unnecessary since, due to noise, the incoming r.f. signal had much more than 100ns jitter. Software handled the jitter and regained the accuracy by averaging over many incoming signals. Thus the link adapter was only needed to connect to keyboard and screen, which are slow devices and do not justify such a high-performance chip.

Secondly, the M212 disc-control Transputer became available. In addition to its disc hardware, it has 16 general-purpose i/o pins. Thus the final design uses just a narrow-band amplifier, the M212 Transputer, a keyboard and an l.c.d.



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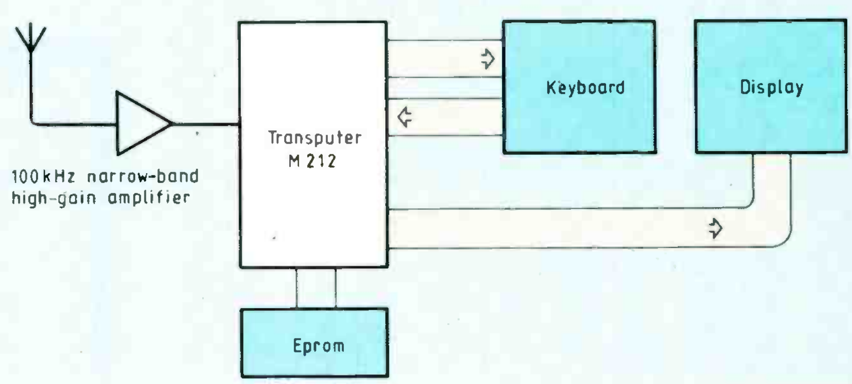
Loran

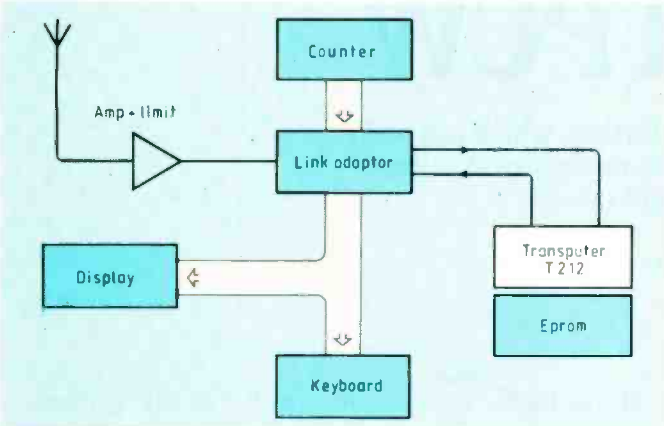
Author of the note, Philip Mattos, adds that the Loran system does not cover south England adequately and although there were some tests of an additional transmitter chain in France and Germany, to make it work correctly would need a further transmitter in Ireland, which no one appears willing to fund.

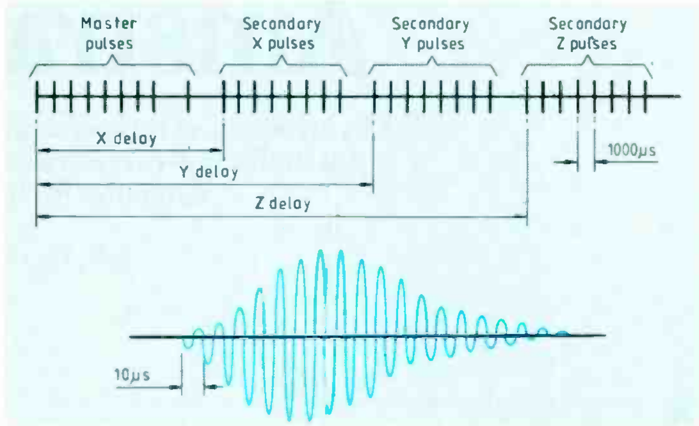
The system will run until at least 1995, when it should be replaced by satellite navigation. He is currently designing a Transputer-based navigation system based on the American Global Positioning System (GPS) satellites. This will require a down converter and a-to-d converter, with the Transputer taking raw data at two megasamples per second and correlating to extract the signal, which is transmitted in spread-spectrum form.

The GPS system is partially available but, due to the Challenger accident, launch of the satellites is behind schedule and 24-hour coverage is not yet available.



APPLICATIONS SUMMARY





64-channel shared p.c.m. codec

Fast analogue multiplexers with low channel-to-channel crosstalk and high-off/low-on resistance are used in this 64-channel shared p.c.m. coder/decoder. This design is part of Siliconix Applications No.3.

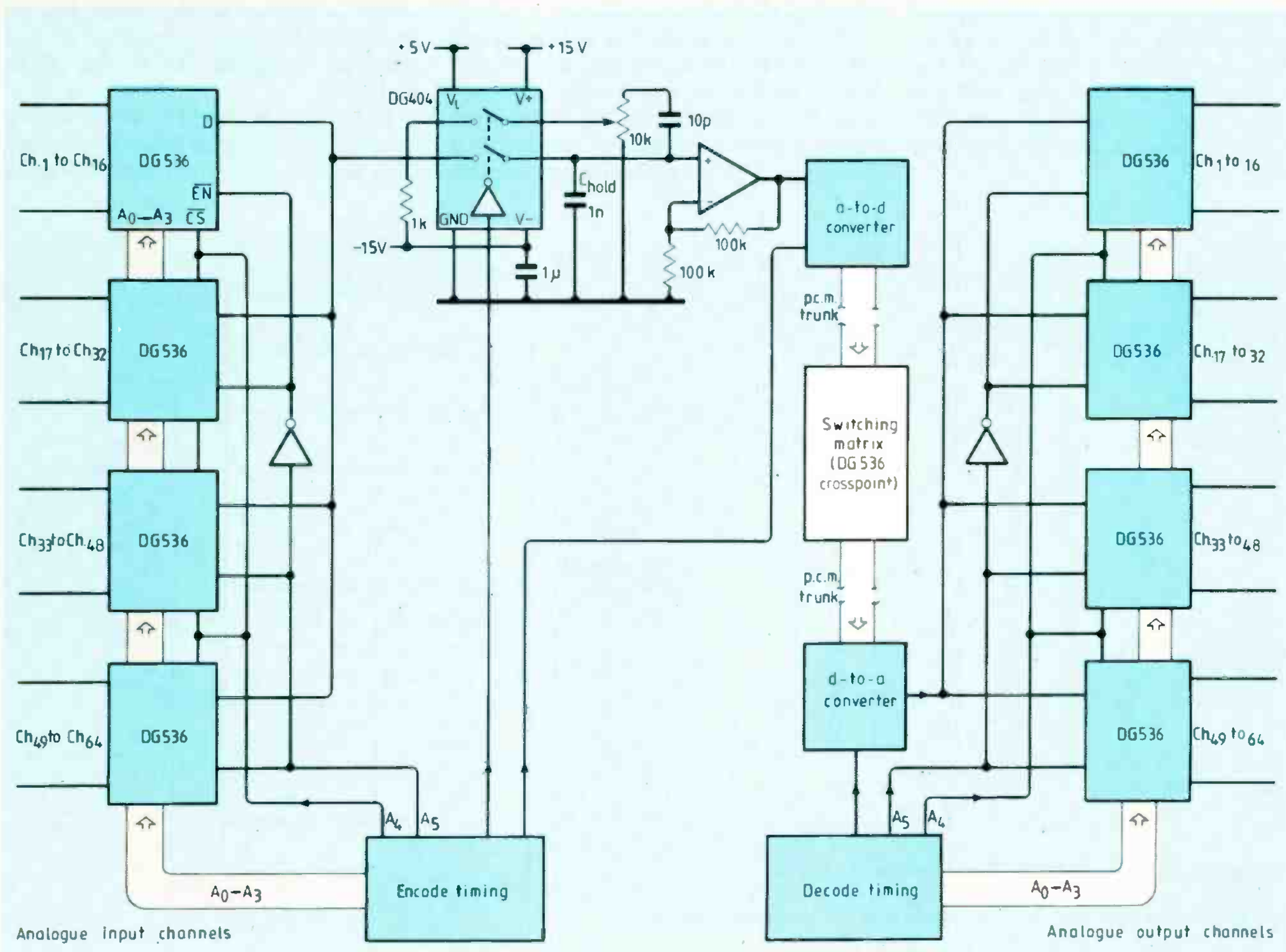
For a 64-channel system, each channel has to be accessed every 2μ (125÷64). Connecting four drains together increases output-node capacitance, but the multiplexer sampling time of 125μ (8kHz) is easily attained.

Digital switching matrixes like the one shown normally use e.c.l. or t.t.l. devices; the 536 switch saves power. Also, using analogue devices for the p.c.m. switching matrix makes code converters and regeneration stages unnecessary.

After transmission, the digital p.c.m. trunk is converted back to analogue form and demultiplexed to provide the analogue output channels.

Crosstalk of the Siliconix DG536 multiplexer is −92dB at 5MHz, off isolation is >100dB at 5MHz and on resistance is 90Ω. The device switches on in 300ns and off in 150ns.

Other applications in the brochure include a multiplexed a-to-d converter for 8085 interfacing, a low-power two-phase clock and a data acquisition system for aircraft. There are also notes on using fet voltage-controlled resistors, source followers and synchronous rectifiers.



Scientific interface for the Amstrad PCW

Circuit details of this versatile interface, which can make Amstrad's low-cost word-processor into an excellent computer for the laboratory.

BRIAN J. FROST

An important requirement was that the interface be kept modular so that sections could be easily omitted or added later. Figures 5 to 9 show optional circuitry that may be included as required. In addition, extra address decoding has been provided to reserve a total of eight 8-bit port addresses, allowing four for the present circuitry and another four for adding later a serial interface and eprom programmer.

Address lines from the expansion connector are taken to decoders IC_{201} and IC_{202} (Fig.2, April issue, page 455) which provide a separate read and write select line for each of the four ports on the card. Port addresses and their hardware assignments (Fig.4) have been chosen in consultation with Amstrad to ensure future upgrade capability.

Any address access to the card triggers IC_{203}, a monostable which drives an 'access' led. This has proved useful during the construction of both hardware. Data bus transceiver IC_{207} is enabled by any card access and provides additional protection and fanout.

Figure 5 shows the eight-bit digital output. A single octal latch IC_{401} latches data written to port address A1. The data output is displayed on leds but no attempt has been made to add extra output buffering. This is the only external connection to the interface where protection is not available since it adds significant complexity if speed or other compromises are to be avoided. Data written to this address remains latched until changed.

Figure 6 shows the eight-way input circuitry. Input signals are pulled down by R_{501} and the Schmitt triggers are fed via R_{502}. This arrangement is highly recommended since it provides very low loading and can be connected directly to 15V c-mos or arbitrary logic levels, so long as the threshold of around 2V is accommodated.

The level of protection is very high: and although it is to be discouraged, an input can be connected to the mains without damage other than increased heating of the input resistors. A speed degradation of 1µs or so is due to R_{502}, but this is small compared with the obtainable processor i/o rate of around 20µs.

The digital to analogue converter circuit (Fig.7) can be added to the address decoding of Fig.2 to form a powerful waveform synthesizer.

The eight-bit converter is a bus-orientated device that latches data written to port address A2 and provides an output voltage controlled from zero to its 2.55V internal reference. This is fed to the optional circuitry of Fig.10 which provides scale and offset adjustment as well as i/o protection.

Figure 8 shows the high-speed eight-bit successive approximation a-to-d converter IC_{701} with its sample and hold buffer amplifier. A minimum system would comprise the address decoding (Fig.2), the d.a.c. (Fig.7), a simple inverter to derive a negative supply and this circuit to provide almost all of the waveform recording, replay and plotting facilities.

This circuit will digitize an input waveform via software at up to 25kHz, although the a-to-d conversion time is set by the clock

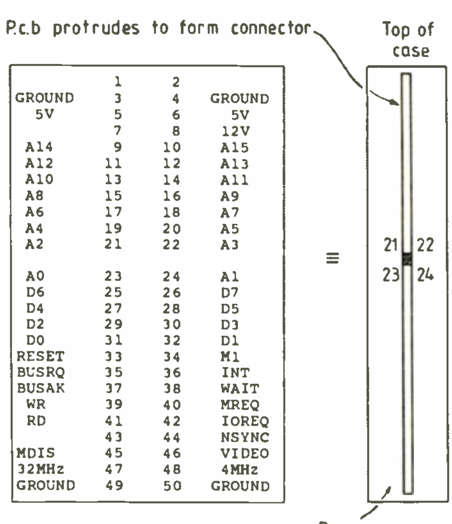


Fig.3. Details of the Amstrad PCW connector.

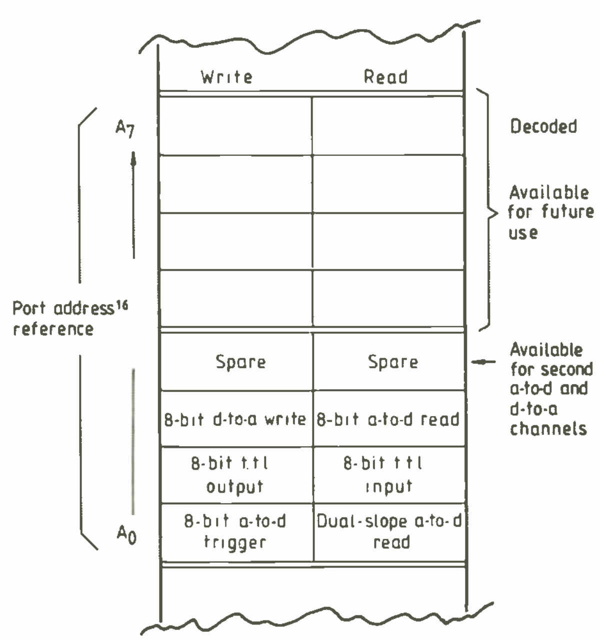


Fig.4 (right). Port address map: assignments for the interface have been chosen in consultation with Amstrad.

generator IC_{702} to around 10μs (100k samples per second). During conversion the Busy output is used to force a Hold condition on IC_{703} to ensure no input change. This allows the fastest sampling of dynamic waveforms without external filtering.

Conversion is started by a write to port address A0. Internal circuitry then performs the conversion and data is available for reading at port A2. The fixed, short conversion time eliminates the need to take the Busy signal to the processor.

For more precise but slower measurements, a dual-slope a-to-d converter is available (Fig.9). This is an auto-zeroing, b.c.d. output device which accepts an input voltage of either polarity in the range +2.000V to −2.000V and provides four 4-bit b.c.d. words at Q0-Q3 together with strobe signals DS0-DS3 which identify their significance.

The device is ratiometric and requires an external 2V reference. The d-to-a converter reference is slightly higher at a nominal 2.55V and for accurate reading of the applied voltage this reference may be adjusted to 2.000 volts by VR_{801}. The adjustment is only needed if the analogue signal conditioning is omitted, since a variable gain factor is inherent in that section. In this case VR_{801} can be replaced by a link, and 100kΩ fitted instead of the 82kΩ shown.

The processor reads each b.c.d. digit and its strobe via IC_{802} (timing diagram Fig.10).

A read cycle begins with the end-of-conversion signal EOC which is stretched by IC_{803} to ensure its visibility to the processor read loop. The processor then loops waiting for the first strobe (DS0) to read the most significant b.c.d. digit, followed by strobes for the other three digits. Strobes DS1 and DS3 are combined since there is no timing ambiguity.

Extra information is available coded into the m.s.d. (inset in Fig.10). The accompanying software extracts the half-digit and polarity and stores overrange and underrange in memory undecoded.

SIGNAL CONDITIONING

A quad op-amp IC_{801} (not shown) buffers and conditions the analogue signals both inward and outward. The circuits allow a scale factor

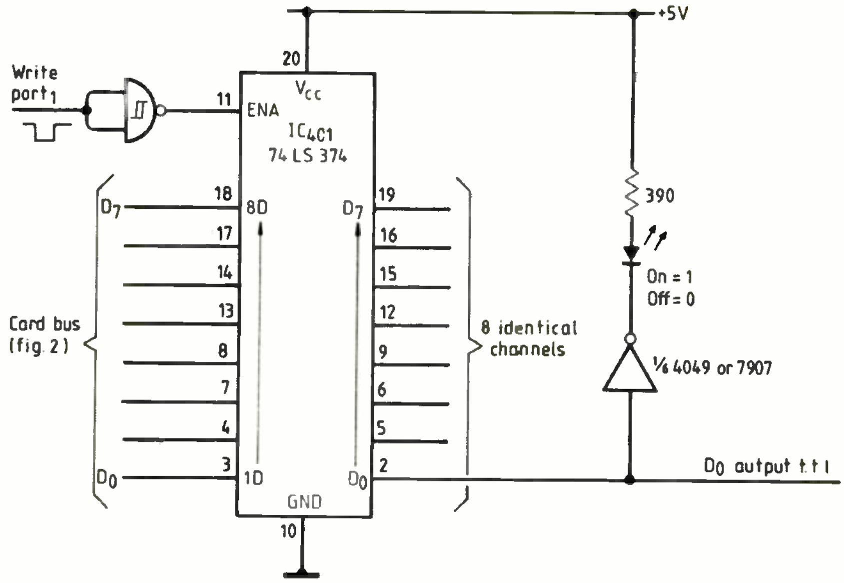


Fig.5. Eight-bit t.t.l.-level output. Further buffering may be needed.

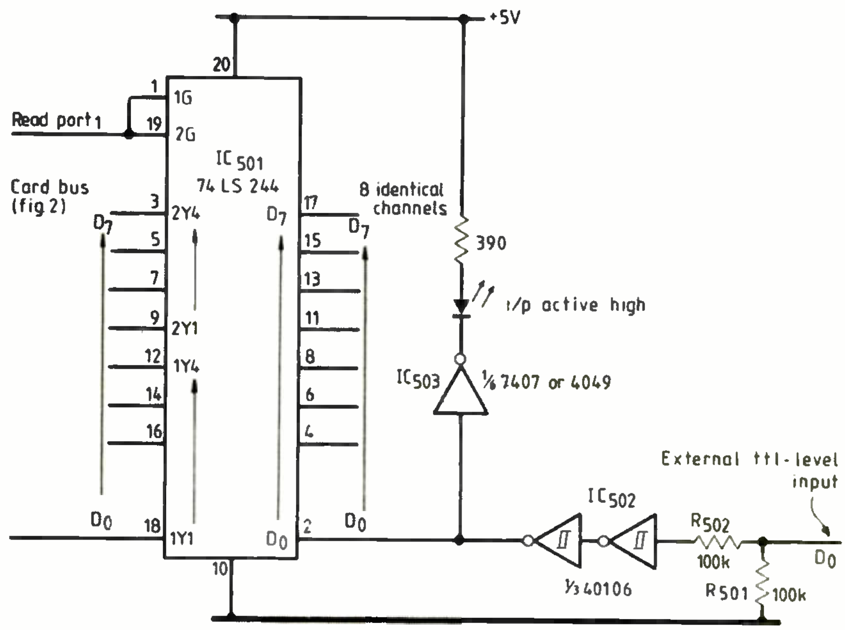


Fig.6. Eight-bit t.t.l.-level input: loading of the external circuit is very low.

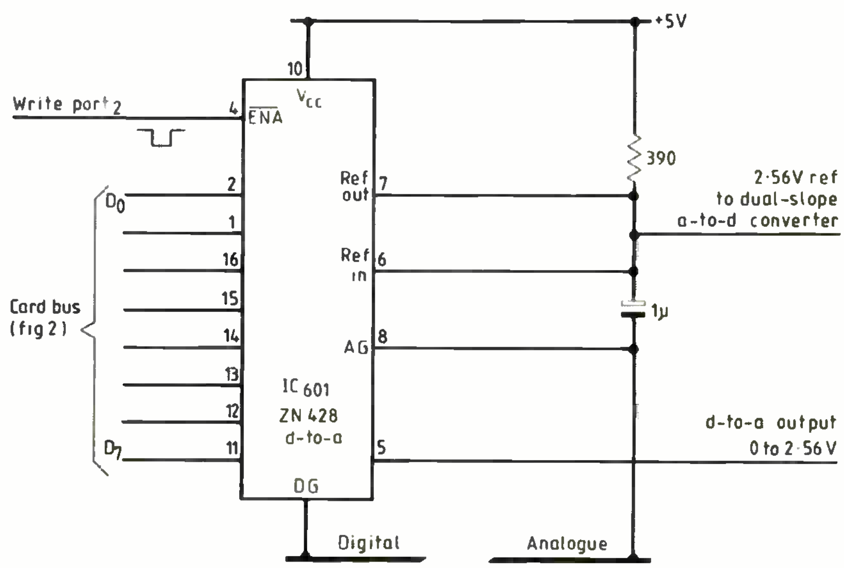


Fig.7. Digital-to-analogue converter: applications include waveform synthesis.

Software

For handling low-frequency waveforms, or where numerical power is required, the interface may be controlled quite satisfactorily from the Basic supplied by Amstrad. But to exploit the unit's high-speed waveform-handling capabilities, additional software is needed.

A suite of software is available from the author (details below): it includes both low-level drivers and high-level programs. If this software is to be used without modification, do not change either the port addresses shown in Table 1 or the layout of the dual-slope a-to-d result word in Fig.10.

LOW-LEVEL ROUTINES

The driver routines help in the construction and testing of the interface and allow its operation from Basic or from assembler:

PORT.com is intended for testing: it allows data and decoded port addresses to be triggered or viewed on an oscilloscope.

SIN.com provides screen and keyboard control of all interface functions. The d-to-a converter and t.t.l. output can both be set to a specified hex value.

DRV.bas is for communicating with all interface functions from Basic. This program contains source code that is merged into the user's Basic program.

AD.asm is an 8080 source-code file which allows users of the CP/M MAC assembler to construct machine-code software for their own applications. This program performs a single read of the dual-slope a-to-d converter and stores the result in memory.

HIGH-LEVEL SOFTWARE

High-level capabilities of the suite are centred on the dedicated assembler program WORD (for waveform output, recording and display). It provides extensive facilities for waveform capture, generation and display as follows:

Recording: any waveform can be recorded via the eight-bit a-to-d converter at rates from 50μs to 50s per sample and for a run of over 50 000 samples. This feature turns an ordinary oscilloscope into a digital-storage oscilloscope suitable for capturing one-off events. It is quite adequate for digitizing speech and music.

At the start of a recording run, a positive-going t.t.l. edge is available at the digital outputs. This has been used to stimulate external component networks and hence to display their transient response.

Replay: stored data can be replayed out through the d-to-a converter at rates from 50μs to 50s per sample, allowing a recorded waveform to be replayed in either a looping or one-shot mode. Data can be a previously recorded waveform, (unmodified or modified) or numerically generated data synthesizing sine, cosine, exponential or user-defined functions.

Plotting: data stored in memory can be examined on the graphics screen and plotted on the printer. The display can be zoomed, panned and measurements made with a cursor on addresses or data.

File handling: stored data can be interchanged between memory and 'waveform' files. These files can then contain pre-recorded waveform data as well as allowing a waveform synthesis program to create whatever shape or function is needed and add it to the library of files.

Waveform synthesis: using simply the address decoding and d-to-a circuitry, this feature gives the user a powerful waveform synthesizer. A Basic program GEN.bas allows numerical synthesis and graphical display of waveform functions such as sine, cosine, random, pulse, with exponential envelope conditioning and user-defined shapes. All functions can be assigned as absolute data or combined with existing data to add, multiply, subtract and divide, allowing distortion synthesis, noise injection and modulation.

Data from this program can be read into the main WORD program and played out at whatever timebase setting is required.

AVAILABILITY

Driver and test routines for the interface can be supplied by the author in full source and object code on CF2 disc for £8.50, or for £3 50 if you provide a blank disc

The full program suite, which includes source and object code fully commented and with instructions, costs £17.50 (or £12.50 if you provide the disc). Prices include postage and packing. The author's address is 'Coppins', 8 Robinswood Drive, Ferndown, Dorset BH22 9RZ; telephone 0202-875743. Please include a stamped, self-addressed envelope with any queries.

For readers wishing to use the CP/M editor and assembler provided by Amstrad, the 8080 source code AD.asm is available as a listing from the Electronics & Wireless World editorial office at Quadrant House. Send a large stamped, self addressed envelope, marking the covering envelope 'Amstrad Interface'

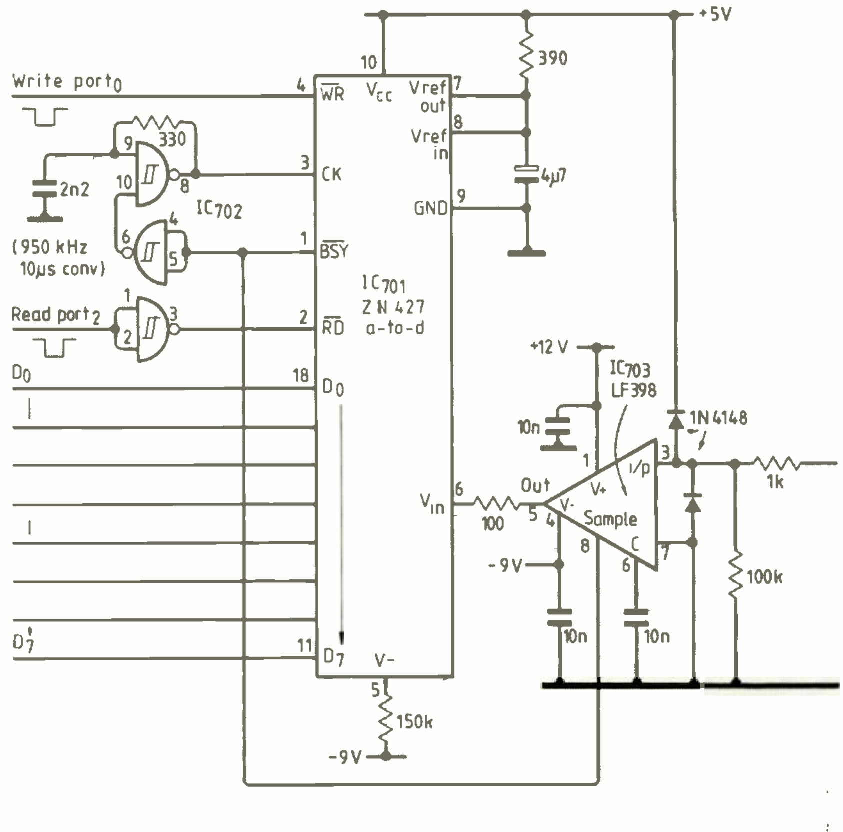


Fig.8. Successive approximation a-to-d converter: conversion rate is set by the clock generator to about 100k samples per second.

to be set from around 0.5 to 5 times gain, together with an offset adjustment to suit either bipolar or unipolar levels.

A switch S_{101} allows a.c. coupling if required.

TESTING

Physical layout of the interface is important since it must mate wih the connector at the rear of the Amstrad PCW enclosure. This connector (Fig.3) carries all the bus signals and will not, in general, permit the use of ribbon cable out to a remote unit.

The prototype unit was therefore constructed in two sections: a logic section with the converters on the rear of the computer, and the i/o section remote on ribbon cable. But it would be better to construct the unit in one piece to mount directly on the computer.

It may be difficult to find a connector designed to fit the rear expansion port. Unless the connector supplied in the kit is to be used, an ordinary 0.1 inch pitch edge-connector can be adapted to fit.

If you adapt an ordinary connector, use of the Amstrad polarizing slot is not recommended since it is placed between the 0.1 inch pitches and so cannot be used with the usual 'pin substitute' type polarized connectors. The best alternative is to remove the outer unwanted pins from a longer connector and to fabricate end-cheeks which will locate the connector snugly on the outer end of the exposed Amstrad p.c.b. without the need to insert anything in the slot between the pins. The end-cheeks can be made using pieces of p.c.b. or other material dropped into the connector and fixed with epoxy before being pushed on to the Amstrad for location as the expoxy cures. Be careful not to be too generous with the epoxy, or the

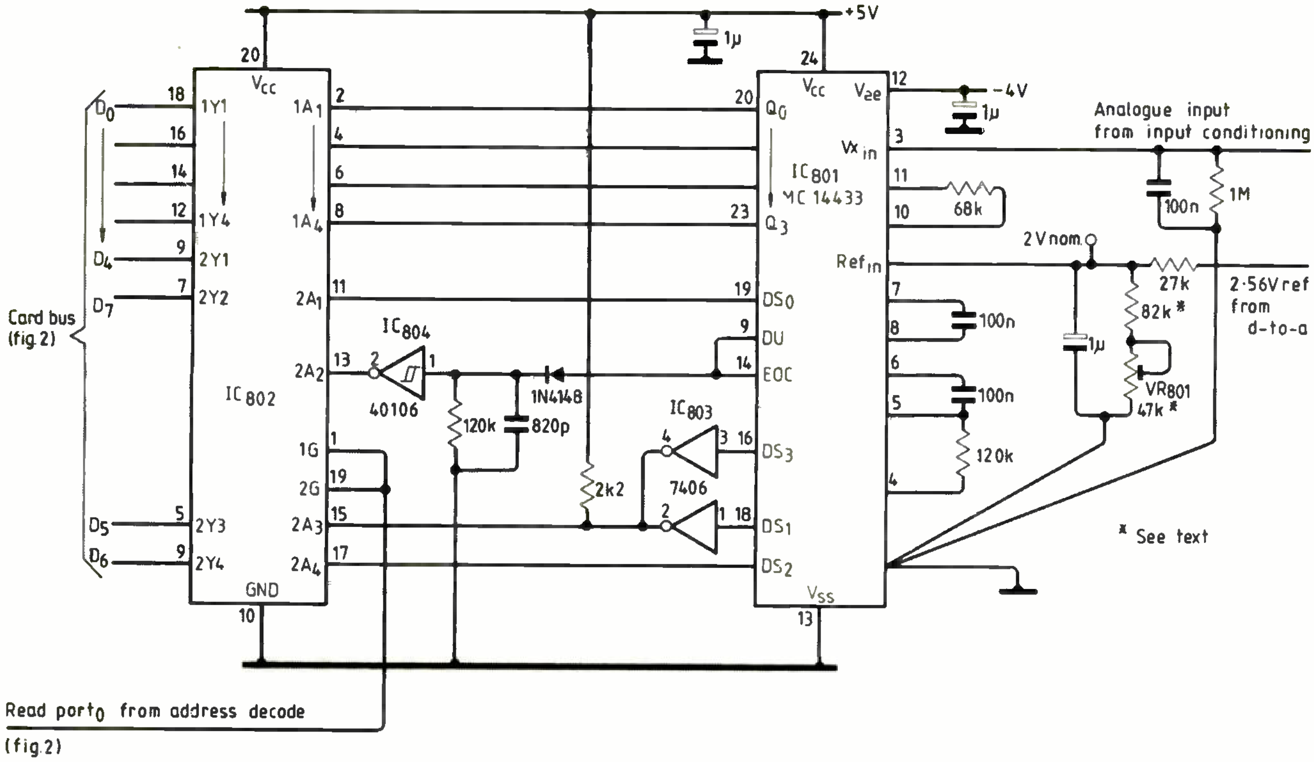


Fig.9 (above). For more precise measurements, the interface includes this eight-bit dual-slope converter. IC_{802} is an LS244.

connector may become a permanent feature of the computer! Wiping the Amstrad connector with a silicone-based preparation such as WD-40 will prevent stray expoxy from adhering.

Begin testing with the address decoding circuit of Fig.2. Having checked it, fit it to the computer and run the program PORT. This asks for the selection of a read-data or write-data fast software loop, allowing an ordinary oscilloscope to be triggered from TP_{201} (the card enable line) and so probe any address or data line.

If there has been an error in construction, it may be that no trigger pulse appears at TP_{201}. In this case, trigger the 'scope from IOREQ (i/o request) using the PORT program and examine the inputs and outputs of the address decoders to establish why the required port address is not being correctly decoded. On the prototype the +5V rail takes around 200mA and the +12V a few mA.

After one or more of the interface functions has been added it can be tested fully using another supplied test program SIX.

AVOIDING PROBLEMS

- Do not unplug the interface with the computer switched on.
- Avoid connecting an oscilloscope to the interface whilst the computer is running. Applying the 'scope ground so close to the processor ground can inject a noise pulse causing the computer to crash.
- Be careful when probing with an oscilloscope directly on the processor output lines. These are connected to large gate array which is not in a socket and would be awkward to replace. When the interface is functioning, all processor lines are buffered by the address decoding circuitry.

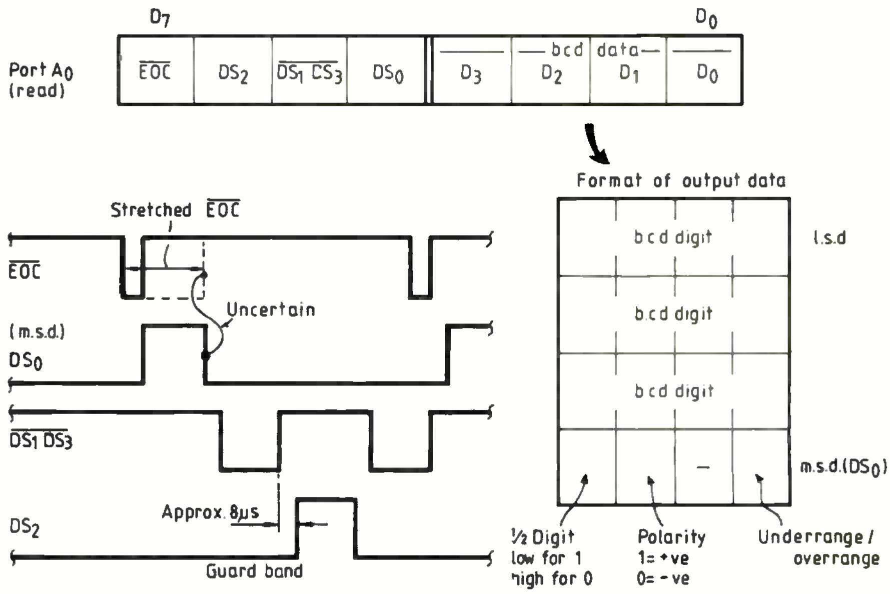
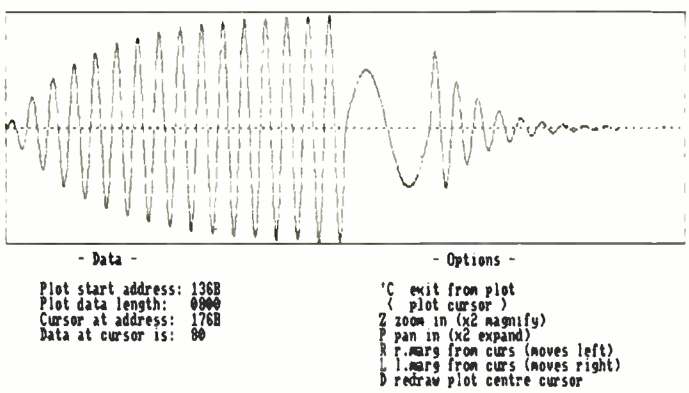


Fig.10. Timing diagram and data format of the a-to-d converter in Fig.9.



Using the interface: this waveform was synthesized numerically using the design program. The waveform may be output through the d-to-a to a 'real-world' application at a variety of timebase rates, but equally it could have been recorded *from* the real world.

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2N5643	11.85	MRF454A	17.25
2N5913	2.50	MRF455	16.50
2N5944	8.20	MRF458	17.20
2N5945	10.60	MRF475	2.30
2N5946	11.50	MRF476	2.15
2N6080	7.00	MRF644	22.50
2N6081	8.75	MRF646	27.00
2N6082	10.90	MRF648	32.70
2N6083	11.95	MRF901	2.75
2N6084	12.50	SD1013	9.75
2SC1729	14.50	SD1019-STUD	23.10
2SC1945	3.45	SD1019-5	22.80
2SC1946A	16.00	SD1127	3.10
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2SC1969	1.80	SD1136	11.90
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BT95	125.00	EL84	3.00	2E26	7.50	6BN8	3.50	5557	24.50
C3J	30.00	EL86	2.10	2K25	114.00	6BZ6	2.50	5559	52.50
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E55L	56.00	EL803S	9.95	3-500ZEIM	99.00	6CB6A	1.80	5867A	140.00
E80CC	14.00	EL821	13.75	3B28	15.00	6CJ3	2.30	5879	6.15
E80L	21.00	EN32	16.25	3C45	24.50	6CW4	8.00	5965	2.20
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ECF86	1.65	QQVO3-10	5.30	5AS4A	2.10	6SL7GT	2.25	7815AL-GE	48.00
ECF801	1.80	QVO3-12	7.00	5R4GYA-B	3.50	6SN7GTB	3.05	7815R	53.00
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ECL82	1.90	QY3-125	63.00	5V4GA	2.50	12AT6	1.90	8906AL	55.00
ECL86	1.60	QY4-250	69.80	6AH6	2.30	12AU6	1.90	150B2	6.50
EF80	1.70	RG1-240A	10.00	6AK5W	2.50	12AV6	2.00	572B CETRON	55.00
EF85	3.00	RG4-3000	90.00	6AK6	1.95	12BA6	1.95	807	2.90
EF86	3.00	XG1-2500	52.50	6AL5W	1.80	12BA7	2.35	810	82.00
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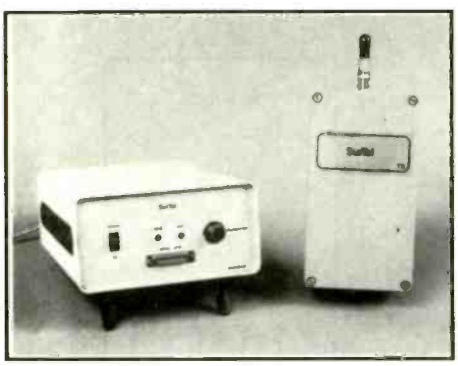

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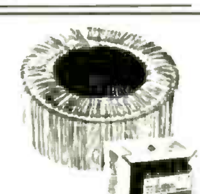

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THE PREMIER ELECTRONICS EXHIBITION IN THE NORTH

The incredible Scophony receiver

With interest in projection sets for HDTV on the increase, the time may be right for a reassessment of Scophony's ingenious mechanical receiver.

T.VOORE

Being prepared for the 1938 Television and Radio Show at Olympia: Scophony's mechanically-scanned television set, at £231 the dearest in the show (BBC Hulton Picture Library).

It is a widely held belief that serious development of mechanical television receivers ceased with the ending of 30-line transmissions in 1935; and that after the adoption of the 405-line system as the UK standard in February 1937, the cathode ray tube reigned supreme. Nothing could be further from the truth.

Engineers concerned with the development of low-definition receivers realized that three major problems had to be solved if mechanical systems were to have any real future.

To give a large, bright high-definition picture a projection system using a video-modulated light beam would be needed; and this would require a suitable light-valve.

The light-valve that showed most promise was the Kerr cell. To vary its light transmission, this made use of the principle of voltage-controlled rotation of the plane of polarization of light as it passed through a liquid.

Despite intensive development, the fundamental drawbacks of the Kerr cell – its high capacitance and its high drive and bias voltage requirements – were never overcome.

The second problem was in obtaining sufficient light energy in the small spot size essential for high-definition pictures.

Finally, synchronization of the received pictures would have to be reliable. None of the synchronization methods (some of them quite elaborate) in use with low-definition systems was really satisfactory.

Success in overcoming all these problems and applying the solutions to the production of a 405-line receiver for sale to the public was achieved by Scophony Ltd.

No other company in the mechanical television field was more deserving of success. Scophony had always set its sights on the development of a large-screen projection system of high definition and had spent many years researching scanning systems.

THE SCOPHONY LIGHT VALVE

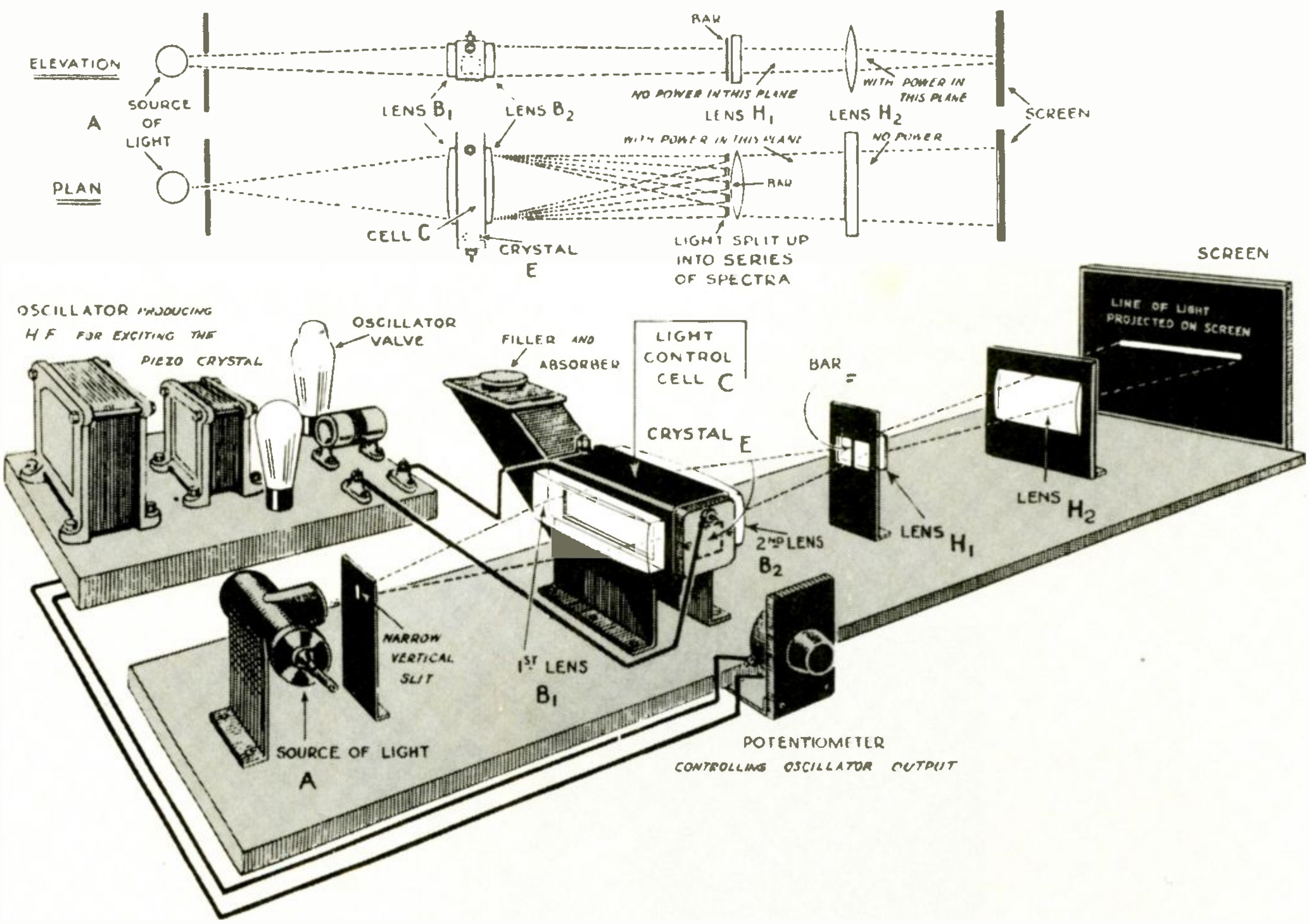
In 1934, J.H. Jeffree of the Scophony company demonstrated how the diffraction of light by ultrasonic waves could be used as the basis of a light control. This brilliant invention was the main reason why Scophony was able to make the leap forward from low to high definition.

This light valve gave adequate bandwidth at acceptable drive levels; and because of its action as a storage device it also solved the problem of supplying adequate light output.

Jeffree's light control consisted of a glass-sided container filled with a transparent liquid of the paraffin group. Immersed in the liquid and mounted on one wall of the cell was a piezoelectric crystal transducer. The opposite wall of the cell contained an absorbent material. A high-frequency carrier drove the crystal transducer, approximately at its resonant frequency. Video information was amplitude-modulated on to the carrier.

Mechanical vibrations in the crystal were then transferred to the liquid as a series of compressions and rarefactions which moved forward from the crystal at the speed of sound in the liquid. This train of ultrasonic waves was completely absorbed at the far end of the cell. The density and thus the refractive index of the cell therefore varied periodically in the direction of the wavetrain.

Light passing through the cell perpendicular to the motion of the waves would be retarded by compressed half-waves and speeded up by rarefied ones. And since the wavelengths were small, interference of the emergent light would take place, producing diffraction spectra. The intensity of the light deflected from the normal beam into the diffraction spectra was proportional to



the amplitude of the h.f. carrier driving the crystal. It was a simple matter to stop out the normal beam and to direct light from the side images to the screen (after suitable spectral correction), giving an intensity proportional to the received vision signal (Fig.1). A bandwidth of 5MHz could be obtained by stagger tuning and the drive required was about 10 watts at 18MHz.

Maximum length of the cell was limited by attenuation of the ultrasonic wavetrain to about 5cm. The wavetrain travelled this distance in about 50 microseconds, forming an information store about half a 405 line long. This meant that the input light beam did not have to be reduced to elemental size as it now contained half a line of information, thus overcoming a major disadvantage of light-beam projection systems.

As the stored information propagated through the cell, line-rate scanning in the opposite direction was needed to produce a stationary image.

SCOPHONY'S HOME RECEIVER

By September 1938, development had reached an advanced stage and a receiver was on sale (Fig.2). This set used back-projection to produce a 24 by 22 inch picture (note the strange aspect ratio) with a 300W mercury vapour lamp as its light source. Figure 3 gives an idea of the layout of the optical components.

The low-speed mirror-drum frame scanner was driven at 250 rev/min by a 1500 rev/min four-pole motor via a single spur reduction gear. Motor drive, from two 6L6 output valves, was provided by filtering and amplifying the separated field synchronization pulses. As the frame scan had two possible lock-up positions (in-frame and displaced by half a frame), correct framing could be achieved by switching a resistor in series with the motor windings, reducing its drive current and so producing frame-slip. When the picture was positioned correctly the resistor was shorted out.

With a 12-mirror drum, 250 rev/min gave a scan rate of $(250\times12)\div60$, or 50 frames per second.

Line scan was produced by a 20-facet stainless steel polygon. For the 405-line system this reflector had to rotate at $(10125\times60)\div20$, or 30 375 rev/min.

Fig.1. How Jeffree's light-valve worked. A fluid-filled cell was excited mechanically by an ultrasonic transducer modulated with the vision signal. When a light beam passed transversely through the cell, compression and rarefaction of the liquid created diffraction spectra corresponding to the intensity of modulation *(Television and Short-wave World,* August 1937 – reproduced here by permission of *Electronic Engineering*).

Fig.3. Vertical scanning in the Scophony receiver was achieved by a mirror-drum (by permission of *Electronic Engineering*).

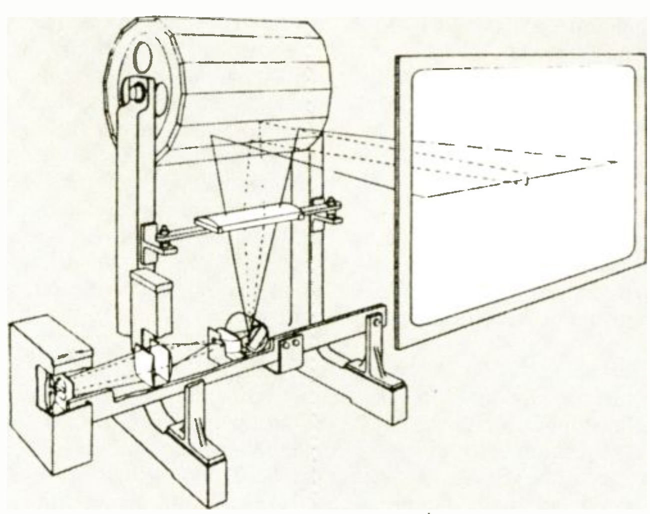
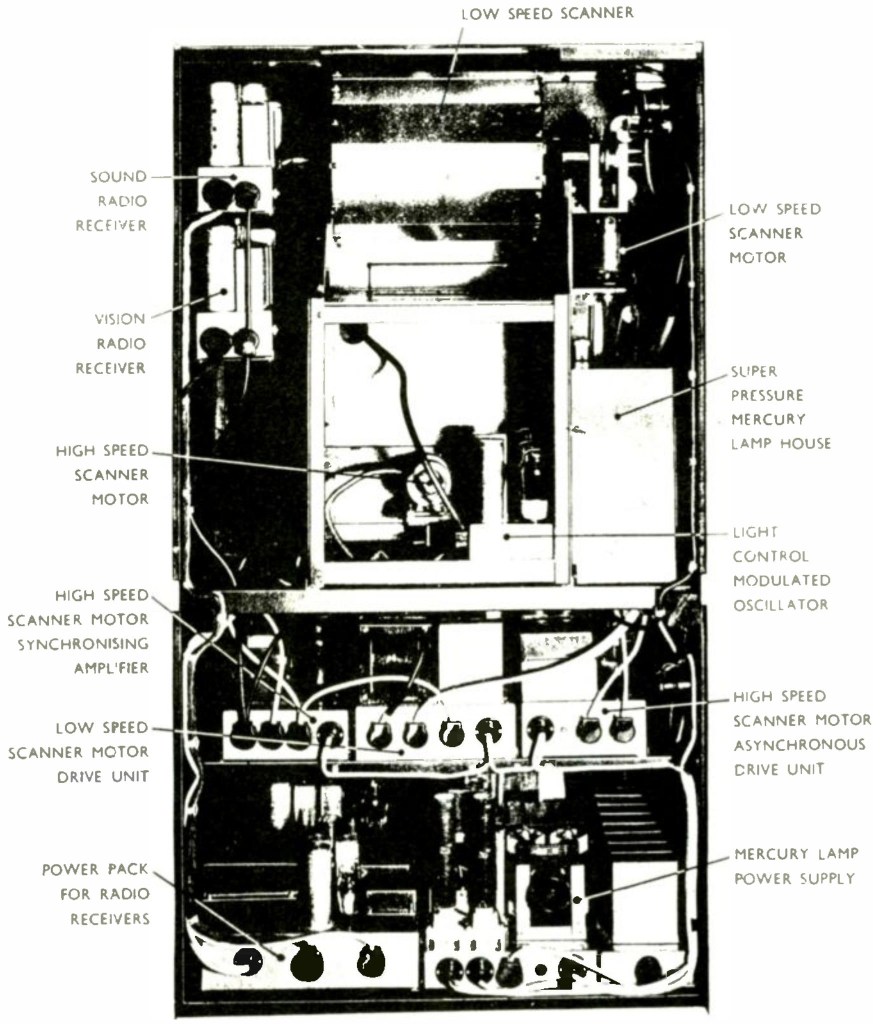
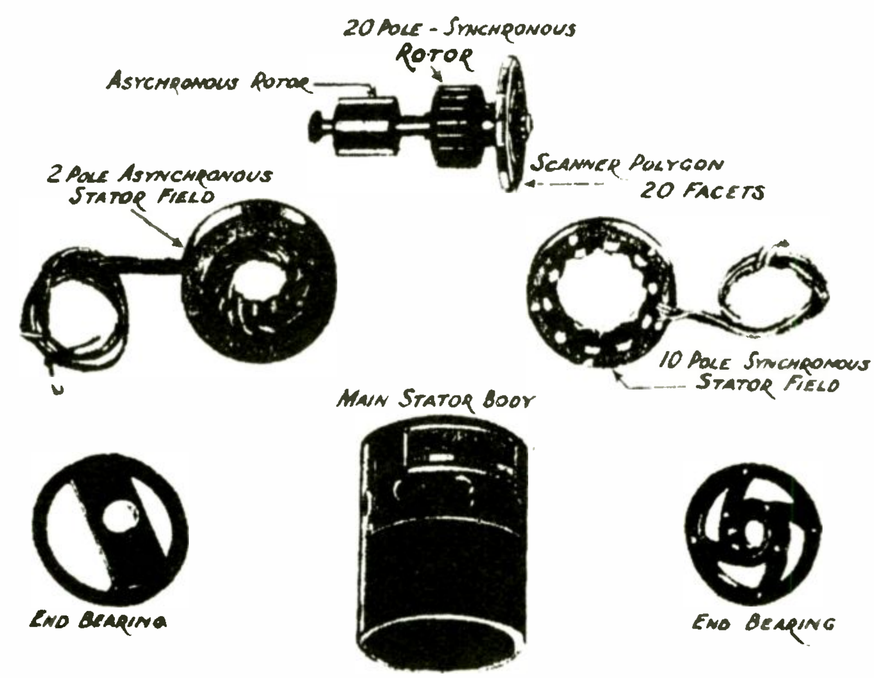


Fig.2 (right). Rear view of the Scophony mechanical-optical 405-line domestic receiver (*Television and Short-Wave World*, December 1938 – by permission of *Electronic Engineering*).

Fig. 4 (below right). Chief parts of the Scophony high-speed line-scan motor (*Electronics and Television & Short-Wave World*, November 1939 – by permission of *Electronic Engineering*).





The design of the high-speed line scan motor was a miracle of mechanical and electrical engineering (Fig.4.) It had to operate safely and continuously at this very high speed, which called for special bearings and very accurate dynamic balancing of the rotating components. To ensure rapid and accurate synchronization, the motor was in fact two motor systems on a common shaft. The first was an asynchronous motor which ran the system up to speed, driven by a 500-550Hz oscillator through a 6L6 push-pull output stage. Synchronization was achieved via the other motor (a synchronous phonic wheel motor) run resonant at line frequency, driven by amplified and filtered line sync pulses.

WHERE ARE THEY NOW?

By the time that the television service was closed on the outbreak of war, Scophony mechanical receivers had been installed in several cinemas of the Odeon group.

But little was known of the history of the Scophony system after the ending of hostilities. Research ought to be undertaken as soon as possible, while the people who designed, installed, sold and used these marvellous receivers are still with us and can give a first-hand account of their experience.

It is sad to record that not a single example of any Scophony receiver has survived.

Or has it? Perhaps, forgotten in some dusty corner, one still awaits discovery. Let us hope so.

Tim Moore is an television engineer working in broadcasting.

Further reading

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J. Sieger. The Scophony television system. IEE Conference Proceedings no.271. International Conference on the History of Television from Early Days to the Present (November 1986).

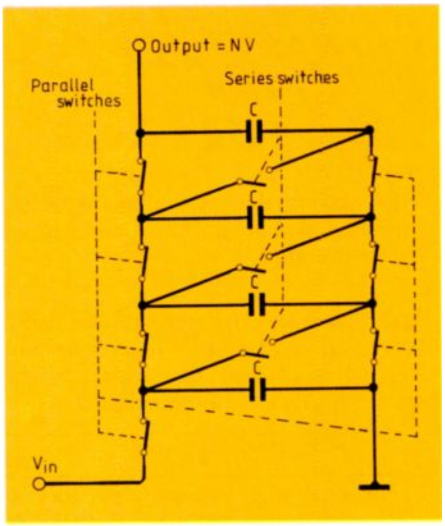
A romance of television: Scophony has arrived. *Television:* Journal of the Royal Television Society (December 1986).

Numerous articles describing the Scophony system appeared between 1936 and 1939 in *Television and Short-Wave World* (from 1939, *Electronics and Television & Short-Wave World*): among these was one in April 1936 covering J.H. Jeffree's patent description (patent no. 439236).

Marx generator for high voltage experiments

This simple device delivers unipolar pulses of up to several hundred kilovolts at very high currents.

E.A. RICHLEY



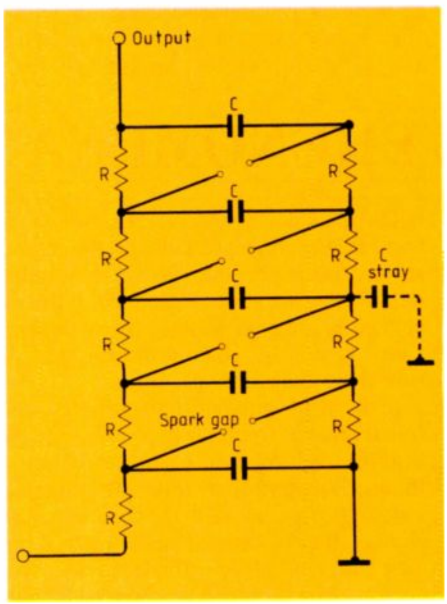


Fig.1 (top). Basic Marx generator with switches shown in charging positions.

Fig.2. Practical Marx generator. Stray capacitance is present at all nodes.

Generating high voltages for laboratory experiments has always been a challenging task, from both a technical and an economic standpoint. High voltage generators are used in many practical and experimental applications, such as accelerating for sub-atomic experiments, generating ionizing radiation and producing ion beams from a variety of plasma diode configurations.

Research applications of high voltage supplies include the study of dielectric breakdown, vacuum breakdown and a wide variety of gaseous conduction phenomena. Furthermore, there is much interest in protecting electronic equipment from high-voltage atmospheric phenomena such as lightning and, of increasing interest, electromagnetic pulse (e.m.p.).

Many readers are familiar with construction techniques for Tesla coils and Van de Graaff generators and the difficulties and limitations of these. A moderate size Tesla coil, for example, requires a large and expensive high-voltage transmitting-type capacitor, a hard-to-find neon sign transformer (which inevitably burns up), and several thousand feet of magnet wire. The output of such a device is in the form of bursts of high-frequency alternating current which, although fine for producing large sparks, has few practical applications.

A Van de Graaff generator, while capable of generating direct current, has a capacity limited to a few milliamperes at best. Corona losses and surface leakage are critical and must be carefully minimized. A large metal sphere must be provided as a capacitor for the output voltage.

Most significant Van de Graaff generators use an insulating system other than air to improve the dielectric strength of the environment. Thus they require a gas system, usually employing an electronegative gas such as sulphur hexafluoride.

Ironically, very little has been written about construction of Marx generators. These devices, originally described by Erwin Marx, provide unipolar pulses of very high voltage (commonly up to several million volts) and very high available currents (several thousand amperes is common). In addition, voltage rise times are extremely fast (about 1µs). Either polarity of pulse can be generated and pulse timing can be easily controlled. Best of all, a Marx generator requires no exotic parts and can be very inexpensive.

GENERATOR DESIGN

A Marx generator can be thought of as a system for charging a bank of capacitors to a high voltage and suddenly switching them into a series configuration (Fig.1). The voltage source is designed to supply as high a voltage as can be conveniently produced. Each capacitor is charged to voltage V with the parallel switches closed and the series switches open. The switch positions are then reversed, and an output pulse of voltage NV is delivered to the output.

This description, of course, is highly idealized and impracticable. The switching arrangement presents a mechanical nightmare. Switching would have to take place very quickly to avoid self-discharging of the capacitors, and without arcing.

Figure 2 shows a general Marx generator. Here the series switches have been replaced by spark gaps and the parallel switches by resistors. Its operation is very simple. The primary requirement is that the time constant RC greatly exceeds the breakdown time of the gaps. As long as all gaps have a breakdown voltage in excess of the power supply voltage V, but not quite as great as 2V, the capacitors all charge to V through the resistors.

If the lowest gap can be induced to break down, an amazing process takes place. When the first gap breaks down, the voltage at point A suddenly rises to 2V. Point B, however, has remained at earth potential because there is a minute stray capacitance to which no current has flowed. Thus, the second gap sees a potential of 2V and breaks down. The stray capacitance is trivial compared to C and is charged instantly. In a similar manner, the third, fourth and all other gaps fire in succession. Since these gaps break down in times of the order of 1µs, all gaps appear to fire simultaneously. The output voltage then rises to NV.

When the gaps fire, the capacitors self-discharge through the fired gaps and nearby resistors (Fig.3). For this reason, the RC time constant must be kept large in comparison to the gap firing time. This ensures that little self-discharging will occur before the total potential appears at the output. Of course, by making the time constant larger, the time required to charge the Marx generator between pulses is increased.

The available power supply may also play a part in determining resistor size. As charging time is increased by making the resistor larger, the current which must be drawn from the supply is reduced. Thus a compromise must be made between efficiency, firing rate and power supply capabilities.

In general, the energy storage requirements of the generator determine the size of the capacitors. Resistors are then chosen to provide a sufficient firing rate with sufficiently small self-discharge.

PRACTICAL MARX GENERATOR

A simple Marx generator can easily be built from ordinary p.v.c. pipe fittings and a modified television high voltage system.

The input voltage to this generator will be slightly in excess of 30kV. Although the output impedance of the power supply is very high and the continuous current available is only of the order of 1mA, capacitors charged to this voltage can deliver quite a jolt.

For this reason it is important to keep a grounding stick nearby when testing. A grounding stick is a long insulating stick (with absolutely no metal parts) to which is taped a length of wire connected to ground. The wire must be routed far from the handle end of the stick. Use this stick to discharge all high voltage components before handling the system.

Furthermore, when operating any of the high voltage apparatus, stay a safe distance away. Instantaneous currents from the top of this generator can easily reach several tens of amperes and would be quite painful and very possibly dangerous.

It is very tempting to get close, especially while looking for corona leaks. The author has more than once felt the tiny hairs on the surface of his nose stand up from the electric field. This is an extremely hazardous situation as an arc can easily jump from a hot electrode to a person's face or metal eyeglasses. It is best to avoid all such dangers.

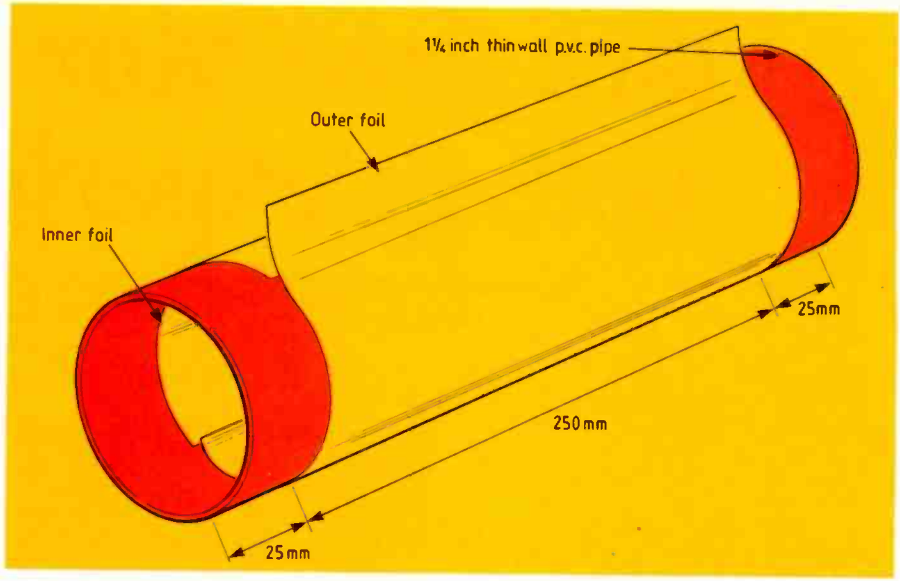


Fig.4. Making the p.v.c. pipe capacitors. Ordinary alumimium foil is secured with thin glue or tape.

CAPACITORS

Commercial high voltage capacitors are quite hard to find and very expensive. For example, a 1nF ceramic capacitor with a 15kV breakdown voltage costs between $10 and $20. This cost is prohibitive for a generator of five to 10 stages. Furthermore, the capacitors must be able to withstand 30kV or more since such a driving voltage can easily be produced.

Capacitors for this design can be made for less than $1 apiece and are more than adequate (Fig.4). A 300mm section of 1¼inch diameter (36mm nominal) thin-

HIGH VOLTAGE PHENOMENA

It might seem at first that a vacuum would provide the ideal dielectric for a high voltage system. There is simply no source of current carriers (electrons or ions) in a perfect vacuum. The dielectric properties of a vacuum gap are very good and, as a result, vacuum interrupters are made for both a.c. and d.c. applications. However, vacuum breakdown does occur and is the subject of much current research. The electrodes, as it turns out, can provide an ample supply of current carriers for the gap.

Several mechanisms exist for the formation of an arc plasma in a vacuum gap[1]. Although the dominating mechanism will depend on gap length and applied voltage, a brief outline of typical mechanisms can be given here.

The onset of gap current generally depends on some sort of imperfection in the electrode surface. These imperfections can consist of small, filmentary protrusions of electrode material or deposits of impurities on the electrode surfaces.

Electron current can start to flow from the cathode by field emission. Field emission is a tunnelling process by which electrons are drawn out of the cathode surface, despite the work function barrier, and subsequently traverse the gap. Current densities are generally extremely small and are strongly field-dependent. However, field-enhancement occurs at irregularities on the cathode surface making the local field at these points many times the average gap field. If the gap voltage is sufficiently high, these electrons gain a significant amount of energy by the time they reach an anode.

If the field emission current is concentrated at an irregularity on the anode, heating, melting, and even evaporation of the anode material may result. This liberated vapour can be ionized by incoming electrons, can cross the gap and liberate secondary electrons at the cathode surface. Thus an avalanche is created, leading to complete breakdown of the gap.

Under some conditions, microparticles can be generated as small pieces of electrode material are torn free from the electrodes. These microparticles can then liberate vapour upon impact at the opposite electrode. At that point, the gap is no longer a vacuum but contains a low pressure gas of electrode material. Any free electrons may then lead to breakdown by ionization of vapour atoms in the gap itself.

GASEOUS BREAKDOWN

When the voltage across a gas-filled gap is increased, a voltage-current relationship similar to the one shown in Fig.1 will be obtained. The general form of this curve will be the same regardless of the gas pressure. However, the scales of voltage and current will depend very much on the particular gas, gas pressure, and electrode shape.

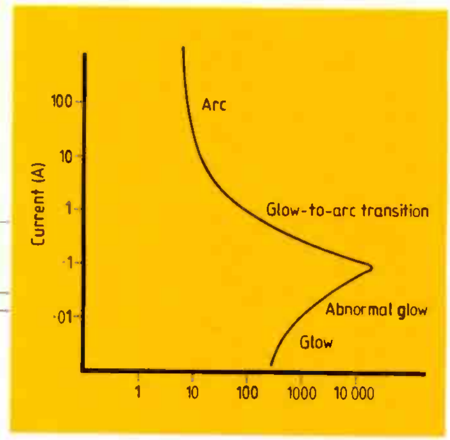


Fig.3. Characteristics of a gas-filled gap: current plotted against voltage.

It is convenient to think of a gas discharge as either low-pressure or high-pressure. The distinction is generally made at a pressure of about one atmosphere. At pressures far below one atmosphere different mechanisms will predominate at a given voltage. The following discussion concentrates on high-pressure phenomena, which include discharges in atmospheric air.

Three principal regions are of interest in arc breakdown: corona, glow, and arc (Fig.3). A fourth, called the Townsend region, is apparent only at much lower currents and is all but unobservable at high pressures.

Corona is the first region of self-sustained discharge where no external ionizing

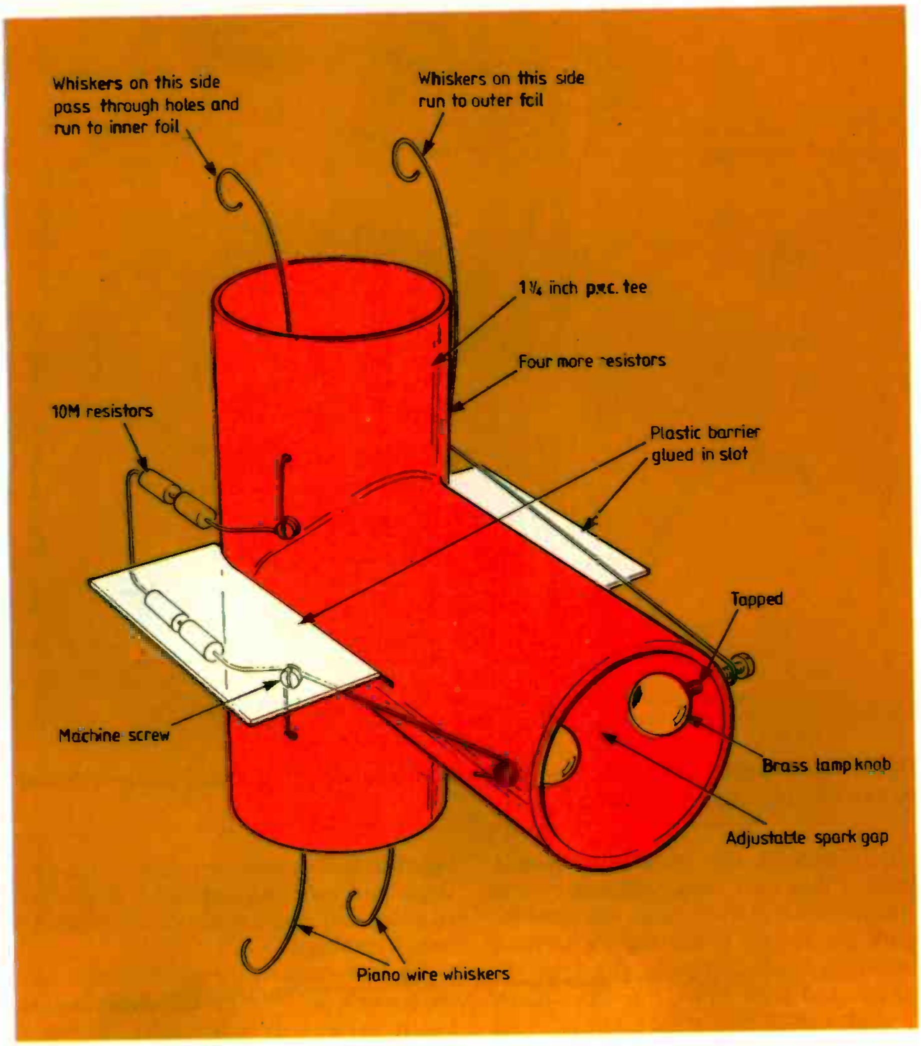


Fig.5. Interstage couplers are made from standard plastics waste-pipe fittings.

walled p.v.c. pipe is covered to within 25mm of its ends with aluminium foil, inside and out. For such a cylindrical capacitor,

$$C=\frac{55.6\varepsilon_r l}{\ln(b/a)}\mathrm{pF}$$

where b and a are the outer and inner diameters, respectively, l is the length in meters, and ε_r is the relative dielectric constant of the material. The relative dielectric constant for p.v.c.[3] is about 3.2. Thus the capacitor should have a capacitance in excess of 200pF (more than adequate for the Marx generator) and it should be capable of withstanding about 50kV.

The ends of each length of pipe should be de-burred to allow them to fit freely into the couplers to be described later. Each capacitor corresponds to one stage of the Marx generator. For the 200kV generator, seven capacitors will be required.

When forming the plates, keep the foil very smooth to make it close to the dielectric and so maximize the capacitance. This can be quite difficult, but a few tricks will help. Small wrinkles can be removed by pushing a fingernail across the foil. With large wrinkles, it may be better to start again. Thin, clear tape can be used to start the outer foil on the pipe. Roll the pipe section over the foil piece until the ends overlap and secure the foil with clear tape or a thin layer of glue.

For the inner plate, begin by forming a tube of foil on the outside of a blank piece of pipe. This curled piece can then be encour-

mechanism is needed to maintain the carriers of discharge current. Typically, corona exists in regions of high non-uniformity of electric field and it can carry currents of up to the order of a milliampere. Thus, sharp edges and fine wires are often causes of corona leakage and can be quite annoying when they draw current away from a desired place.

Corona shows as a faint glow around the electrodes. In air, corona is purple and can actually make an audible hiss. Far away from the electrodes the discharge is very diffuse. Electron density is too low to provide much light from recombination.

The glow discharge is what is commonly seen in neon signs, although such signs operate at low pressure. Glow discharges occurs in regions of uniform field but remain quite diffuse in nature. A glow discharge represents a situation of extreme non-equilibrium in which electrons become much 'hotter' than ions and neutrals owing to the inefficiency of energy transfer between electrons and the heavier species. As long as the available power is limited and the situation remains diffuse, the glow will be maintained.

At high pressures, such a density of heavy species exists that the inefficiency of energy transfer is partially compensated for by an extremely high frequency of interactions. Thus, at high pressure, glow discharges are very difficult to maintain. A high pressure glow can be thought of as a highly advanced corona just before the onset of an arc.

An arc discharge occurs as the conduction region collapses into a narrow region. As more power is made available to the discharge, a slight, random concentration of that power will occur and will cause enough heating to increase the ionization in that region.

Increased ionization liberates more electrons which carry more current and cause further heating and ionization. Soon a narrow conducting channel forms and complete breakdown occurs.

This is somewhat analogous to thermal runaway of bipolar transistors connected in parallel. The hotter transistor draws more current and so gets even hotter. Eventually, one device is drawing virtually all of the current. In a similar manner, the hot conducting channel draws all the current away from the other regions of the diffuse discharge and the glow makes the transition to an arc.

A fully developed arc has a high degree of ionization and is nearly in thermal equilibrium as the ions and neutrals become as hot as the electrons. Arc temperatures can easily reach 20 000K. An arc can carry many thousands of amperes and typically exhibits a very low voltage drop (tens of volts).

The mechanism by which breakdown occurs in high pressure gaps is not obvious. Undoubtedly, some positive ion bombardment of the cathode occurs releasing secondary electrons in what is considered a Townsend process. But the speed of breakdown cannot always be theoretically explained by this cathode process. Breakdown typically takes place in less than a microsecond. A Townsend process would depend on ion transit times and so would take much longer.

Fortunately, another effect originating at the anode has been observed – streamer formation. Streamers are luminous filaments moving from the anode to the cathode and are thought to be columns of positive ions generated by electron impact.

As an ionized region is formed, the field in that region is enhanced by the presence of positive space charge and further electron impact is thus encouraged. Although the ions themselves need not move, this ionization front propagates like a wave toward the cathode at a very high speed. Theoretical investigations of these processes are very complicated and much has yet to be determined.

aged to fit inside by gently compressing it inward while sliding it down the pipe. If it crumples, start again. Secure the inner plate with clear tape or a thin layer of glue anywhere it tries to pull away from the wall.

In general, avoid all sharp edges on any electrically conducting surface. Smooth any rough edges on the foil plates and, if necessary, cover them with a thin layer of silicone sealant. Rough edges are prone to emit corona. Such losses should be minimized as they lower the system operating voltage. Silicone sealant is an excellent high voltage insulating material and is very useful for suppressing corona leaks. It is available in small toothpaste-type tubes or larger rigid tubes for a caulking gun.

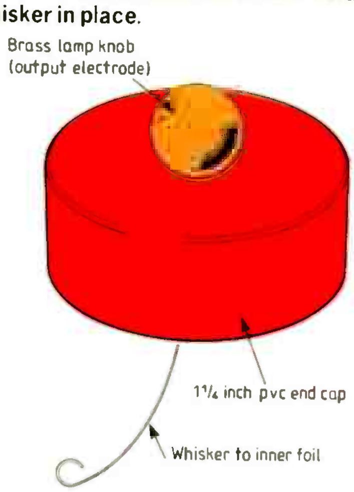
INTERSTAGE COUPLERS

The resistors and spark gaps are built into coupling units placed between the capacitors. Six such couplers will be needed for the seven stage generator. In addition, a top cap and bottom feeder will be needed. The couplers have been designed to keep the outer foil of the capacitors at ground potential except while firing, both to minimize corona losses by confining the high voltage conducting surfaces and as a safety precaution.

Figure 5 shows the general layout of an interstage coupler. Spark gaps are adjustable and are made by threading holes in the leg of the tee fitting to accept 6-32 bolts. The ends of these bolts are fitted with small brass spheres of the type sold as knobs for lamp switches or pull chains. These are ideal spark gap electrodes. It is important to use perfectly round, smooth knobs to minimize corona losses. Screw threads and bolt heads give off large amounts of corona and are not suitable.

High voltage resistors must be carefully constructed. Although much lower values could be used for higher repetition rates, each resistor is made from four 10 megohm carbon resistors. This is primarily a precaution to keep the continuous current available at any point at a harmless level. A single carbon resistor of 10MΩ would easily break down during operation.

Fig.7. Top cap is made from a p.v.c. end cap. The brass lamp knob is secured with a bolt from underneath which also holds the whisker in place.



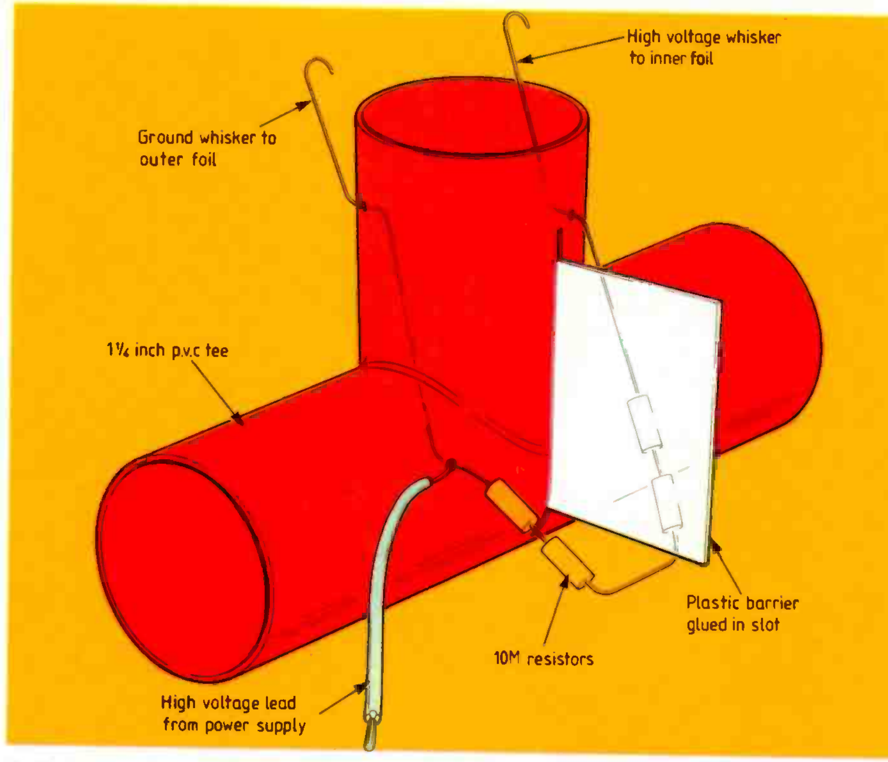


Fig.6. Bottom feeder: only one is required. To avoid troublesome corona leakage it should be carefully insulated from the floor.

Connections to the capacitors are made by forming thin steel piano wire into contact whiskers. Two of these wires run from the spark gap screws, over a resistor terminal and off to a capacitor plate. One is on the outside and runs down, the other passes through a small hole to the inside and runs up to the inner foil. The opposite two run only from the resistor terminals to the capacitors as shown. Care must be taken to ensure that enough curvature and spring tension are provided to make contact with the foil surfaces. Tiny air gaps can appear as mysterious voltage drops and cause problems later.

Resistors, bolt heads, and even some of the piano wire surfaces must be covered with silicone glue to prevent corona and suppress arcs. Especially important are the inside ends of the resistor terminal screws. Care must be taken not to get glue on the foil contact loops. When properly constructed, these couplers will fit nicely between two capacitors. There is no need to glue them together as they will fit tightly. Since the stages pull apart, any number of stages can be added and maintenance or development work is very easy.

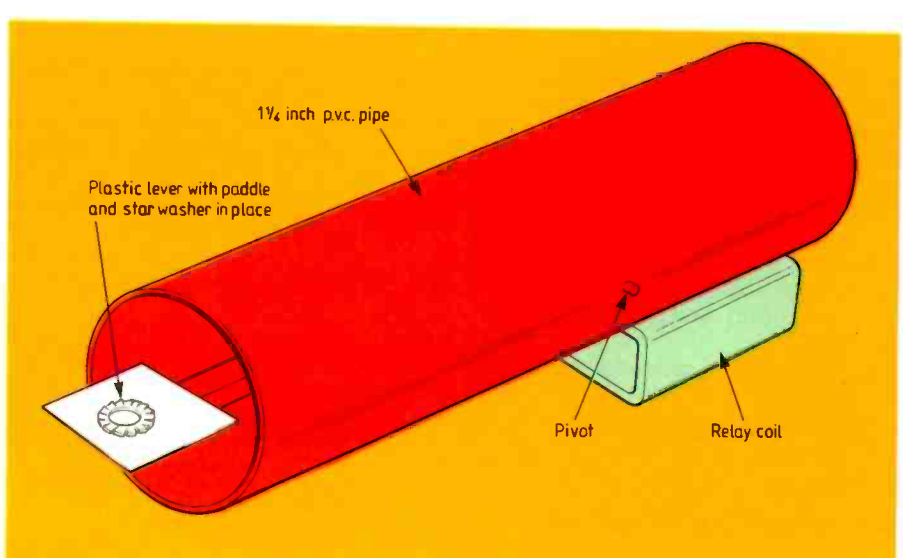
A bottom feeder is needed to connect to the power supply (Fig.6). The earth connection passes directly to the outer foil, while another resistor is provided for the inner foil connection. It is again important to cover all sharp surfaces with silicone sealant.

The top cap carries the output electrode for the Marx generator (Fig.7). A single brass sphere of the type used in the adjustable spark gaps is bolted to a p.v.c. end cap from the inside and a piano wire whisker makes contact with the inner foil of the top capacitor.

BASE

A base for the Marx generator can be made from more p.v.c. pipe and fittings. These are formed into an H arrangement built around the bottom coupler. The base can be glued together with p.v.c. cement for rigidity. To allow the generator to tilt over, it is a good

Fig.8. Elecromechanical remote trigger.



idea not to glue the connections to the bottom coupler. This will also allow the generator to be stored more conveniently when dismantled.

REMOTE TRIGGER

A remote trigger device is especially useful for photography. A very simple electromechanical trigger is reliable and quite satisfactory for most applications.

The basic idea of the trigger is to set the first gap too wide to break down from the power supply voltage. A long plastic lever then brings a metal star washer into the gap. The increased field strength in the gap allows breakdown to occur and fires the generator.

Figure 8 shows the trigger built into a section of p.v.c pipe. The lever just protrudes from the far end to place the washer into the gap. A relay coil at the other end actuates the lever. A long cord with a push-button built into a plastic film canister serves as the remote switch. The design of the trigger will depend on the coil or solenoid available. It is important to maintain a lever length of several inches to keep high voltage away from the coil. The trigger is then press-fit into the leg of the first interstage coupler.

POWER SUPPLY

The power supply should deliver slightly more than 30kV to the Marx generator. The design is based on a modified television flyback transformer, which will yield about 10kV of alternating current at about 15kHz. A voltage tripler produces the final output. Any common unit intended for large colour televisions will do.

Unfortunately, these modules produce only positive output voltages. If applied to the inner side of the Marx generator these will deliver positive pulses at the top. If the input leads are reversed, negative pulses can be obtained, but at the risk of placing high voltage on the outside of the generator. Otherwise, negative pulses can be produced only by making a negative-output tripler and applying power to the inner side.

The circuit diagram for the power supply is shown in Fig.9. The primary of the flyback transformer must be removed and insulating tape should be applied to the core for winding a new one. The new primary winding is formed with five bifilar turns of no.18 (1mm diameter, 19s.w.g.) magnet wire with the ends joined in a centre-tapped arrangement. The tickler coil is made from five turns of no.24 (0.5mm diameter, 25s.w.g.) or larger magnet wire. It is essential to connect the windings in proper phase.

The tripler and high-voltage side of the transformer should be kept as far away as possible from the low voltage connections to prevent corona leakage and even breakdown in the power supply itself.

The output lead of the power supply should produce some corona and a grounded lead will draw small discharges continuously from it. Since the tripler contains capacitors, take care never to touch the output directly. Discharges of the order of an inch long should be possible.

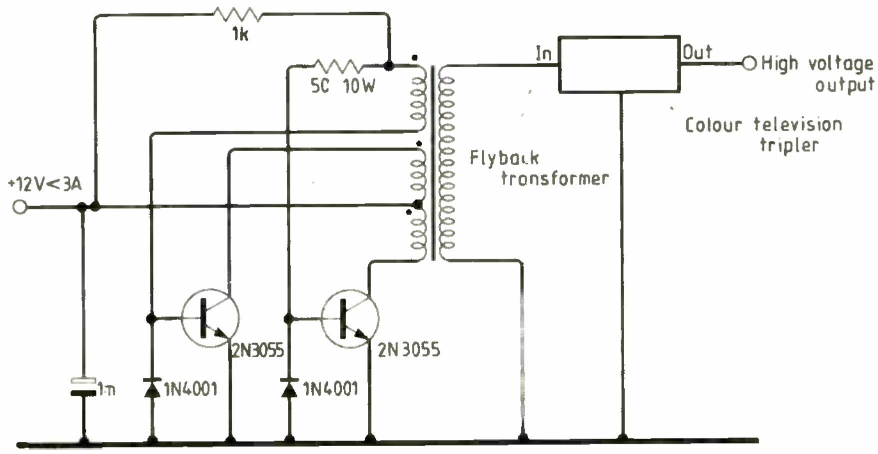


Fig.9. High voltage power supply. Both transistors must be secured to a heat sink with insulating hardware. The 12V unregulated source should be able to provide up to 3A.

TESTING

Begin testing the generator with two capacitors and one coupler on the base. Set the spark gaps to greater than one inch. Carefully apply power and look for any corona leaks in the generator itself or from the connecting leads. If the gap breaks down, make it wider. Having noted any leaks, remove power and *discharge the inner side of the Marx generator*.

Discharging can be accomplished by bringing the grounding stick in contact with the 'hot' end of the spark gap. Always do this before handling the Marx generator.

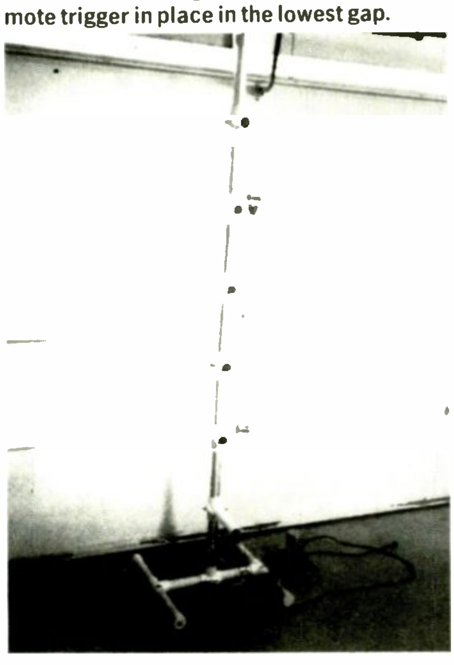
Dismantle the capacitor column and treat the corona leaks with silicone sealant or by removing sharp edges. Re-assemble and test for more leakage. When the first stages have been perfected, add the next ones and repeat the procedure.

When the entire column has been purged of corona leaks, the remote control trigger can be installed. Actuating the trigger while power is applied to the Marx generator should break down the first gap. If it doesn't, adjust the first gap (after discharging the column) until it does. Other gaps should follow at the same time as the first. If they do not, look for bad connections between the whisker contacts and the foil and adjust the gaps down until they fire synchronously with the triggered gap.

An earthed wire can be dangled from the ceiling to within a few inches of the top cap of the column. This wire will allow arcs to be drawn when the Marx generator is triggered. The difference between corona and arc will become apparent as the gap discharges change from faint purple filament to a hotter white spark.

Arcs of up to six or seven inches are easily obtained. This indicates that output voltages of 200kV are available. Charging times of two or three seconds are required between firings.

Assembled Marx generator. Note the remote trigger in place in the lowest gap.



IMPROVEMENT

For an improved generator, the resistors on the interstage couplers could be reduced to 1MΩ or so (four 250kΩ resistors in series). This would greatly increase the firing rate if a more powerful power supply could be found. A 30mA 30kV supply could possibly be made from a 15kV power transformer and a specially constructed voltage multiplier using large transmitting capacitors or, possibly, large p.v.c. pipe capacitors.

Furthermore, a completely re-designed unit with two or three-inch pipe could be built to increase the available current.

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Edward Richley attended Carnegie-Mellon University in Pittsburgh, Pennsylvania from 1975 to 1984. He gained a B.S. in 1979, an M.S. in 1980, and in 1984, a Ph.D. with a thesis on non-equilibrium effects in high-pressure electric arcs. He now works for Xerox Corporation at their Palo Alto Research Center in California. He also holds an advanced-class amateur radio licence, KD8KZ.

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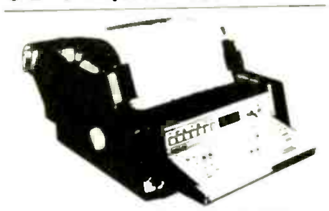

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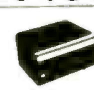

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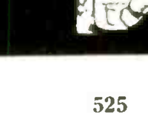

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Skynet-4 military comsat

Britain's Skynet-4 military comsat system is almost ready to go into operation. One spacecraft has already been built by British Aerospace, with Marconi Space Systems providing the communications payload. The second is still being constructed (see photo). The first of these was due to be launched by the US space shuttle in June 1986, but the Challenger disaster and its aftermath put paid to this plan. It was to have been placed in geostationary orbit at 1°W over the Atlantic Ocean, above a point just south of Accra on the African coastline. From here, when it eventually arrives, the comsat will have an east-west coverage roughly from Iran to the West Indies – the region in which UK military forces are mainly deployed.

The Skynet-4 system will have a much greater communication performance than Skynet-2, which was based on a single satellite launched in 1974. (Systems 1 and 3 did not come into being). First, it will use larger comsats than Skynet-2: spacecraft similar to the ECS (European Communications Satellite) with solar-cell 'paddles' and three-axis stabilization, rather than a cylindrical (1.9m diameter) construction. Their power supplies will provide 1200 watts.

Secondly the communications payload will give higher transponder powers, with e.i.r.ps in different channels ranging from 26 dBW to 39 dBW. Thirdly the new comsat will have a greater communications capacity than Skynet-2. In addition to the extra r.f. power, the transponder bandwidths are wider, allowing high traffic densities and handling a variety of data rates from 50 bit/s upwards into the Mbit/s region.

Communication frequencies to be used range from u.h.f. to e.h.f. There are two 40-W u.h.f. transponders, each serving a channel of 25 kHz bandwidth. Here the receiving band is 305-315 MHz and the transmitting band 250-260 MHz. The u.h.f. antenna is a helical type intended to give overall coverage of the military area (approximately 120° of longitude). In the form of a flat spiral, it is only extended to its full height of 2.4m when the spacecraft arrives on station.

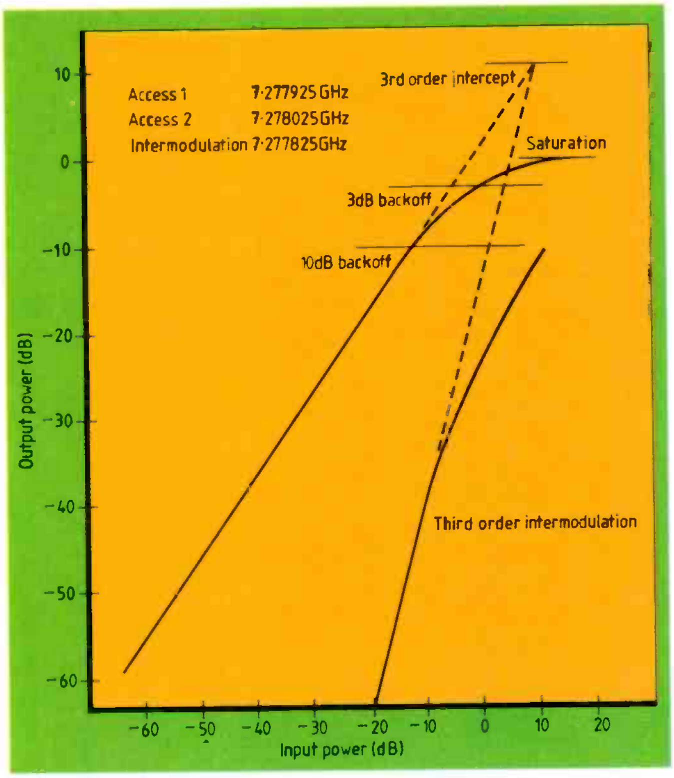


Fig.1. Transfer characteristic of prototype Channel 1 transponder for Skynet-4 comsat. (Courtesy *JIERE*)

A very large part of the communications capacity is provided by four s.h.f. channels. Channel 1 receives at frequencies from 7975 to 8110 MHz and downconverts these by 725 MHz to the band 7250 – 7385 MHz for transmission (bandwidth 135 MHz). Channel 4 receives at 8340 – 8400 MHz and downconverts to 7615 – 7675 MHz for transmission (bandwidth 60 MHz). Between these, Channel 2 has a bandwidth of 85 MHz and Channel 3 a bandwidth of 60 MHz. There is a guard band of 35 MHz between Channels 1 and 2 and one of 25 MHz between the other channels.

In the s.h.f. repeater the total receiving frequency range of 7975 – 8400 MHz is first selected by bandpass filter then all signals in this are amplified by a broadband amplifier. Next, four input-channel filters separate the broadband signal output into four channels. These channel signals pass through four amplifiers with programmable gain and on to four downconverters. A combiner feeds Channels 2 and 4 to one of three 40-W travelling wave tube amplifiers (t.w.t.as), while Channels 1 and 3 are each handled by a separate 40-W t.w.t.a. in the group of three. Other, spare t.w.t.as are also carried in the spacecraft.

Finally the outputs of the t.w.t.as pass through filters to the s.h.f. antennas. These provide various radiation patterns: full area coverage from a horn, and wide, narrow and spot beams from dishes.

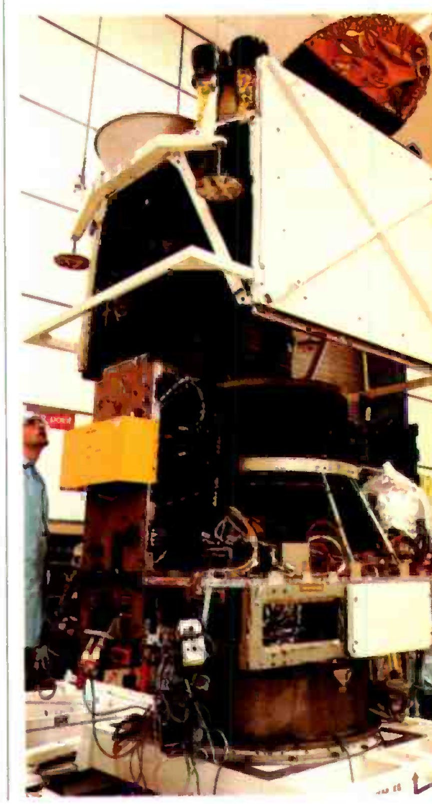
One of the problems which had to be faced in the design of the s.h.f. repeater was the high density of the communications traffic to be carried by Skynet-4. Broadly this consists of data transmission at various rates on various carriers. When a given transponder carries a number of such signals, called 'accesses', mutual interference could occur as a result of intermodulation if the transponder had a non-linear transfer characteristic.

C.H. Jones of the Royal Signals & Radar Establishment explained this problem last year in an IERE paper describing a traffic simulator for Skynet-4 (*JIERE*, vol. 56, No. 2, Feb. 1986). Skynet-2 used hard-limiting transponders and these required considerable skill in the planning of frequency spacing and the positioning of the various accesses to avoid intermodulation interference. The Skynet-4 transponder is mainly linear, but with "the wider bandwidths, higher traffic densities at diverse data rates and programmable channel gains within the satellite up to saturation condition for the output travelling-wave amplifiers, the inherent non-linearity of the system is still an important factor."

The Channel 1 transponder transfer charactertistic in Fig. 1 (from the IERE paper) illustrates this problem. This shows the frequencies of two accesses to Channel 1 and a 3rd-order intermodulation frequency. The transfer characteristic is on the left and the 3rd-order intermodulation product curve on the right. Where the linear projections of these two curves meet (shown by broken lines) is called the 3rd-order intercept, a parameter used in design. It is a theoretical point where the signal and the intermodulation product are of equal amplitude.

In using a t.w.t. the design aim is to get the highest possible output power for the highest possible intercept point for the

Bringing together the communications and service modules of a Skynet-4 communications satelite at British Aerospace, Stevenage, Hertfordshire.

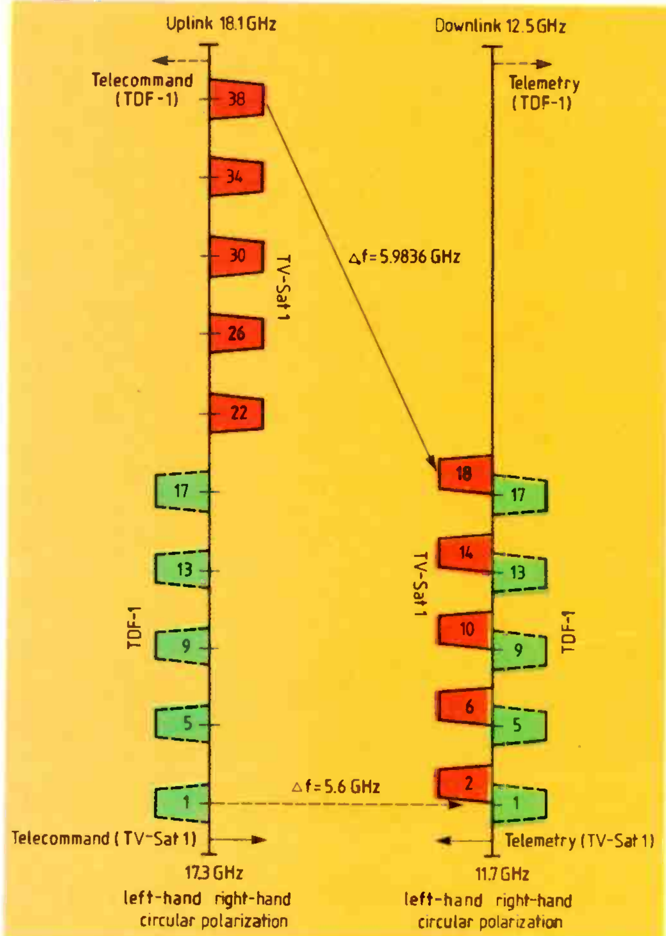


lowest possible d.c. power going into the tube. But as can be seen from the transfer characteristic the t.w.t.a. gain and power fall off sharply towards saturation. If the t.w.t.a. is over-driven into this non-linear region various intermodulation products result. Mr Jones mentioned that with two frequency accesses of equal amplitude, giving a total power just saturating the tranponder, the 3rd-order product is only 12dB below the main access levels. Larger numbers of accesses give a complexity of intermodulation levels.

Thus the t.w.t.a. has to be backed off so that it is not driven into this region, as indicated by the 3-dB and 10-dB back-off levels. In practice the semiconductor amplifier driving the t.w.t.a. does this: it is arranged to limit at a level that ensures that the t.w.t.a. is not over-driven.

Military satellites, of course, are subject to jamming. One precaution taken against this in Skynet-4 is the use of spread-spectrum technique in the telemetry and telecommand system. In general the spread-spectrum principle embraces such things as frequency hopping and time hopping, but the technique hitherto used in military satellites (e.g. GPS/Navstar and Skynet-2) is the direct sequence method. Here the data signal is directly modulated (multiple) by a fast-random code sequence from a synthesizer with a rate typically in the range 1 – 10 MHz. This takes place prior to phase modulation at i.f., then the i.f. is upconverted to the microwave carrier frequency. At the receiving end the signal is multiplied by the same pseudo-random sequence to recover the original data by correlation.

The IERE paper mentioned above refers briefly to e.h.f. transponders, though the use of these has not yet been confirmed by BAe/Marconi. Of course, e.h.f. means frequencies of 30 GHz upwards, or millimetre waves. Such short wavelength transmissions are subject to heavy absorption in the Earth's atmosphere and water vapour, but they can be used to advantage for inter-satellite radio links directly through space, where there is no such absorption. So inter-satellite links between Skynet-4 and other spacecraft appear to be a possibility.



Frequency assignments and relative channel and polarization arrangements for TV-Sat 1 and TDF-1 direct broadcasting satellites.

More on Franco-German d.b.s.

The April issue included a brief description of Eurosatellite's common spacecraft design for the French TDF-1 and German TV-Sat 1 direct-broadcasting satellites, but did not give details of frequencies and channels or explain how these are handled in the repeater.

Accompanying this item is a diagram showing the uplink and downlink frequency assignments to the two satellites. In common with other ITU Region 1 countries, France and W. Germany were each given five d.b.s. channels at WARC 77. In the downlink (transmitting) frequency band of 11.7 – 12.1 GHz the German satellite TV-Sat 1 has the five channels, 2, 6, 10, 14 and 18, while the French TDF-1 has 1, 5, 9, 13 and 17.

There is likely to be a particularly critical mutual interference situation at the 19°C W orbital position of the two spacecraft. Because of this the uplink groups of channels for the two satellites are kept well apart, as can be seen. TV-Sat 1 uses the upper half of this 17.3 – 18.1 GHz uplink band (channels 22, 26, 30, 34, 38) while TDF-1 uses the lower half (channels 1, 5, 9, 13, 17).

Further protection against possible interference is given by the two satellites' having opposite directions of circular polarization, in both uplinks and downlinks. Also, the telemetry and telecommand frequencies are kept widely separated. Those for TV-Sat 1 lie in the lower guard bands at 11.7 GHz and 17.3 GHz, while those for TDF-1 are in the upper guard banks at 12.5 and 18.1 GHz.

The repeater used in both spacecraft is manufactured by two members of the Eurosatellite consortium, ANT Nachrichtentechnik of W. Germany and Alcatel-Thomson Espace of France. In this equipment the received uplink signals, in a power range of −68 to −46 dBm, pass into a common broadbank receiver. Here they are frequency converted to the transmission band and amplified. Circuitry at this point takes the form of integrated fets.

A demultiplexer separates the broadband group of signals into the five individual channels. In each channel the group delay distortion is compensated by equalizers. Each channel chain also has an a.g.c. system to compensate for variations in received signal power caused by changes in atmospheric attenuation. These fluctuations cannot be corrected in the broadband receiver because of the presence there of relatively high level unwanted signals unavoidably picked up by the satellite. This channel a.g.c. is provided by p-i-n diode attenuators between fet amplifier stages.

For the transmitting part of the repeater, 230-W travelling-wave tubes are used. The t.w.t. amplifier (ANT type TL12260) with all related assemblies including the output multiplexer, has been designed with special attention to heat dissipation. Such a t.w.t.a., with an efficiency of about 40% and losses of typically 1.2 dB up to the repeater output, requires a power dissipation of over 400 watts to achieve the high radiated power for a d.b.s. channel. So the tube collector has been designed as a self-radiating unit which send the greater part of the dissipated power directly into space. You might say it re-cycles a bit of the energy which the spacecraft takes from the sun.

Finally the r.f. outputs of the transmitters in the five channels are combined in an output multiplexer. Insertion loss of this multiplexer has been kept low by making use of the H_{112} resonance.

Apart from an extra, switchable t.w.t.a. in one channel, the repeater has no redundancy within its channels. The satellite relies on the 'frequency redundancy' principle in the sense that it provides five channels for an actual broadcasting requirement of only up to three of these.

Satellite Systems is written by Tom Ivall.

Image acquisition system

This hardware adds vision to any computer with an RS232 serial interface.

G.J. AWCOCK, F.W. STONE AND R. THOMAS

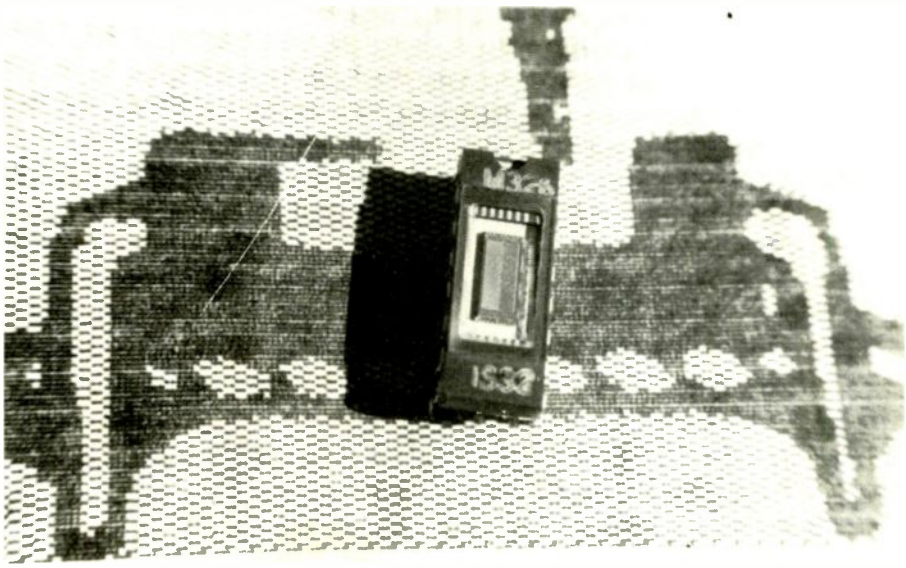
A main aim of the design was to produce a hardware interface that would be able to support the IS32 fully and be controlled by a few simple commands from the host computer via a serial link (Fig.8, April article). In this way the host can be relieved of the routine interface task and problems associated with it: it merely issues commands to select the required sensor quadrant and then requests execution of one of the major macro-tasks, Scan or Read.

The scan command serves to initialize, expose and interrogate the whole of the selected sensor quadrant. In doing so, it packs the image data into bytes and stores them in an on-board 2K×8 static ram chip. On receipt of the read command, the packed data is transmitted to the host as a continuous stream of 2048 words on the RS232 link. The host is then responsible for processing the received data by applying algorithms to perform the second stage of linearization.

The initialize-expose-interrogate cycle chosen for this array operates by setting a column address and then performing a write cycle to each of 128 cells whilst incrementing the row addresses. This scheme is know as row fast addressing. It is also used for reading the cells: it prevents reading of one cell in the column from causing refresh of any of the other 127.

After initialization, the array is deactivated for the chosen exposure time to allow the photosites to discharge under the influence of incident light. When this period has elapsed, the column of cells is read in the same order as it was written and the resulting data stream is packed into sixteen bytes and stored in consecutive locations of the static ram.

This method has the advantage that each cell receives precisely the same exposure (the exposure delay time plus 128 memory access cycles) without the need to expose them individually, and without anti-refresh complications. It is not the fastest method of scanning such an array, since 128 exposure periods are required to acquire all the data in a 128 column array; but it does provide a suitable compromise when combined with the RS232 serial link to the host. It takes a little over one second to transmit the image data, even at 19 200 baud, and this limits the image update rate.



Beneath this sensor device is a profile of itself captured by the system.

Table 2. Command list for the interface.

Command word		Function
00	SCAN:	initiates the sequence to scan the IS32. CTS is negated during this activity.
01	ROWL:	sets the m.s.b. of the row address low, selecting the 'upper' array.
02	ROWU:	sets the m.s.b. of the row address high, selecting the 'lower' array.
03	COLL:	sets the m.s.b. of the column address low, selecting the lower column addresses.
04	COLU:	sets the m.s.b. of the column address high, selecting the upper column addresses.
05	MR:	resets the uart.
06	READ:	initiates the sequence to send image data back to the host computer. CTS is negated during this activity.

HARDWARE

In the prototype, a double Eurocard was used for the control hardware. A separate p.c.b. about 60mm square holds the sensor, to simplify its integration into the optical system. The two boards are linked by a ribbon cable, which carries the d-ram signals and therefore must not be too long. However, experience has shown that the system operates successfully with several feet of cable.

At the heart of the serial system is a 6402 uart which is interfaced to the RS232 standard voltage levels by line drivers and receivers. The serial protocol may be selected by means of a switch-bank S_1 and the data rate by S_2.

Command decoder IC_8 is capable of accepting eight commands, although only seven are implemented in this design (Table 2). The decoder produces transient pulses because the receive latch of the uart is reset by a delayed version of the Data Ready status flag. Decoded commands are registered by S R latches implemented in IC_{18} and IC_{19}. The outputs of the Scan and Read latches are combined in IC_{17d} and buffered by IC_1 to implement a serial control protocol by negating the clear-to-send (CTS) signal when the board is busy and thus unable to respond to further commands from the host. In this design the ready-to-send signal is not used, but the necessary hardware is present and may be selected with Lk_1 on the board.

The clock controller consists of an S R latch, IC_{20a} and IC_{20b}, to control the enabl-

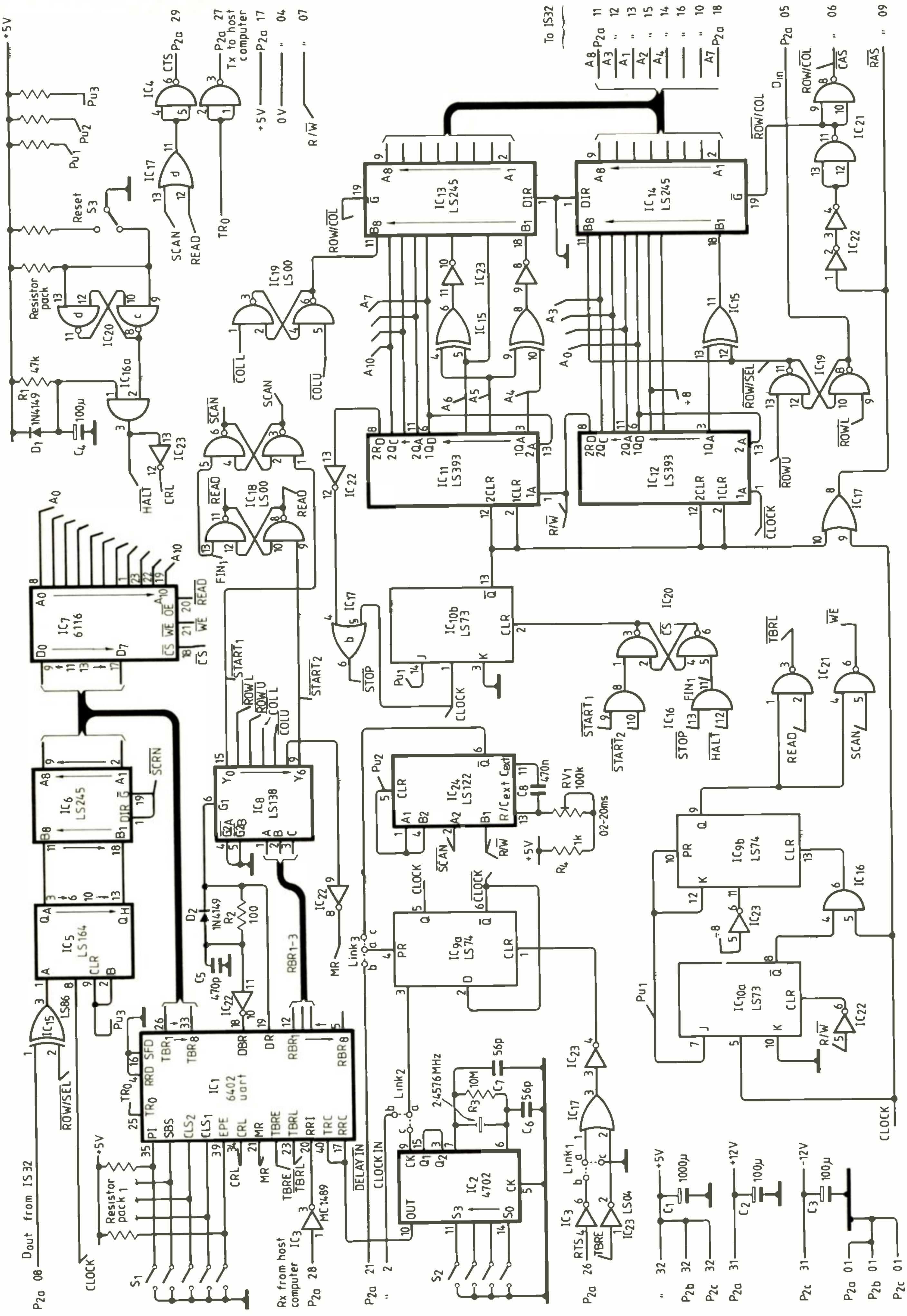


Fig.9 (left). The control circuit accepts commands from the host computer via an RS232 serial link. It returns image data for further processing.

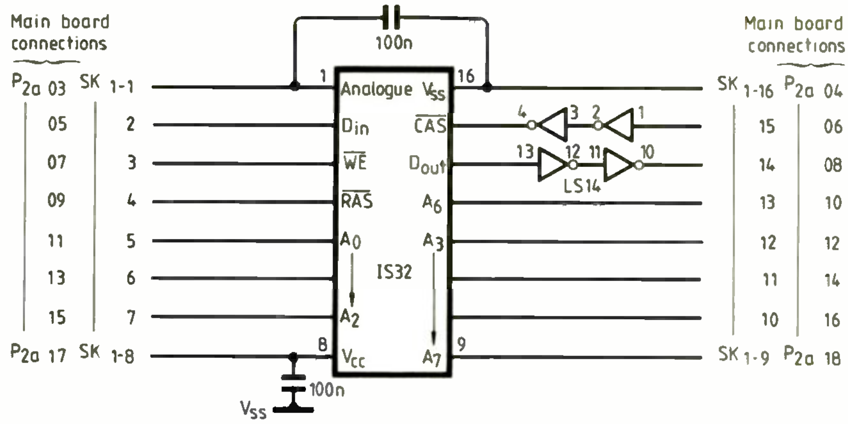


Fig.10 (right). The sensor i.c. is mounted on a separate small p.c.b. which can be accommodated in the optical system.

ing of the address counters and the RAS/CAS generator; the latter is synchronized to the falling edge of the clock by flip-flop IC10b. The RAS and CAS signals are derived from the clock by making use of delays in the associated gates of IC_{21}, IC_{22} and the buffer package on the sensor p.c.b.; they are used by the IS32 to strobe in the row and column addresses respectively. This circuit also produces row and column select signals to control the enable inputs of the octal three-state buffers IC_{13} and IC_{14}, so that they behave as an address multiplexer/buffer.

Row and column addresses for the IS32 are furnished by the two dual four-bit counters IC_{12} and IC_{11}, which are also jointly responsible for providing addresses for the on-board static memory IC_7. Note that the most significant output of each of the counters is not used to provide an address bit to the d-ram, since the m.s.b. of IC_{12} is used as the R/$\overline{W}$ signal. The m.s.b. of IC_{11} is synchronized to the clock by means of IC_{7b} and it then becomes the $\overline{STOP}$ signal, responsible for terminating the scan or read macro-tasks. M.s.bs of the addresses are derived from the row and column select latches, IC_{19}, rather than the counters, to allow quadrant selection by means of the command decoder. Gating by IC_{15} and IC_{23} performs the first stage linearization of the IS32 addresses.

Data retrieved from the sensor during a scan sequence is in the form of a serial bit-stream, whose polarity with respect to dark or light pels at the sensor will depend upon which bank of pels is selected. The exclusive-or gate IC_{15a} in conjunction with $\overline{ROWSEL}$ compensates for this automatically; but it is also necessary to feed $\overline{ROWSEL}$ to the D_{IN} pin of the IS32 to ensure that the photosites are appropriately initialized. The bit-stream is then formatted in bytes by shift register IC_5, whose parallel outputs are presented to the data bus of the byte-wide static ram IC_7, after buffering by IC_6, which is enabled only during the scan sequence to avoid bus clashes with the memory output drivers. A transceiver device was chosen for IC_6 rather than a three-state buffer merely because its straightforward pinout simplified the p.c.b. design.

Since the capacity of the static ram is 2K-bytes, i.e. 16 384 bits, it is capable of storing data from one whole quadrant of the sensor when packed in this manner, which also gives a convenient word length for transmission back to the host during the read sequence.

The delay required for exposing each column of 128 pels is generated by IC_{24}. This monostable is enabled only during the scan sequence, and is triggered by the R/$\overline{W}$ signal which is asserted when the row counter exceeds 127, and which is also used to determine whether initialize (write) or interrogate (read) cycles are performed by the sensor. The output of the monostable is used to inhibit the clock by holding flip-flop IC_{9a} in its preset condition for the duration of the delay. This halts all activity on the board, allowing the photosites to be exposed for a period controlled by the monostable time constant.

Circuitry associated with IC_{9b} and IC_{10a} is required to provide pulses to be used as a byte write-enable ($\overline{WE}$) for the static ram during scan sequences, and as a transmit buffer register load ($\overline{TBRL}$) for the uart during real sequences. These pulses are generated by extracting half a clock pulse after every eight row address counts, and are designated as $\overline{TBRL}$ or $\overline{WE}$ by the gates IC_{21b} and IC_{21a} and IC_{1b}, under the control of the Read and Scan outputs respectively of IC_{18}. The role of IC_{10a} is to prevent the generation of either of these signals when the R/$\overline{W}$ signal is low, and so to avoid both writing to the static ram whilst the IS32 is being initialized and double transmission to the host of each column of pel data.

It is necessary to provide a reset pulse on power-up and under certain other conditions such as a change of status of the uart control register. This signal is generated by the circuitry associated with the manual reset button, S_3; IC_{20c} and IC_{20d} are responsible for de-bouncing the switch. These sources are combined in IC_{16a} whose direct output, called $\overline{HALT}$, is used to initialize the board so that it is awaiting commands from the host, whilst the inverted output CRL is used to load the control register of the uart, thus establishing the protocol in use.

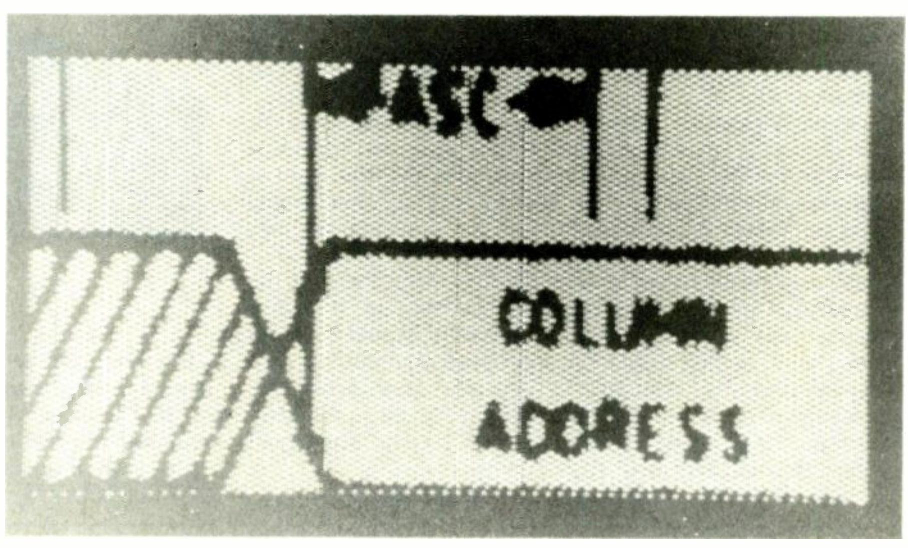
SCAN COMMAND

When a valid Scan command is received via the serial link, and decoded and latched, a number of operations take place.

The CTS signal is negated and the address counters, RAS/CAS generator, exposure delay generator, data-packing shift register, byte-wide buffer and $\overline{WE}$ signal are all enabled. The address counters increment from a cleared state and thus R/$\overline{W}$ is low for the first 128 counts, making the IS32 perform a write cycle to each of 128 logically consecutive rows. This ensures that a column-initialize operation is executed at the currently-addressed column of the sensor bank. When, after 128 states, the row address count returns to zero R/$\overline{W}$ is set high, triggering the exposure delay generator and stopping the clock.

After the delay, the clock is re-started and counting begins once again with the row addresses at zero. However, these addresses are issued to the column of cells which has just been initialized, because the column

Image quality is good enough for many practical applications.



counter has yet to be incremented; but on this pass the 1S32 performs read cycles in response to the high state of the R/W line. Image data retrieved from the sensor in this way is formatted into bytes by the shift register and loaded into the static ram by the WE pulse.

When the row counter is clocked back to zero the column-interrogate operation is complete, R/W returns to zero (i.e. Write) an the column counter is incremented, ready for the entire initialize-expose-interrogate sequence to begin again at the next column of the sensor-bank. This action continues until 128 logically consecutive columns have been accessed. Completion of the last column causes the m.s.b. of IC_{11} to be set, initiating the generation of the Stop signal. This signal terminates the Scan macro-task by resetting the clock-control and command latches, and so asserting CTS and disabling the relevant functional blocks to ensure a tidy exit.

READ COMMAND

On receipt of a valid Read command the CTS signal is once again negated. The address counters are enabled, but this time the data outputs of the static ram are enabled together with TBRL. However, the row address counter increments through 128 states without generating TBRL signals because of the inhibiting action of the low R/W line.

During the next 128 counts R/W is high and a TBRL pulse is produced after every eight counts, when a new address has been set up for the static ram. This pulse causes data from the ram to be loaded into the transmit buffer register of the uart, which responds by negating its transmit buffer register empty (TBRE) signal to prevent another byte being loaded before transmission of the current one is complete. The negated TBRE inhibits the clock until the uart is ready to send more data, which it will indicate by asserting TBRE, thus allowing the clock to re-start. Eight clock periods later the next static ram address will be set up, TBRL will be generated and the next byte of data transmitted. In this way each 256-count pass of the row address counter, which is actually now being used to provide the four low-order bits of the static ram address, causes sixteen bytes of image data to be transmitted back to the host. Thus all 2048 bytes will have been transferred when the column address counter has been through its 128 states. As before, the m.s.b. of IC_{11} initiates the Stop signal to terminate the Read macro-task and ensure an orderly exit.

To be continued with a description of driver software for the interface.

Hugh Pocock

We are sad to report the breaking of a personal link with the earliest days of this journal. Hugh S. Pocock, editor of *The Wireless World* from 1920 to 1941, then managing editor of its publishing company, died in March this year at the age of 92. He had retired in 1962.

As a later editor once commented, "To him, more than any other one person, must go the credit for the development of *Wireless World*, both in its formative years and in its later growth." He became fascinated by radio from the very beginning, while still in his 'teens and not yet launched in a career. He was born in 1894, only six years after Hertz demonstrated the existence of electromagnetic waves and three years before Thomson discovered the fundamental properties of the electron. It was a time when, for example, Lodge and Marconi were developing Branly's coherer as a detector for receivers.

Pocock's long career in radio journalism started in 1913, when, already the holder of an Experimental Wireless licence, he joined *The Wireless World* as an editorial assistant. The journal was then owned by the Marconi Company and had just been broadened in scope and re-named after its previous existence as *The Marconigraph*. But war broke out in 1914 and Pocock became an officer in the Royal Engineers, with wireless and intelligence duties at home and overseas. He was mentioned in despatches. In 1920, while stationed in Baghdad, he received an invitation to re-join the journal as editor and promptly accepted.

During the early 'twenties he was very active in organizing the first short-wave transatlantic tests, both amateur and broadcasting. Then in 1924 he guided the journal into the new world of independent publishing, when Marconi sold its troublesome offspring (which had been attacking one of the firm's own customers, the Post Office) to Iliffe & Sons Ltd.

As a result of his experience with the short-wave trials, and the pioneering work of the amateur Gerald Marcuse on 30 metres, Pocock proposed that short-wave broadcasting should be set up throughout the then British Empire. Initially the BBC opposed the idea, but he managed to persuade John Reith, the director-general, and in 1932 the Empire Service was started. Subsequently it became the BBC's General Overseas Service and is now the World Service.

Hugh Shellshear Pocock was liked and respected by everyone.

He was reticent by nature but had a most charming smile and always radiated a quiet courtesy. One felt he somehow belonged to that era when publishing was being accepted as 'a career suitable for a gentleman.' But Hugh's good manners came from deep down in his nature, and he was a gentleman in the truest sense of that word.

Using 68020 coprocessors

In robotics applications using a 68020 with a floating-point coprocessor can result in a polar-to-Cartesian translation in just three instructions.

DAVID BURNS AND DAVID JONES

Coprocessors are intelligent peripheral devices that are coupled to the main processor to give added functions. There are currently three 68000 family coprocesors; the 68851 paged memory-management unit, the 68881 floating-point unit and a newly announced 68882 enhanced floating-point unit. These coprocessors are easily interfaced to all 68000 family processors.

Having the 68020 as the main processor is a considerable advantage since the coprocessor interface protocol is used to transfer instructions and data between devices. As far as the programmer is concerned adding coprocessors just increases the processor's programming register set.

FLOATING-POINT COPROCESSOR

The 68881 floating-point coprocessor fully complies with IEEE P754 floating-point specifications and handles a range of trigonometric and transcendental functions. This coprocessor is tightly coupled with the 68020 and the programmer need not be aware that the devices are separate chips.

Internally the HCMOS 68881 has eight general purpose registers for 32bit single, 64bit double and 80bit extended precision values.

The coprocessor concept means that the instruction set, data types, and addressing modes of the 68881 are a logical extension of the 68000 family architecture, Fig.1. The coprocessor interface allows the 68020 and 68881 to share tasks; for example the 68020 will perform effective-address calculations and then fetch the data and pass it to the 68881. This means that the 68881 can make full use of all 68020 addressing modes.

Standard bus cycles are used for the coprocessor interface so the 68881 can be interfaced as a standard peripheral (68000 systems) or used in a 68020 system with multiple coprocessors. Because of the standard interface, coprocessors are not tied to any particular processor; a new processor will not require a new coprocessor and a new coprocessor will not require a new processor.

Seven data types can be used with the 68881; byte integer, word integer, long-word integer (32bit), single-precision binary real (32bit), double-precision binary real (64bit) extended-precision binary real

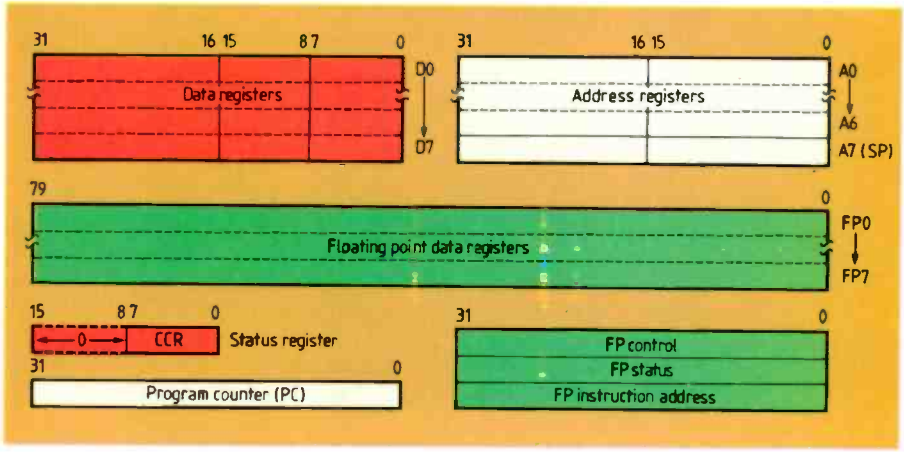


Fig.1. Combining the 68020 and 68881 over the coprocessor interface gives the programmer a larger register set to program with. Software is written as though the registers are all part of one device.

Fig.2. The 68881 floating-point coprocessor handles seven data types in a variety of data forms and floating-point standards.

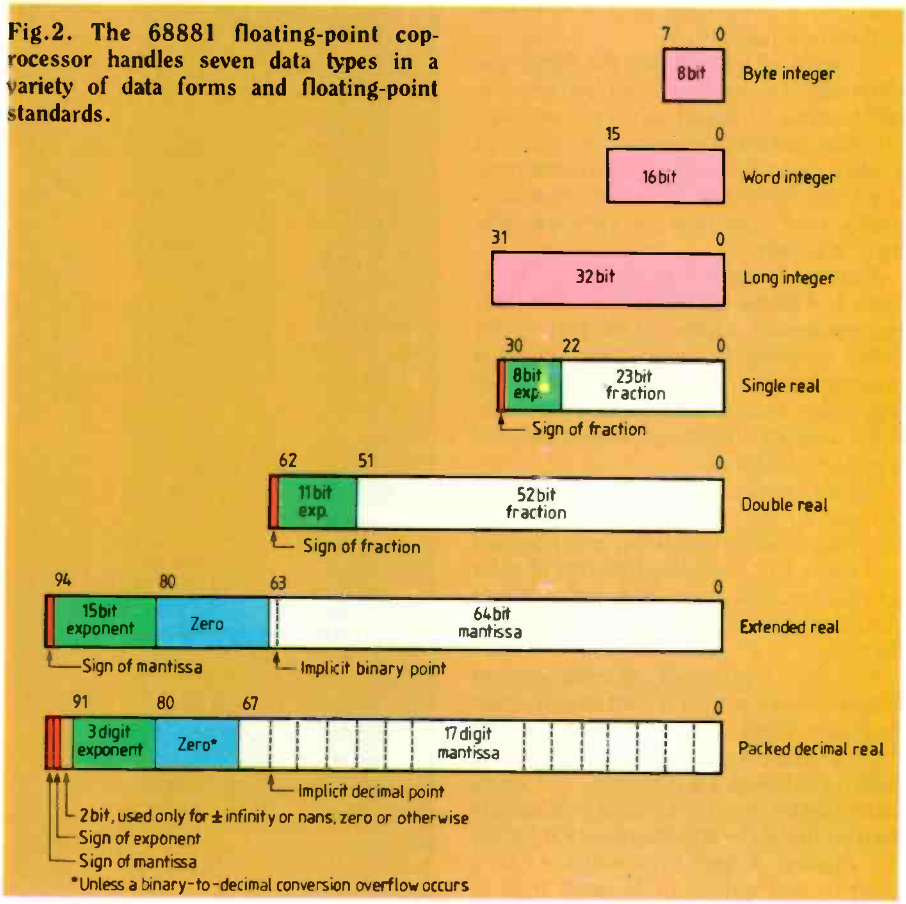
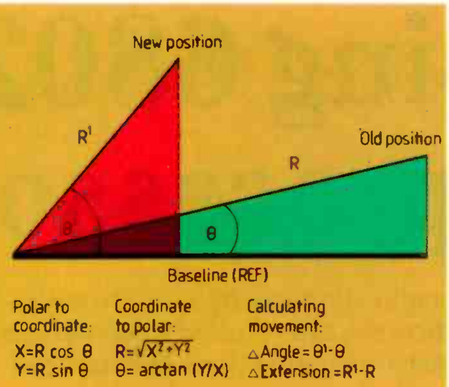


Fig.3. Robot control involves calculating positions using trigonometrical functions. This example shows how to determine angular difference between current elbow position and required position, then instruct the robot to move the elbow. Polar to Cartesian translation takes 29µsec. (Three instructions) and Cartesian to polar translation takes 39µsec. (six instructions).




```
GET POSITION  FSINCOS.S  RBOT-THETA,FP0,FP1   Calculate X/Y coordinates
              FMUL.S     RBOT-R,FP0
              FMUL.S     RBOT-R,FP1
              •                               Display current position and get new
              •                               position in FP0/FP1
              •
              FMUL.X     FP2,FP2              Calculate new R
              FMUL.X     FP3,FP3              (R=√(X²+Y²))
              FADD.X     FP2,FP3

              FSQRT.X    FP3

              FDIV.X     FP0,FP1              Calculate new Θ
              FATAN      FP1                  (Θ=arctan(Y/X))

              FSUB.S     RBOT-R,FP3           Calculate ΔR
              FSUB.S     RBOT-THETA,FP1       Calculate ΔΘ
```

(80bit), and packed-decimal real string (96bit), Fig.2. All internal operations are performed in full extended precision, signed integer operands being converted to extended precision values before the specified operation is performed. Thus mixed-mode arithmetic is possible.

In terms of instructions the 68881 has arithmetic, trigonometric and transcendental functions. All functions operate to 80-bit precision internally which is equivalent to a 17-digit decimal mantissa. An internal constant rom contains some of the more commonly used mathematical constants like ln(2), e, pi, zero.

Transcendental functions are shown in Table 1. With the coprocessor concept these transcendentals appear to be part of the 68020 assembly language. This simplifies programming at assembly-language level and makes mathematics routines in high-level languages easier to implement and much more efficient.

Figure 3 shows how useful 68881 instruction set is. The aim of the example is to calculate the difference between the old and new robot-arm positions, in terms of polar coordinates, and then change that into a change of angle and change of extension on the arm.

The first three lines of code convert coordinates from polar to Cartesian in order to display them. This conversion requires the sine and cosine of the arm's old angle; these calculations are performed in a single instruction – FSINCOS. Obtianed values are then multiplied by arm extension R to obtain the existing X and Y coordinates. In a robot-control system, these would then be displayed as a prompt for a new set of Cartesian coordinates.

When these new coordinates are obtained they are changed into polar form so that the change in angle and change in arm extension can be derived. Conversion involves squaring the X and Y coordinate inputs and then taking the square root of the sum. Obtaining the square simply involves multiplying the register value by itself (FMUL.X FP2,FP2); the square root of the sum can be obtained by using the square root instruction. This value is now the new arm extension and is contained in floating point register FP3.

The arctangent of ratio X/Y gives the new arm angle which is contained in floating-point register FP1. Differences between the old angle and extension (RBOT-THETA and RBOT-R) and the new ones (FP1 and FP3) can now be obtained by subtraction in order to determine the changes required in the arm to reach the new X, Y coordinates. Using these techniques, complex calculations and control systems can be implemented.

REMOVING BOTTLENECKS

Analysis of code written for the MC68881 showed that a number of bottlenecks occur with the coprocessor dialogue. It was found that the 68881 would be busy for a large portion of the time, often performing tasks which did not use the full power of the 67bit arithmetic and logic unit (a.l.u.).

An example of this is conversion of single or double-precision numbers to extended-precision real numbers (all internal operations on data are performed with extended-precision real numbers). The 68882 was designed to alleviate these bottlenecks and so obtain a noticeable performance improvement over the 68881.

To gain this improvement three hardware features were added to the 68882. Firstly special hardware conversion logic was included to allow conversions between single/double-precision real numbers and extended precision real numbers without using the main a.l.u. A finite state machine (the communication-dialogue sequencer) was also added to sequence instructions. This allows the processor to transfer the next opcode before the previous instruction has finished execution. Finally, the existing 80bit internal registers were given dual ports to allow simultaneous access to registers from both the new conversion hardware and the existing execution unit.

Figure 4 shows that the coprocessor divides into four main sections. The bus-interface-unit contains all the logic and coprocessor-interface registers required for communication with an external processor. Associated with the response interface register is a response program-logic array containing all coprocessor response primitives required for dialogue with the main processor. When the 68020 is the main processor, coprocessor dialogue is transparent to the user. The bus-interface unit also contains select logic for the coprocessor interface registers and DSACK control logic.

Operation of the whole 68882 is controlled by the microcode control unit. The clock

Table 1. Operations performed by the 68881 floating-point coprocessor

Transcendental instructions

Mnemonic	Function
FSIN	Sine
FASIN	Arc sine
FSINH	Hyperbolic sine
FCOS	Cosine
FACOS	Arc cosine
FCOSH	Hyperbolic cosine
FSINCOS	Simultaneous sine/cosine
FTAN	Tangent
FTANH	Hyperbolic tangent
FATAN	Arc tangent
FATANH	Hyprbolic arc tangent
FETOX	e to the power x
FETOXM1	e to the power x−1
FTENTOX	10 to the power x
FTWOTOX	2 to the power x
FLOG10	Logarithm base 10
FLOG2	Logarithm base 2
FLOGN	Logarithm base e
FLOGNP1	Logarithm base e of x+1

Main arithmetic instructions

Mnemonic	Function
FADD	Add
FSUB	Subtract
FINT	Take integer part
FNEG	Negate
FNOP	No operation (sync.)
FSQRT	Square root
FGETMAN	Return mantissa
FTST	Test the operand
FGETEXP	Return exponent
FCMP	Compare
FMUL	Multiply
FDIV	Divide
FMOD	Modulo
FREM	Remainder
FSCALE	Scale exponent
FSGLMUL	Single prec. multiply
FSGLDIV	Single prec. divide

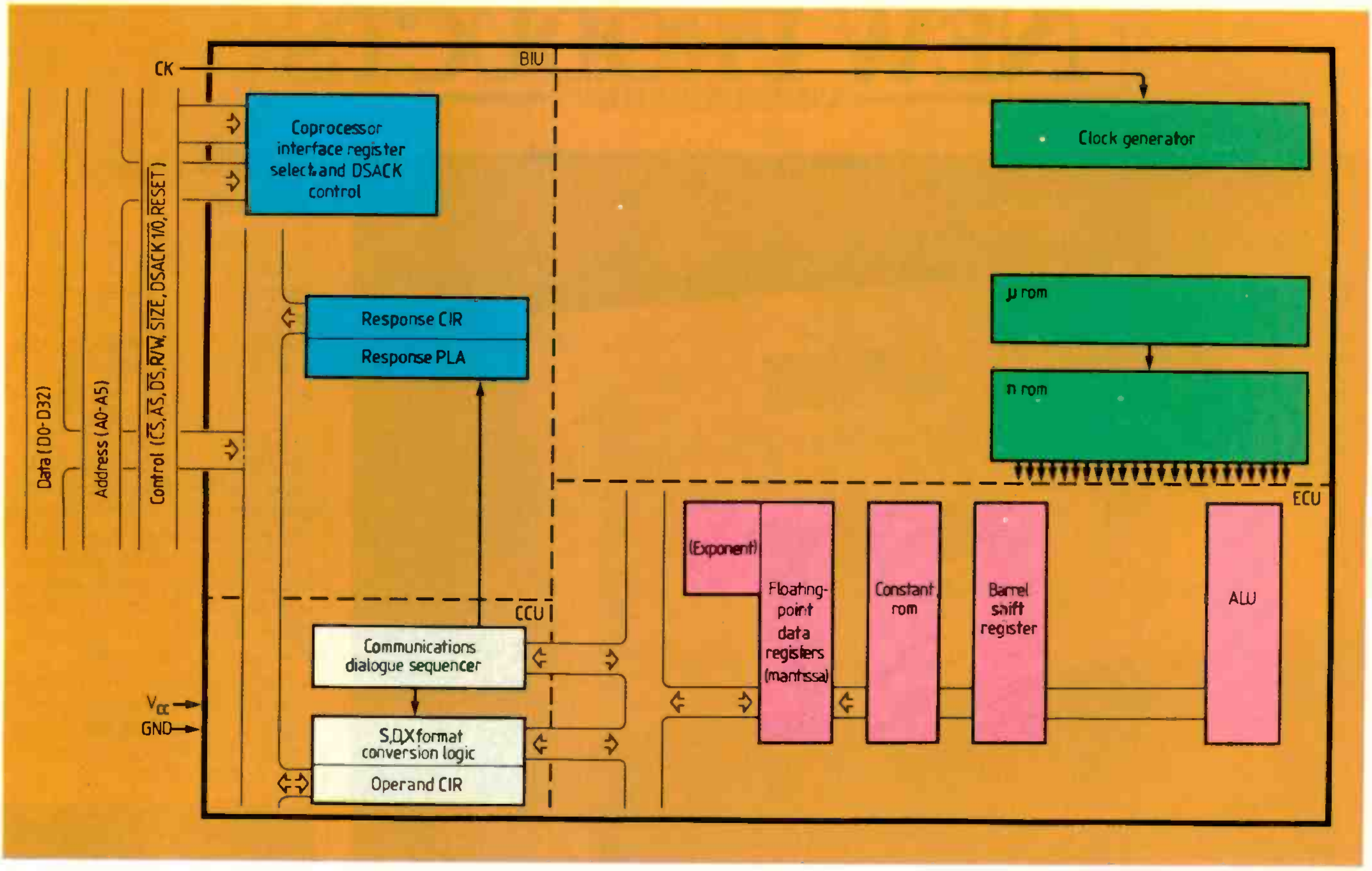


Fig.4. The MC68882 can be considered as being made up of four separate units; the bus-interface unit, the microcode-control unit, the execution-control unit and the conversion-control unit.

signal is fed into this section and control signals are generated from the microrom and nanorom* to control data movements throughout the various sections.

All the floating-point calculations are performed by the execution control unit. It contains the 67bit a.l.u., a 67bit barrell shift register, a scientific and mathematical constant rom and the eight floating point registers.

A new section of logic called the conversion-control unit has been added to the 68882. Logic required to do simple conversion between single/double-precision real numbers and extended real numbers is contained in this control unit as are the operand interface register and communication dialogue sequencer.

To understand how each of these features improves performance consider this code sequence:

FMUL.D <EA>,FP4

FMOVE.X FP1,FP2

EA = effective address and

FP1,FP2,FP3 = floating-point registers 1, 2 and 3

This code performs a floating-point multiplication between the double-precision value contained at effective address <EA> and the contents of floating-point register FP4 and puts the result in FP4. Next is a

* For each microcode instruction there is a nanorom output which feeds the execution unit. Nanorom contains information relating to the configuration of the execution unit for the microcode instruction currently under execution.

X(i) = (A • B(i)) + (C • D(i)) + (E • F(i)) + (G • H(i))

			Clocks '881	Clocks '882
	FMOVE.D	<eaA>,FP0		
	FMOVE.D	<eaC>,FP1		
	FMOVE.D	<eaE>,FP2		
	FMOVE.D	<eaG>,FP3		
LOOPST	FMOVE.X	FP0,FP4	33	21
	FMUL.D	<eaB>,FP4	102	100
	FMOVE.X	FP1,FP5	33	0
	FMUL.D	<eaD>,FP5	102	72
	FADD.X	FP4,FP5	53	40
	FMOVE.X	FP2,FP6	33	0
	FMUL.D	<eaF>,FP6	102	92
	FADD.X	FP5,FP6	53	40
	FMOVE.X	FP3,FP7	33	0
	FMUL.D	<eaH>,FP7	102	92
	FADD.X	FP6,FP7	53	40
	FMOVE.D	FP7,<eaX>	86	55
	BRA	LOOPST		
Total Clocks:			785	552
Performance Ratio			1.0	1.4

Fig.5. Due to the new 68882 hardware features all instructions execute slightly faster. In addition, FMOVE X, FPX and FP instructions execute instantaneously as they are now completely hidden by the execution time of the floating-point multiplication instructions.

floating-point move instruction carried out on an extended-precision data value which moves a floating point value from FP1 to FP2.

In the 68882 the operand is written to the operand interface registers and immediately a data conversion is performed by the conversion-control unit to transform the double precision value into an extended-precision number. With the earlier 68881 the processor is told to wait while this operand is routed through the execution-control unit and the a.l.u. performs the conversion. Next the 68882 performs the actual floating-point multiplication.

The communication diagloue sequencer can request the next opcode (input into the response interface registers causes a repeat primitive to be sent to the processor) so the FMOVE.X instruction is fetched. The 68881 does not have this capability and informs the processor to wait unitl the FMUL has executed (a busy primitive is sent from the response interface registers to the processor).

Since the register set has dual ports and the move instruction is executed on registers that are not being used by the multiply instruction, the move instruction can execute at the same time as the multiply instruction. Multiply instructions take a lot longer to execute than move instructions hence fetching and execution of the move instruction are hidden by the multiply instruction and so in effect the move instruction excecutes instantaneosly. This was a bottleneck with the 68881 as the registers are not dual ported.

Code sequence in Fig.5 shows the performance gain by plugging in an 68882 into a 68881 system. The example shows hidden execution time of the FMOVE instruction for this iterative calculation. Improvements of greater than twice that of the 68881 can be achieved if the code is optimized to take full advantage of the 68882 conversion-control unit.

Memory-management coprocessing is discussed in the next article.

David Burns and David Jones are applications engineers at Motorola's East Kilbride plant.

NEW PRODUCTS
COMMUNICATIONS

Communications monitor

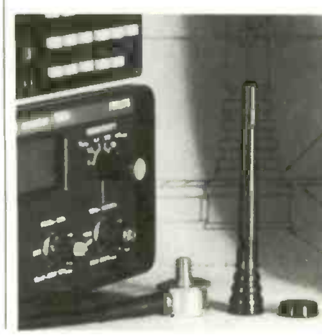
An RS232 breakout box and asynchronous data monitor is provided by the Miniscope from Componedex. When inserted into a communications line it can monitor and capture all the data present.

The instrument has a 32-character l.c.d. to review the data: half each for the transmit and receive lines. An additional display will indicate the state of the sixteen RS232 signals, show the floating and negative lines and indicate 'pulse' or 'glitch'. All control characters are displayed as symbols.

Patching is provided by 24 switches and there are sockets for all 25 signals. Believed to be the world's smallest communications monitor, the Miniscope is claimed to provide easier access to asynchronous protocol analysis. Componedex Ltd, 21 Alston Drive, Bradwell Abbey, Milton Keynes MK13 9HA. Tel: 0908 322177.

Cellular radio antenna

A roof-mounted car antenna for cellular radio telephones has won its designer a British Design Award. Only 89mm long, the Cellmaster antenna offers a 70MHz bandwidth, from 890 to 960MHz. It is machined from solid aluminium and brass and is anodized to a black finish. Although intended for roof mounting, Cellmaster is so small that it could be incorporated into a wing mirror. The screw fitting can be replaced by magnetic mount for portability. Les Wallen, the designer, was a marine engineer and radio ham who became interested in antennas when CB radio became legal and now runs his own company, manufacturing antenna for all types of mobile radio communications. Les Wallen Manufacturing Ltd, Unit 1, Trinity Place, Ramsgate, Kent CT11 7HJ. Tel: 0843 582864.



NEXT MONTH

Document management system, based on an optical disc, offers powerful indexing to link any number of documents, as well as giving near instant access to the equivalent of many hundreds of filing cabinets.

Image processing algorithms suitable for many applications in security, character recognition and robotics form the concluding part of the series describing a low-cost alternative to a tv camera.

Pioneers takes up Lord Kelvin: 'When you can measure what you're talking about and express it in numbers, you know something about it.'

Noise factor or noise figure? 'Joules Watt' explains the difference, and shows why h.f. operation is 'environment-limited' and v.h.f. is 'equipment-limited'.

Serial eprom programmer. How to design an eprom programmer that requires no processor, no firmware, and no memory.

High resolution graphics: programming the new 82716 display chip that can produce pictures like that on our front cover.

Rechargeable lithium cells – a report on one of the most exciting recent developments from the world of electrochemical power sources.

NEW PRODUCTS
TEST & MEASUREMENT

Pulse generator with 125MHz

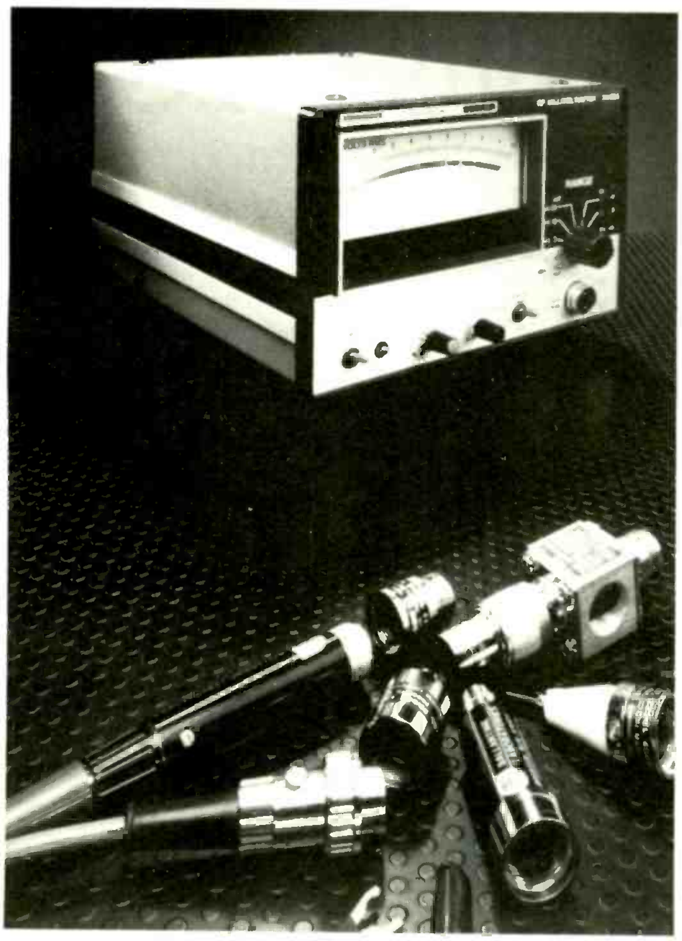
Particularly suitable for high-speed t.t.l. and e.c.l. circuit testing, the Philips PM5786 is a dual-output, variable rise and fall-time pulse generator. With a bipolar output mode and a four-range output attenuator, the generator is also useful in testing analogue circuits. The generator offers bipolar, positive or negative pulses in a complementary or simultaneous pair of outputs. Easy selection of pulse type eliminates the need for adjustments of the offset and inverter controls. A switch reverses the polarity of the pulses, allowing a change in logic level without having to change cables.

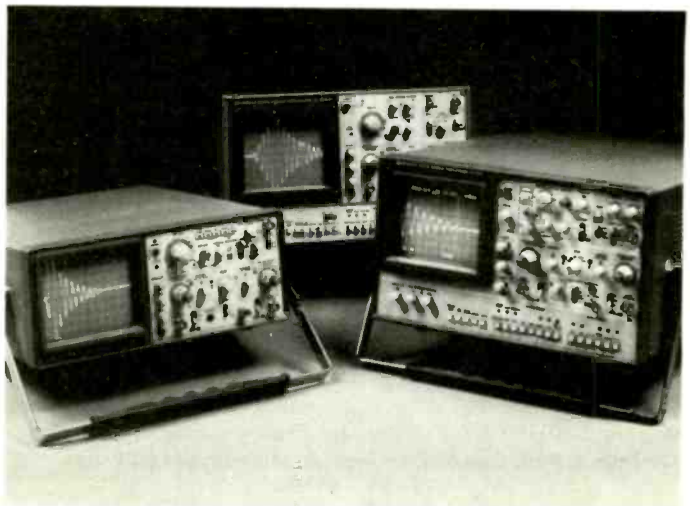
Other features of the PM5786 include an external input which provides a number of external control facilities such as triggering, gate, burst, duration, and square wave. The external control signal defines the start and duration of the various control facilities. Start/stop conditions can be adjusted with the positive or negative-going slope selection and the ±3V trigger level controls. Available from Electronic Brokers Ltd, 140-146 Camden Street, London NW1 9PB. Tel: 01-267 7070.

Millivoltmeter for high frequencies

Signals over the frequency range 10kHz to 1.2GHz are measured in eight ranges from 1mV to 3V (full-scale) on the Ballantine 3440A r.f. millivoltmeter. The instrument is suitable for field or lab. measurement and is designed to withstand hostile r.f. environments, vibration and shock. Reliability is enhanced by using a solid-state, chopper-stabilized amplifier which reduces audible noise to zero. The probe incorporates a self-regulating heater to keep the detector diodes at a constant temperature, eliminating calibration errors caused by variations in temperatures.

Up to 30mV, response is true-r.m.s., permitting accurate calibration of non-sinusoidal waves. Above that, peak-to-peak linear readings are taken, though an analogue 'curve matching' circuit ensures a linear meter response in the higher ranges. The instrument's ranges can be programmed by t.t.l. or through an optional GPIB link. PPM Instruments Ltd, Hermitage Road, St. Johns, Woking, Surrey GU21 1TZ. Tel: 04867 80111.





GPIB digital oscilloscopes

The newly-expanded range of Hitachi digital storage oscilloscopes features GPIB interfaces on every model.

The range starts with the VC6020 which has a real-time bandwidth of 20MHz and includes two 1MHz a-to-d converters to provide simultaneous, dual-channel storage of single-shot or repetitive waveforms. For very low speed events a 'roll' mode is provided which makes the screen act like a chart recorder, with new data being written onto the right-hand side of the screen while the old data scrolls off the left. An analogue plotter output allows stored data to be plotted using an x-y or y-t pen plotter. The GPIB interface enables waveform data to be transferred to or from a computer, enabling its use in a.t.e. systems.

The VC6041Z has a maximum sampling speed of 40MHz and a memory length of 4K words per channel. For single-shot events the VC6041Z can capture waveforms up to 10MHz (at 4 samples per cycle), whilst repetitive waveforms of up to 40MHz can be captured with a resolution of 0.25ns (100 samples per cycle). Two separate 4K word stores are available as reference memories independently of the acquisition memories, enabling four waveforms to be held simultaneously. Other features include fully variable pre-trigger, digital averaging, and waveform magnification up to one hundred times.

The new VC6050 adds to the features of the VC6041Z, full dual timebases and a cursor measurement system that gives on-screen readout of voltage, time and equivalent frequency. Repetitive waveforms of up to 60MHz can be captured via the high-speed sample-and-hold digitizers which provide an equivalent sampling speed of 8GHz. Available through Thurlby Electronics Ltd, New Road, St. Ives, Huntingdon, Cambs. PE17 4BG. Tel: 0480 63570.

Data acquisition and control

A larger version of their ADU range of measurement and control modules has been produced by Mowlem Microsystems. The ADU 800 can accept up to 128 analogue or 256 digital inputs, and has a networking capability allowing up to 72 units to work together, giving access to a virtually unlimited number of channels.

The units have a choice of plug-in modules to provide direct input from a variety of transducers, including strain gauges, thermocouples and pressure sensors. The outputs are similarly varied and include closed-loop servo and stepper motor controls, as well as analogue and digital signal outputs.

Onboard processing allows the unit to monitor all logging or control operations itself, with readings stored in a battery-backed memory. A host computer is used to set up an operation, but is then free for any other use. Systems can be configured to commence their tasks automatically without intervention from a computer or even an operator.

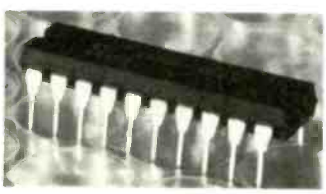
The ADU800 can work any computer that has RS232 or GPIB interfaces. Software, called Dialog, allows full use of the system without any need for programming. It provides all the facilities necessary to configure logging and control sequences, as well as displaying or plotting real-time graphs, data processing and links into standard computer data management packages such as Lotus 1-2-3, Supercalc etc. Mowlem Microsystems Ltd, Eastman Way, Hemel Hempstead, Herts HP2 7HB. Tel: 0442 218444.

Overhead computer view

A means of allowing several people at once to view a computer screen is provided by the Davis Transview, a thin transparent liquid crystal display which will fit onto an overhead projector and allow the image to be projected onto a screen. The l.c.d. module replaces the monitor and graphics adaptor in an IBM XT or AT (or clone) and offers the same resolution when displaying word processors, spreadsheets, pictures and the like. Further information from Engberg (UK) Ltd, PO Box 33, Basingstoke, RG21 3JB. Tel: 0256 24299.

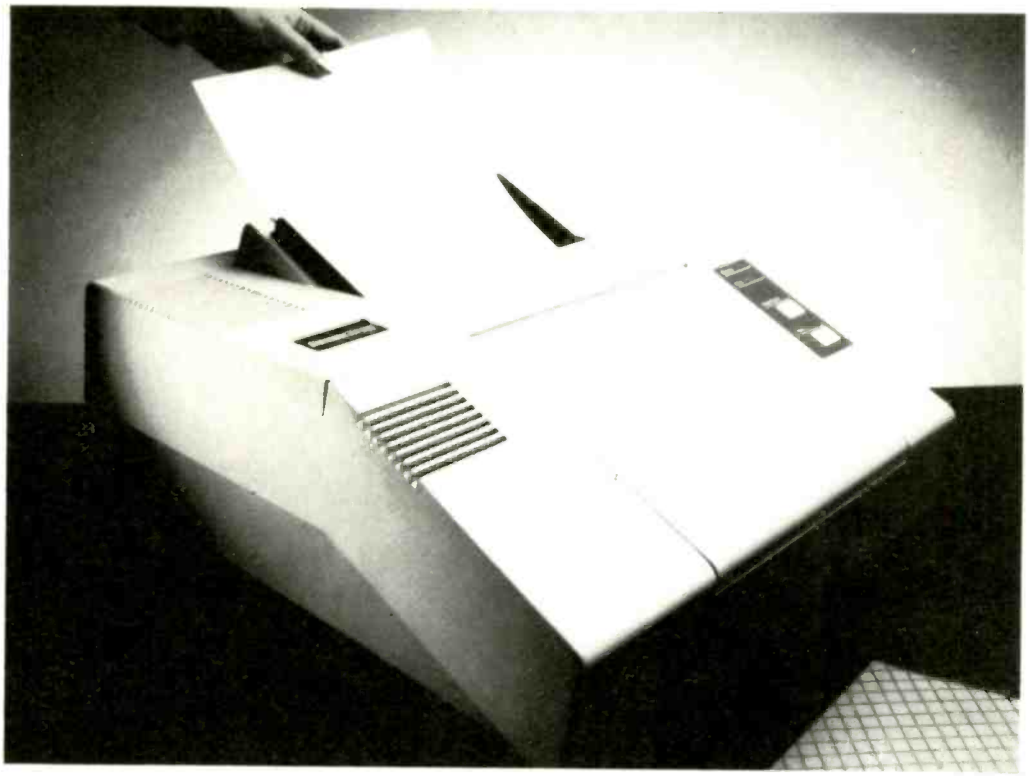
Programmable logic

An integrated circuit from Mullard can be configured to be pin-compatible with 19 different standard logic devices. PLS153 has 42 AND-gates and 10 OR-gates with fusible link connections for programming signal direction and polarity. The device can be programmed using standard equipment, but those without a programmer can have it done for them by the distributor, Gothic Crellon, who can also offer design and application support. The i.c. is one of a number of programmable logic devices and can be used as a function generator, fault detector, code converter or in such applications as address mapping, random logic and multiplexing. Gothic Crellon Ltd, 3 The Business Centre, Molly Millars Lane, Wokingham, Berks RG11 2EY. Tel: 0734 788878.



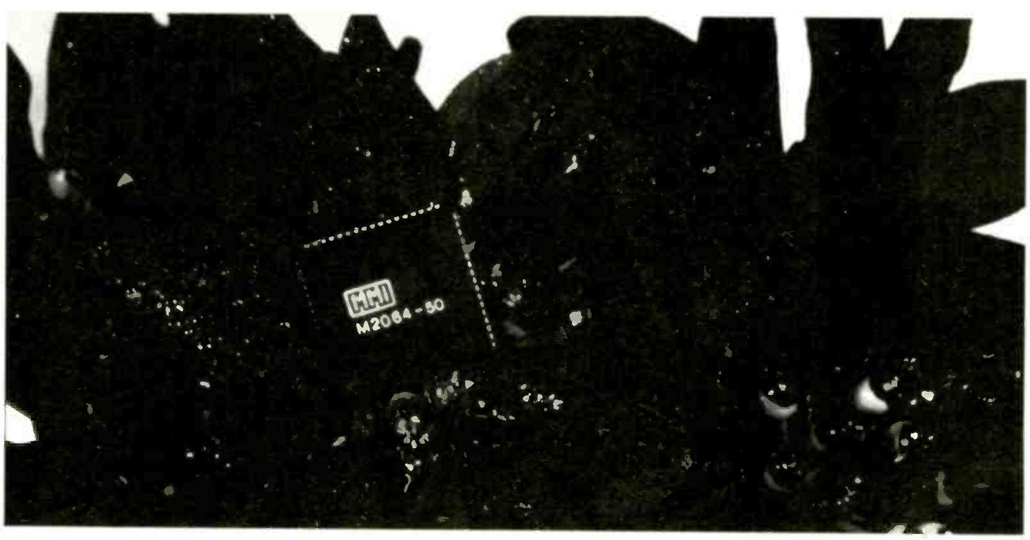
Eeprom and eprom combined

A high-density, non-volatile, electrically eraseable, programmable read-only memory has the additional ability to be completely erased in 20s. This makes the Seeq 48128 especially suitable for applications with infrequent updates, such as program storage. The read cycle is 200ns, and the write time of 2ms/byte is claimed to be five times faster than in other eeproms. The 28-pin d.i.l. package is pin-compatible with the 27128 eprom. Available from ITT MULTIcomponents Ltd, 346 Edinburgh Avenue, Slough, Berks, SL1 4TU. Tel: 0753 824212.



Document scanner

An optical character reader can enter text into a computer at up to 600 words per minute. Pages can be stacked into the loading tray and the scanner will read them at the rate of about a page every 30 seconds. It is thought to be especially useful for communications by telex or electronic mail and for typesetting. The Compuscan PCS can recognise all popular type faces and it can automatically accommodate different page sizes, margins, type styles and line spacing as well as justified or unjustified text. The scanner communicates through an RS232 interface and is available in three versions for use with dedicated word processors or IBM-compatible PCs. The third version adds image scanning to the IBM-compatible device. Kendata Peripherals, Nutsey Lane, Totton, Southampton SO4 3NB. Tel: 0702 869922.



Logic cell array

Claimed to bridge the gap between field-programmable logic and gate-array i.cs, the M2064 from Monolithic Memories offers user-programming with the gate density usually associated with gate arrays.

The cell array has an internal structure similar to that of a gate array with a matrix of 64 configurable logic blocks surrounded by a ring of i/o interface circuits. An interconnect program is used to define the overall device.

The M2064 is the first of a family of such devices which will have different switching speeds, up to 50MHz. It incorporates several features to monitor its configuration including a verification progranrand the reading back or complete resetting of its register contents. Monolithic can also provide a comprehensive software development package which includes a configuration development system, simulation, in-circuit simulation and an in-circuit emulation pod for connecting to a target system. Monolithic Memories Ltd, 1 Queens Road, Farnborough, Hants GU14 6DJ. Tel: 0252 517431.

WARC-87: a few steps on

A cut-off date for d.s.b. is among the proposals agreed by the Geneva h.f. broadcasting conference

D.P. LEGGATT

The second session of WARC-HFBC occupied five weeks during February and March 1987. It was held in the International Conference Centre in Geneva and 131 International Telecommunication Union member states participated. Very few delegations comprised fewer than two people and most were a good deal larger, so the total attendance was over 500.

Seven committees were formed to progress the work, the most significant being Committee 4 (technical), Committee 5 (planning method and associated procedures) and Committee 6 (regulatory matters).

Technical matters, although often quite complex, were dealt with in timely fashion and Committee 4 finished its work according to schedule. But agreement on planning matters was far more difficult to achieve and Committee 5 ran seriously late, to the extent that the conference finishing date had to be delayed from the intended March 6th to Sunday March 8th. Only by working until around midnight during most of the final week (and to 2 a.m. on the last night) was the conference able to finish with Final Acts to show for its five weeks of work.

MAIN RESULTS

Technical criteria were agreed in a number of important areas including transmitting antennas; propagation prediction procedures; measures of reception quality and interference protection ratios; double sideband and single sideband transmission parameters; and the technical standards to be used in further development of the IFRB planning systems.

Not many countries favoured the IFRB's proposed planning system*. It was soon agreed that no system could be accepted which left any broadcasting requirements without an assigned frequency, or which involved frequency changes or time breaks within a requirement, or which offered an interference protection ratio less than the accepted minimum usable value of 17dB.

Accordingly, much discussion was devoted to how the system could be improved. Agreement was not easy to achieve. In broad terms, some Arab and African countries, with India and Pakistan, favoured immediate application of an improved planning system; the South Americans were anxious to exclude their domestic h.f. broadcasting services from any planning limitations; and the larger international broadcasters wished to ensure that any revised system would be thoroughly tested and proved acceptable before being put into effect. Largely through the energetic chairmanship of Committee 5 by the representative of Senegal, a compromise package was finally agreed.

A future WARC would consider implementing an improved planning system (i.e. with frequency assignments produced by the IFRB computer system), to be applied in specified parts of the h.f. broadcasting bands.

- There would be no frequency changes or time breaks within a given requirement, apart from any frequency changes necessitated by propagation considerations.
- Interference protection ratios should be progressively reduced in congested hours, as necessary, down to a value of 17dB.
- If congestion still persists, some of the erstwhile 'suspension rules' should be applied as 'transfer rules' to move a number of requirements to the parts of the h.f. bands subject to consultation procedures under the improved Article 17. Requirements would be transferred in this way to the point where each country had at least one requirement left in the parts of the bands covered by the planning system, irrespective of the extent to which interference protection ratios had had to be reduced to achieve this. However any country whose requirement were offered protection less than 17dB might request that their requirements be transferred for treatment under the improved Article 17.
- When initially registering its requirements, a country might nominate those which it wished to have dealt with under this planning system and those which were to be included *ab initio* in the improved Article 17 procedures.

* Deciding h.f. radio's future, by D.P. Leggatt. *Electronics & Wireless World*, February 1987.

AN IMPROVED ARTICLE 17

Consultation procedures currently set out in Article 17 are to be improved. The main improvement will stem from application of the recently developed computer programs, so that the IFRB will be able to give each country a more precise indication of incompatibilities between its requirements and those of other countries; and to offer more specific advice as to what changes could be made to the requirements to reduce or eliminate the incompatibilities.

It is proposed that the improved planning system be applied to the extension bands agreed by a WARC in 1979 plus some parts of the currently-used h.f. broadcasting bands. These extensions are being vacated by existing non-broadcasting users and were intended to come into use for broadcasting in 1989, or 1994 in the case of the 9MHz band.

The improved planning system will require thorough testing and will be brought into use only when accepted as satisfactory by a future WARC. The IFRB will need two to three years to develop and test this new system, and it is therefore recommended that a further WARC be convened not later 1992 to consider the results and, if they are found satisfactory, to set a date for introduction of the system together with the improved Article 17 consultation procedures.

To avoid premature establishment of unplanned broadcasting services in the extension bands, it was resolved that they shall become available for broadcasting only from a date to be set by the future WARC, rather than from 1989 or 1994 as suggested hitherto.

OTHER IMPROVEMENTS

The conference recognized that improved planning and consultation procedures may lessen congestion but cannot be expected to eliminate it. Several other improvements were accordingly agreed:

- It was recommended that a future WARC be empowered to consider the possibility of further extending the h.f. spectrum allocated to broadcasting.
- The conference recommended an immediate start to the transition from d.s.b. to s.s.b. broadcast transmissions. The date for final cessation of d.s.b. broadcasts is set as the year 2015 subject to review by a future WARC.
- Continuing study of the development of low cost s.s.b. receivers is recommended, as is the provision of sets with digital frequency display.
- All countries are urged to avoid "causing harmful interference" [jamming]. The conference recommended periodic monitoring of such interference and publication of the results.

DOMESTIC SERVICES ON H.F.

Countries using h.f. for domestic broadcasting, notably in South America, require uninterrupted use of specific frequencies year in and year out. These countries strongly resisted any constraints that a planning system might imply and made representations throughout the Conference that domestic h.f. broadcasting be excluded from the planning system.

It proved impossible to secure general agreement on this point, many delegates citing one of the planning principles agreed at the 1984 first session, that 'all the broadcasting requirements, national and international, shall be treated on an equal basis, with due consideration of the differences between two kinds of broadcasting requirements'. Finally it was decided that the question must be left for the future WARC to settle.

The conference urged that broadcasting stations operating in the 7000-7100kHz amateur band cease such operation immediately.

THE FUTURE

Decisions on the exact nature and application of an h.f. planning system have effectively been postponed for some years until the proposed future WARC: in the meantime h.f. broadcasting is to continue under the existing regime.

Recommendations of 1987's WARC will be considered by the ITU Administration Council meeting in June; and decisions as to whether and when to convene the proposed WARC (and perhaps another to consider re-allocation of h.f. spectrum) will rest with the ITU Plenipotentiary Conference in 1989. An important question will be the availability of finance for these future WARCs and for the very costly redevelopment and operation of an improved planning system by the IFRB.

The crystal ball is clouded. Will ITU member states contribute the necessary funds? And will a future WARC be able to agree that the revised planning system has been sufficiently improved and tested to be acceptable for h.f. broadcasting into the 21st century?

Pat Leggatt is the BBC's chief engineer, external relations.

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TELEVISION BROADCAST

How good is good enough?

The European delegates to the CCIR meeting at Dubrovnik in May 1986 played a major role in ensuring that a decision on adopting the Japanese 1125-line, 60-Hz wide-screen high-definition television system as a world "production" standard for h.d.tv was postponed at least until 1988 or to the next full plenary meeting in 1990. This has led to intensive efforts to come up with alternative production and transmission standards that would be compatible with 50-Hz MAC, yet conform to the loose definition of h.d.tv as representing a system having about twice the horizontal and twice the vertical resolution of existing systems. Many European organizations are taking part in Eureka projects or within EBU committee work.

It will clearly take time to reach consensus views but some of the early work was aired recently at an IEE colloquium "HDTV bandwidth reduction" and in an issue of *EBU Review-Technical* (No 219) devoted almost entirely to this subject. What emerges clearly is the difficulty of squeezing more information into the planned 12 GHz satellite frequencies without introducing compromises.

On the other hand, there is support for using 1250-lines as a production standard, converting this down to 625 lines for transmission, and then, where required, using digital processing in the receiver to provide, say, a 100 Hz display. Intercarrier techniques introduce degradations, yet remain an unrivalled method of limiting transmission bandwidth. A major requirement for 1250 or 1125-line studio production would be an electronic camera with adequate performance on a system having a luminance bandwidth of the order of 25 to 30 MHz, still a difficult undertaking.

Some engineers believe that countries in ITU Region 1 (Europe and Africa) should think instead of putting "true" h.d.tv on to 22 GHz, leaving the possibility of "enhanced" systems on 12 GHz. At present there is no 22 GHz allocation for satellite broadcasting in Region 1 and it would require renegotiation of the WARC 1979 table of frequency allocations. Region 1 does have broadcasting bands at 42 and 84 GHz but both are regarded as likely to remain beyond the boundaries of the technology for more than the 10-15 years assumed for the introduction of h.d.tv services.

While there are proven methods of bandwidth compression, most appear to involve compromises that would take away part of the attraction of h.d.tv. There are indeed those who would argue that by accepting "component" rather than "composite" colour systems, 625 lines can achieve a resolution entirely sufficient for present home display devices; that the next step should be the elimination of flicker and interline twitter and changing the aspect ratio to 16:9 or 5:3 by means of digital processing in the receiver. It has not been lost on some observers that MAC (multiplexed analogue components) is essentially a bandwidth-expansion rather than a bandwidth-reduction technique.

Most of the UK and European projects draw upon the NHK research which started in 1968 in respect of human vision, but even here the conclusions drawn are not always the same. P.E. Wilcock (ITCA), for example, believes that an 861/50 system with a luminance bandwidth of about 20 MHz could provide subjectively identical image quality to 1125/60.

Bandwidth reduction by spectrum folding, shuffling or sub-sampling techniques has the result of trading dynamic versus static resolution. The BBC digitally-assisted (DATV) system eliminates the need for motion detection in the receiver but requires substantial digital capacity (up to about 2 Mbit/s) to obtain optimum benefit and it might be difficult to provide both this and wide-screen pictures with MAC within a 1 GHz channel. DATV uses motion vector techniques not unlike those in the high-quality Japanese h.d.tv standards converter. The Japanese MUSE system, which can pack a 1125/60 system into a single d.b.s. channel, is regarded as resulting in "a most objectional 'blow focus' effect where picture resolution varies with picture dynamics".

There are still doubts as to the commercial viability of h.d.t.v. transmission and whether viewers would regard the better quality picture as having sufficient "perceived value" to compensate for what is bound to be a high-priced receiver.

In particular, the absence of any firm indication of what form future display devices may take is seen as a continuing problem. At present back-projection and direct-viewed picture tubes limit picture size to a width of between 30 to 50 inches. The Eduard Rhein Foundation (West Germany) is offering a prize of £1-million to the first development team to design a large-format, flat-screen colour tv set that can be easily mass produced. The high-resolution display should have a minimum resolution of 1200 lines, at least a 22-inch diagonal, and be not more than 2 inches deep. To qualify, designers need to come up with their design within the next four years.

WELL, BROADLY SPEAKING THATS IT IT NEEDS A LITTLE MORE WORK TO WEATHER-PROOF IT WHEN CAN I EXPECT THE CHEQUE?

Meanwhile most of us would be happy if all the pictures transmitted on 625 lines were closer to the standard possible with live or recorded programmes from well-lit studios.

C.c.d. cameras

Although the future of solid state display devices for colour television remains obscure, the other end of the chain has already begun to move away, if only for limited applications, from thermionic pick-up tubes.

BBC Television News has announced that in future it will buy only solid-state c.c.d. cameras for its 27 news teams, and is in process of equipping seven teams with Sony BVP-5 c.c.d. cameras.

The drive towards the elimination of one of the last two subsystems based on thermionic devices (pick-up tubes and cathode-ray tubes) began in the mid-1970s when it was often suggested that solid-state charge-coupled-device arrays would be adopted for studio and portable cameras within a year or two. In practice it took over a decade before they began to challenge pick-up tubes for e.n.g. and even now there is some way to go before c.c.d. arrays are used in studio operation.

BBC News are convinced that the advantages of c.c.d. arrays more than compensate for the slightly higher centre resolution of units based on modern pick-up tubes. C.c.d. units can give better performance at low light levels and suffer no permanent damege if pointed at the sun.

In 1975 Bell Laboratories produced a c.c.d. black-and-white camera with about a quarter-of-a-million sensing elements. RCA at Montreux 1975 showed a colour camera that concealed its profound insensitivity to blue by a carefully arranged demonstration. It was not until 1983 that RCA began to demonstrate portable c.c.d camera using a frame-transfer arrangement and a resolution of roughly 200,000 pixels. A 625-line prototype was shown at IBC84 and gave an impressive performance in respect of registration, lag, absence of burn-out and low power consumption, and with a resolution only slightly down on most ⅔-in pick-up tubes. Indeed it seemed to maintain resolution better at low light levels or on moving objects.

But the RCA prototype camera, which had been originally funded by c.c.d. work for defence electronics, never went into production and the project lapsed when General Electric took over. It has been left to the Japanese to bring such cameras to the market place and to convince broadcasters that this is a technique whose time has come.

There would seem no immediate prospects of high-grade solid-state studio cameras entering service, although these should appear in the course of time. But beyond that is the even more demanding requirements of h.d.tv with its need for over 400,000 pixels, good signal-to-noise performance and reasonable depth of focus despite the very large luminance bandwidth.

Television Broadcast is written by PAT HAWKER.

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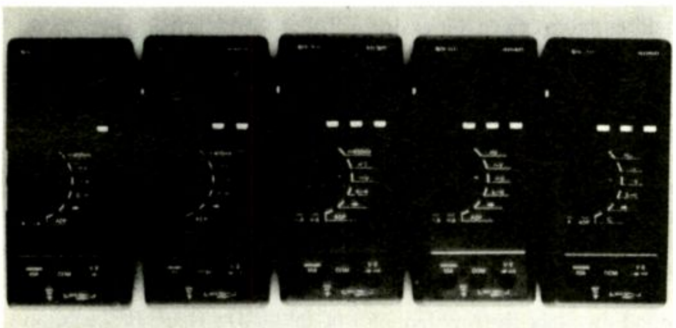

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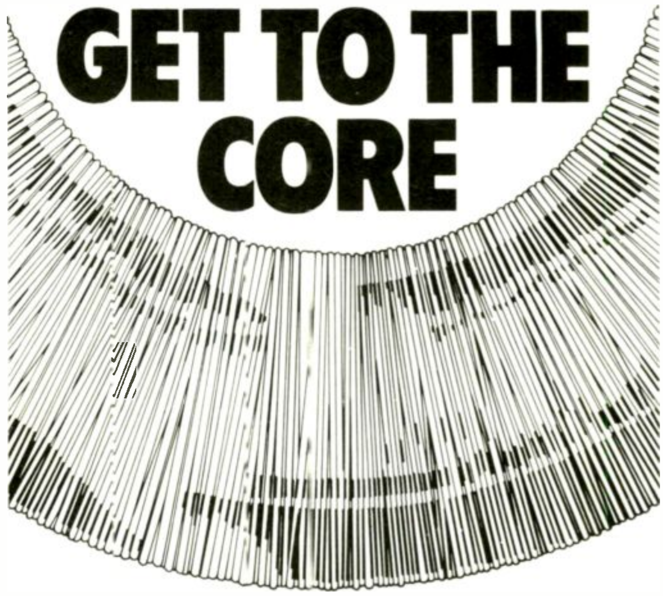

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RADIO BROADCAST

Green Paper and "simulcasting"

The Home Office's consultative document "Radio: Choices and Opportunities" (HMSO, Cm 92, 1987, £5) has certainly thrown into the arena an enormous number of discussion points that could profoundly influence the future of radio broadcasting in the UK. Whilst most of those concerned professionally have welcomed the document as a basis for discussion, one suspects that many of the proposals will be opposed strongly, if only behind closed doors.

The 44-page document has little to say on the long-term effects on radio audiences of the continuing extension of television broadcasting hours, although this seems bound to increase still further the percentage of radio listening on car or walk-about radios. Nor does it go very far into the very different costs, on the technical, programming and administration sides, between running local and national-network stations or whether it is realistic to suppose that there could be enough advertising to support three national, some 60 local and "hundreds" of community services funded solely by advertising and sponsorship, particularly in view of the growth in recent years of the "free-sheet" local newspapers, no matter how "loosely" the commercial radio services might be regulated.

But the Green Paper does consider in some detail the question of what it calls "simulcasting" (more usually known as "duplication"): the transmission of the same programmes on both medium- or long-waves and on v.h.f./f.m. with the extended Band 2, which will eventually span from 87.5 to 108 MHz. In paragraph 4.17, the Home Office expresses the view that "with increasing availability of and public familiarity with v.h.f./f.m. services, there is a good case for ending simulcasting altogether... If the BBC retained v.h.f./f.m. networks, m.f./l.f. networks would then be available to provide new commercial services... It would be sensible to set a target date now for the ending of simulcasting, so that the necessary planning can be put in hand and the public prepared for what will be a large change in listening habits and expectations. The target might be 1995, after which (more) v.h.f./f.m. frequencies will be available for local (community) use."

At present the BBC has four national m.f./l.f. networks, plus the high-power External Services m.f. channel which attracts about a 4 per cent share of the UK audience. The 1987 BBC Handbook lists 26 Radio 1, 23 Radio 2, 21 Radio 3, 12 Radio 4, 6 Radio Wales, 5 Radio Scotland and 3 Radio Ulster m.f./l.f. transmitters, many forming parts of synchronized chains. And it is from these transmitters, despite the gradually increasing use of v.h.f./f.m. transmissions, that a significant majority of home listening and the great majority of car listening is done. This is despite the promotion for over 30 years of v.h.f./f.m. as usually providing better quality reception much freer of interference than is possible on m.f., particularly during the hours of dusk and darkness.

For the failure to convert most listeners to the benefits of v.h.f./f.m. and stereo, some blame the policy of duplication, arguing that if v.h.f/f.m. had been treated as the "main" way of broadcasting, listeners would have been forced to change. Others blame the lack of sustained promotion and pressure by broadcasters, the difficulty of receiving "noise-free" stereo without a good external aerial from transmitters located well outside the centres of population, the poor sensitivity and poor selectivity of many low-cost and some high-cost receivers, etc.

The Green Paper does show that, unlike the situation in the USA, younger listeners in the UK have never become committed to v.h.f./f.m. listening, undoubtedly influenced by the absence of a dedicated v.h.f./f.m. channel for Radio 1, although this is planned for the fairly near future.

There is little doubt that if simulcasting ends by 1995 and BBC "public service" broadcasting is confined to v.h.f./f.m., the Corporation could be faced with the loss of over half of its audience from this cause alone, unless it embarks on an all-out campaign to persuade listeners to change to v.h.f./f.m. Such a campaign would be bound to be very unpopular to the many who still find, despite the drawbacks, that m.f./l.f. transmissions give them adequate reception.

Then again there are an increasing number of professional broadcast engineers who believe that the real future for national coverage radio lies in satellite broadcasting on about 1 to 1.5 GHz from highly-elliptical orbits. Such satellites can hover almost directly overhead for about eight hours at a time so that continuous coverage could be provided by three synchronized satellites and received, for example, in moving vehicles by means of a simple planar antenna on the roof. Ideas for such radio satellites are currently being studied by EBU working parties with the object of presenting a case for a frequency allocation at the next World Administrative Radio Conference. Such systems are technically very attractive though they face the problem of the enormous cost of getting a series of satellites into orbit and then persuading listeners to buy suitable receivers.

The only form of satellite radio considered in the Green Paper is the possibility of carrying radio channels on 12 GHz MAC-family satellite transponders basically providing d.b.s. television services to fixed locations and unlikely ever to be suitable for reception in cars or on portable radios.

Cellular growth

The rapid build-up of the coverage and use of the 900 MHz Cellnet and Vodafone cellular radio networks with now over 150,000 subscribers has run ahead of most predictions. Their growth is proving a near match to the Scandinavian experience where cellular systems have been in operation for over five years. The systems have perhaps been fortunate in establishing the technology ahead of the 200 MHz national private mobile networks licensed to GEC and Band Three Radio, the first of which (Band Three) is expected to open in the London area this autumn.

Vodafone has issued some illuminating statistics on its operations. At the beginning of March, with 430 cells representing 3,700 voice channels, it is handling over 2 million calls per week through four "exchanges" and 235 base stations. Some 64 per cent of the traffic is now outside the London orbital ring area where frequency congestion has been a considerable problem.

An interesting figure is the 15 per cent "churn", the rate of disconnections from the network, based on operations since about the beginning of 1985. This rate of churn is comparable to that of some of the cable-television systems and is perhaps not unduly high for new, energetically-sold services, but it does seem to reflect the feeling of some observers that what with equipment costs, installation charges, standing charges and connection fees, plus the actual call charges, it can prove to be a costly, if useful, service.

Then, not all subscribers are tolerant of the basic fallibilities of 900 MHz radio propagation and expect the system to function as reliably as their desk telephones. In practice, calls get lost when hills intervene between the vehicles and the base station and there can be a good deal of "popping" due to the rapid fading brought about by the standing wave patterns resulting from multipath propagation.

The safety aspects of mobile radio attracted attention in the media with the publication, early March, of the new edition of the Highway Code with its specific warning against the use of hand microphones and handsets while driving. Surveys have shown that over half of mobile radio users expect to receive calls without stopping and many make outgoing calls on the move.

It seems odd, incidentally, that the RSGB, which has for many years included similar warning in its own safety code for radio amateur mobile operation, should feel aggrieved that it was not fully consulted by the Department of Transport and claims to be unaware of any accidents resulting from the use of hand-held microphones.

Radio Broadcast was written by PAT HAWKER.

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7 4 – in flex line switches with neons
9 2 – mains transformers with 6V 1A secondaries
10 2 – mains transformers with 12V ½A secondaries
11 1 – extension speaker cabinet for 6½" speaker
13 12 – glass reed switches
17 2 – ultrasonic transmitters receivers with circuit
19 2 – light dependent resistors
25 4 – wafer switches – 6p 2 way, 4p 3 way, 2p 6 way, 2p 5 way, 1p 12 way small one hold fixing and good length ¼ spindle your choice
28 1 – 6 digit counter mains voltage
30 2 – Nicad battery chargers
31 1 – key switch with key
33 2 – aerosol cans of ICI Dry Lubricant
34 96 – 1 metre lengths colour-coded connecting wire
39 1 – long and medium wave tuner kit
41 8 – rocker switch 10 amp mains SPST
45 1 – 24 hour time switch mains operated (s h)
49 10 – neon valves – make good night lights
50 2 – 12V DC or 24V AC, 3 CO relays
51 1 – 12V 2 CO miniature relay very sensitive
52 1 – 12V 4 CO miniature relay
54 10 – rows of 32 gold plated IC sockets (total 320 sockets)
55 1 – locking mechanism with 2 keys
56 1 – miniature uniselector with circuit for electric jigsaw puzzle
60 5 – ferrite rods 4" × 5/16" diameter aerials
61 4 – ferrite slab aerials with L & M wave coils
63 1 – Mullard thyristor trigger module
66 1 – magnetic brake – stops rotation instantly
67 1 – low pressure 3 level switch can be mouth operated
69 2 – 25 watt pots 8 ohm
70 2 – 25 watt pots 1000 ohm
71 4 – wire wound pots – 18, 33, 50 and 100 ohm your choice
77 1 – time reminder adjustable 1-60 mins clockwork
85 1 – mains shaded pole motor ¾" stack – ¼ shaft
89 1 – mains motor with gear box 1 rev per 24 hours
91 2 – mains motors with gear box 16 rpm
96 1 – thermostat for fridge
98 1 – motorised stud switch (s h.)
101 1 – 2½ hours delay switch
103 1 – mains power supply unit – 6V DC
104 1 – mains power supply unit – 4½V DC
107 1 – 5" speaker size radio cabinet with handle
112 1 – heating pad 200 watts mains
114 1 – 1W amplifier Mullard 1172
115 1 – wall mounting thermostat 24V
118 1 – teak effect extension 5" speaker cabinet
120 2 – p c boards with 2 amp full wave and 17 other recs
121 4 – push push switches for table lamps etc
122 10 – mtrs twin screened flex white p.v.c outer
124 25 – clear plastic lenses 1½" diameter
127 4 – pilot bulb lamp metal clip on type
128 10 – very fine drills for pcbs etc
129 4 – extra thin screw drivers for instruments
132 2 – plastic boxes with windows, ideal for interrupted beam switch
134 10 – model aircraft motor – require no on/off switch, just spin to start
137 1 – 6½" 4 ohm 10 watt speaker
142 10 – 4 BA spanners 1 end open, other end closed
145 2 – 4 reed relay kits 3V coil normally open or c/o if magnets added
146 20 – pilot bulbs 6.5V 3A Philips
154 1 – 12V drip proof relay – ideal for car jobs
155 3 – varicap push button tuners with knobs
169 4 – short wave air spaced trimmers 2-30f
172 10 – 12V 6W bulbs Philips m.e.s.
178 3 – oblong amber indicators with lilliputs 12V
180 6 – round amber indicators with neons 240V
181 100 – p.v.c grommets ⅜ hole size
182 1 – short wave tuning condenser 50 pf with ¼" spindle
184 1 – three gang tuning condenser each section 500 pf with trimmers and good length ¼" spindle
188 1 – plastic box sloping metal front, 16 × 95mm average depth 45mm
193 6 – 5 amp 3 pin flush sockets brown
195 5 – B.C. lampholders brown bakelite threaded entry
196 1 – in flex simmerstat for electric blanket soldering iron etc.
197 2 – thermostats, spindle setting – adjustable range for ovens etc.
199 1 – mains operated solenoid with plunger 1" travel
200 1 – 10 digit switch pad for telephones etc.
201 8 – computer keyboard switches with knobs, pcb or vero mounting
206 20 – mtres 80 ohm, standard type co-ax off white
211 1 – electric clock mains driven, always right time – not cased
216 1 – stereo pre-amp Mullard EP9001
232 2 – 12V solenoids, small with plunger
236 1 – mains transformer 9V 1 amp secondary C core construction
241 1 – car door speaker (very flat) 6½" 15 ohm made for Radiomobile
241 2 – speakers 6" × 4" 4 ohm 5 watt made for Radiomobile
243 2 – speakers 6" × 4" 16 ohm 5 watt made for Radiomobile
244 1 – mains motor with gear-box very small, toothed output 1 rpm
245 4 – standard size pots, ½ meg with dp switch
249 1 – 13A switched socket on double plate with fused spur
266 2 – mains transformers 9V ½A secondary
267 1 – mains transformers 15V 1A secondary p.c.b. mounting
291 1 ten turns 3 watt pot ¼ spindle 100 ohm
296 3 car cigar lighter socket plugs
298 2 15 amp round pin plugs brown bakelite
300 1 mains solenoid with plunger compact type
301 10 ceramic magnets Mullard 1" × 3/8 × 5/16
303 1 12 pole 3 way ceramic wave charge switch
305 1 tubular dynamic microphone with desk rest
308 1 T.V. turret tuner (black & white T.V.)
310 2 oven thermostats
313 5 sub miniature micro switches
316 1 round pin kettle plug with moulded on lead
453 2 – 2½in. 80ohm loudspeakers
454 2 – 2½in. 8ohm loudspeakers
463 1 – mains operated relay with 2 sets c/o contacts
464 2 – packets resin filler/sealer with cures
465 3 – 5A round 3 pin plugs will fit item 193
466 4 – 7 segment l.e.d. displays
470 4 – pc boards for stripping, lots of valuable parts
473 1 – 5" 4ohm speaker with built in tweeter Radio mobil
480 1 – 3A double pole magnetic trip, saves repairing fuses
498 4 – 1000uf 25V axial electrolytic capacitors

FROZEN PIPES Can be avoided by winding our heating cable around them, 15 mtrs connected to mains cost only about 10p per week to run. Hundreds of other uses as it is waterproof and very flexible. Resistance 60ohms/metre. Price 28p/metre or 15m for £3.95.

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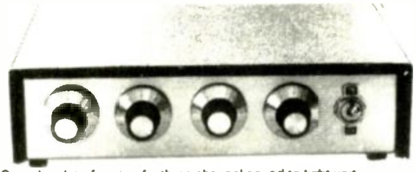
SOUND TO LIGHT UNIT



Complete kit of parts of a three channel sound to light unit controlling over 2000 watts of lighting. Use this at home if you wish but it is plenty rugged enough for disco work The unit is housed in an attractive two tone metal case and has controls for each channel, and a master on/off. The audio input and output are by ¼" sockets and three panel mounting fuse holders provide thyristor protection A four pin plug and socket facilitate ease of connecting lamps Special price is £14.95 in kit form

12 volt MOTOR BY SMITHS

Made for use in cars, etc these are very powerful and easily reversible Size 3½" long by 3" dia They have a good length of ¼" spindle –
1/10 hp £3.45
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25A ELECTRICAL PROGRAMMER

Learn in your sleep Have radio playing and kettle boiling as you wake – switch on lights to ward off intruders – have a warm house to come home to You can do all these and more By a famous maker with 25 amp on/off switch. A beautiful unit at £2.50

THIS MONTH'S SNIP

3" floppy disc drive unit plug in and with all electronics. Japanese made, brand new. We are told that this is a standard replacement in many Amstrad and other popular computers, and we supply with technical information. Special snip price £29.50 including post and VAT.

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(Or you can work this off a 24V transformer). Makes a shocking noise, will frighten away any intruder Japanese made one 50p each, 2 for £1, ref BD106 American, storage soiled but unused and guaranteed perfect, only 20p each, 5 for 21, ref BD221

WONDERFUL BREAKDOWN VALUE – HAND HELD STEREO UNIT

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Powerful mains operated induction motor with gearbox attached Shaft has square hole which gives very easy coupling and quick release if required. Shaft speed 5rpm Price £5, ref 5P54

PUSH SWITCH REF 14DM

Double pole c/o switch, able to handle 10A at mains voltage Mounts through an oblong hole like a rocker switch Has its own push rod, so does not require a knob. Change over occurs when switch is depressed and returns to normal when pressure removed. 3 for £1, ref BD489

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Upright mounting Primary thermal cutout to interrupt the supply if transformer overheats Price £2, ref 2P138.

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Book 1 describes the Mullard Unilex amplifier and gives details of a suitable cabinet. Book 2 describes several useful pieces of test equipment which could be quite easily constructed Book 3 is electronic projects. Book 4 describes short wave receivers which can be easily constructed and is intended for mainly beginners Our ref BD400

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24V 5A output Ideal for garden lighting or to operate pond pump etc Case has cable glands for mains in and low voltage output leads Price £5 plus £1 post, ref 5P88

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2P8 – Mains motor with gear box and variable speed selector Series wound so suitable for further speed control
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2P10 – 12 volt 5 amp mains transformer
2P12 – Disk or Tape precision motor – has balanced rotor and is reversible 230v mains operated 1500 rpm
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2P19 – Disco switch-motor drives 6 or more 10 amp change over micro switches supplied ready for mains operation
2P20 – 20 metres extension lead, 2 core – ideal most Black and Decker garden tools etc.
2P21 – 10 watt amplifier, Mullard module reference 1173
2P22 – Motor driven switch 20 secs on or off after push
2P26 – Counter resettable mains operated 3 digit
2P27 – Goodmans Speaker 8 inch round 8ohm 12 watt
2P28 – Drill Pump – always useful couples to any make portable drill
2P31 – 4 metres 98 way interconnecting wire easy to strip
2P32 – Hot Wire amp meter – 4½ round surface mounting 0–10A – old but working and definitely a bit of history
2P34 – Solenoid Air Valve mains operated
2P38 – 200 R.P.M. Geared Mains Motor 1" stack quite powerful, definitely large enough to drive a rotating aerial or a tumbler for polishing stones etc.
2P43 – Small type blower or extractor fan, motor inset so very compact, 230V
2P46 – Our famous drill control kit complete and with prepared case.
2P49 – Fire Alarm break glass switch in heavy cast case
2P51 – Stereo amplifier, 3w per channel
2P55 – Mains motor, extra powerful has 1½" stack and good length of spindle
2P62 – 1 pair Goodmans 15 ohm speakers for Unilox
2P64 – 1 five bladed fan 6½" with mains motor
2P66 – 1 2Kw tangential heater 115v easily convertible for 230V
2P67 – 1 12v–0–12v 2 amp mains transformer
2P68 – 1 15v–0–15v 2 amp mains transformer
2P69 – 1 250v–0–250v 60 mA & 86.3v 5A mains transformer + 50p post
2P70 – 1 E.M.I. tape motor two speed and reversible
2P72 – 1 115v Muffin fan 4" × 4" approx. (s.h.)
2P75 – 1 2 hour timer, plugs into 13A socket
2P82 – 9v–0–9v 2 amp mains transformer
2P84 – Modem board with press keys for telephone redialler
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2P88 – Sangamo 24 hr time switch 20 amp (s.h.)
2P89 – 120 min. time switch with knob
2P90 – 90 min. time switch with edgewise engraved controller
2P94 – Telephone handset for EE home telephone circuit
2P95 – 13A socket on satin chrome plate
2P97 – mains transformer 24V 2A upright mounting
2P98 – 20m 4 core telephone cable, white outer
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2P101 – 15V mains transformer 4A upright mounting
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2P108 – mains motor with gear box giving 110rpm
2P109 – 5" wide black adhesive pvc tape 33m, add £1 post if not collecting

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5P23 – miniature (appr. 2½" wide) tangential blow heater, 1·2kw
5P24 – ½ hp motor, ex computer, 230V, mains operation 1450rpm. If not collect add £3 post
5P25 – special effects lighting switch. Up to 6 channels of lamps can be on or off for varying time periods
5P27 – cartridge player 12V, has high quality stereo amplifier
5P34 – 24V 5A toroidal mains transformer
5P35 – modem board from telephone auto dialler, complete with keypad and all ICs
5P37 – 24 hour time switch, 2 on/offs and clockwork reserve, ex Elec. Board loading up to 50A Add £1 post
5P41 – 5" extractor fan, very quiet runner (s.h.), gntd 12 mths.
5P48 – telephone extension bell in black case, ex-GPO
5P52 – mains transformer 26V 10A upright mounting, add £2 post
5P54 – mains motor with gear box, final speed 5rpm
5P58 – Amstrad stereo tuner FM and LM. AM
5P60 – DC Muffin type fan 18 to 27V, only 3W
5P61 – drill pump mounted on frame, coupled to mains motor
5P62 – 2½kw tangential blow heater, add £1.50 post if not collecting
5P73C high pressure mains operated gas or water valve with tube connection suitable soldering
5P74 6rpm 60W mains motor and gearbox with instant stop
5P79 30rpm 60 watt mains driven motor with gearbox
5P82 1 25rpm mains 60w motor with gearbox
5P84 1 delay time switch, adjust 0–20 seconds
5P69 1 light box size 14" × 12" for circuit tracing pcb's. Add £3 for postage and packing
5P72 1 turntable for vdu or scope
5P81 1 stepper motor bi-directional, 7.5° steps 12–14V coil
5P86 1 mains transformer with 2 × 100V 1A secondaries. Add £1.50 post
5P88 1 24V 5A mains transformer in waterproof case, ideal for garden lighting, pond pump etc.

LIGHT CHASER KIT motor driven switch bank with connection diagram, used in connection with 4 sets of xmas lights makes a very eye catching display for home, shop or disco, only £5 ref 5P56.

Ageing enthusiasts

The number of UK licensed radio amateurs increased spectacularly in the early 1980s, partly because of the ready availability of effective medium-priced transceivers, partly as a result of the publicity surrounding the introduction of Citizen's Band radio into the UK and the subsequent realization that legal c.b. was primarily a short-range service more suited to base/car, base/handheld or handheld/handheld communications than talking to people in other countries. This became more evident with the decline of sunspot cycle 21, with 27 MHz suitable for ionospheric reflection only for limited periods and seasons, mainly by means of unpredictable Sporadic E reflection.

The number of valid c.b. licences has fallen to about one-third of the number reached during the first year of 1982-83. But there has also been a significant decline in the number of new amateur radio licences being issued, although the total of valid licences (not necessarily all active) has remained relatively steady during the past couple of years. Importers of amateur radio equipment report sales roughly about half of the peak reached in the early 1980s, although the unit-cost of equipment has risen significantly with the continuing strengthening of the Yen exchange-rate. Equipment costs except for those prepared to buy secondhand or build simple equipment is proving a barrier for youngsters and indeed the hobby itself now seems to be losing much of its appeal to teenagers. One result is that the average age of those still active on the amateur bands or attending local club meetings seems to be rising.

This trend seems likely to be increased still further by the recent (welcome) policy changes introduced by the Department of Trade & Industry as the licensing authority. During 1986, it was agreed that a pass in the 12 words per minute Morse Test for Class A licences remains valid for life. Since the beginning of this year it has similarly been agreed for anyone who can prove conclusively that they have ever held a UK amateur licence, including all pre-war amateurs who never had to take the Radio Amateurs Examination and also the immediate post-war licences issued to those with Service or civilian qualifications that exempted them from the written RAE and/or the Morse test. There must be many thousands of such lapsed amateurs still retaining an interest in the hobby (or at least in the hobby as it was in the days before the dominance of the factory-built black boxes).

It has always been the case that many who obtain licences while young tend to find their hobby activities restricted by increasing family or business responsibilities and let their licences lapse, but have been put off re-applying in later life by the prospect of having to retake one or both of the examinations. Now, by applying in writing, fully supported by firm documentary evidence of their having previously held a licence, the call sign then held, and all changes of address notified to the licensing authority while the licence remained valid, date of original issue of the licence, proof of identity etc., it is possible to have the licence and usually the original callsign re-issued.

Applications have to be made in writing, with the necessary documentation, to DTI Radiocommunications Division, Amateur Radio Section, Room 613, Waterloo Bridge House, Waterloo Road, London SE1 8UA.

Data privacy

Legislative procedures in one's own country always seem tortuous and opaque – those of other countries just plain unfathomable. This is my excuse for having suggested (*Radio Communications*, March 1987) that President Reagan had failed to ratify the "Electronic Communication Privacy Act". In fact, although the Senate Bill S-2575 did lapse, a parallel House of Representatives Bill was duly ratified and became US law last October. As it now stands, the Act makes it illegal to access an electronic mailbox without authorization, including protection against government access without a court order. At least in theory, it gives all persons and organizations using electronic mail and data communications a similar right to privacy as already exists for telephones and the US mails, protecting data and on-line computers from industrial espionage, "private eyes" and amateur "hackers". But, as noted in the March issue, the original intention of restricting casual listening even to "readily accessible" radio transmissions appears to have been much watered down.

The high cost of government "security" equipment, a term that generally includes surveillance, crypianalysis as well as cryptographic systems and secure communications equipment, and the practice in many countries of burying the costs in general government defence budgets, was underlined by the Project Zircon row. In the USA, it has been estimated that the federal market for security equipment required by some 28 US government agencies has already climbed to over £1-billion per annum and will double in the next few years, without counting the cost of shielding equipment in order to confirm with "Tempest" requirements, or the classified projects whose costs, like Zircon, are hidden in various budgets.

World of radio data

Both "radio teletext" based on American SCA technology and the European "radio data system (RDS)" are due to be operational in the UK before long, with radio teletext using the Telerate data system due to start in the London area any day now. It is clear that radio teletext, offering subscription services of financial information, will function primarily as a business and professional aid based on compact pocket special-purpose v.h.f. receivers. The initial purpose of the more sophisticated RDS will be for automatic switching and control of car radios, and then for positive station identification.

A specialist group of the European Broadcasting Union is currently preparing "Guidelines for the implementation of the RDS system" due to be published this year. The group is also collaborating with European set makers and the transport ministries in considering the possibilities of using the system for the transmission of comprehensive information to motorists. This could be done, for example, by the transmission of coded and/or uncoded digital data based on international vocabularies with the messages conveyed by a speech synthesizer or possibly using a compact printer. The driver would simply select the appropriate language channel. Such a service would require set makers to fit a suitable interface connector on all new receivers incorporating an RDS decoder in order to allow peripheral devices to be plugged in.

Work has also started with a view to providing some of the features of RDS on medium- and long-wave a.m. transmissions to support automatic tuning and station identification.

Radio Broadcast was compiled by PAT HAWKER.

RESEARCH NOTES

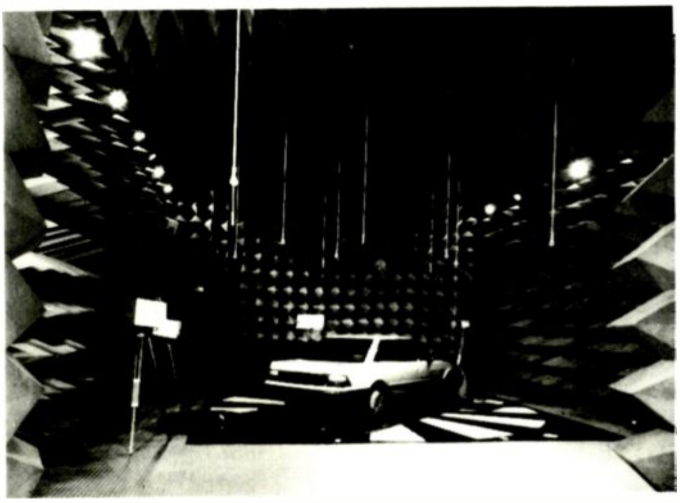
Speed record for digital gallium arsenide

Scientists at GMHE/Hughes Aircraft Co. have reported a divide-by-two counter chip that will run at just over 18 GHz without the need for cryogenics. This comfortably exceeds the previous record for digital GaAs chips of 13 GHz, established in 1984 by AT&T Bell Laboratories.

The Hughes chip achieves its performance by means of a number of advances, both in circuit configuration and fabrication techniques. Metal-semiconductor (mesfet) technology avoids the cryogenic requirement of high electron mobility transistors (hemts); and buffered fet logic, based on depletion mode active devices, contributes to the high speed of operation. As for fabrication, the use of direct-write electron beam lithography allows for minimum chip dimensions as small as 0.2μm. Active regions down to 700A are formed by molecular beam epitaxy using a technique being developed for the US Navy.

At the moment, the mesfet logic requires level-shifting circuitry, which demands a high power consumption – 657mW per divider – but work is in progress to bring this within more acceptable limits.

Electronic vehicle testing



Electronic devices in modern vehicles now feature in engine and transmission management systems, door locks, brakes, air conditioning, instrumentation and even mirror adjustment. Suspension, steering and navigation are now following. The problem is that some of these devices may be sensitive to external electromagnetic interference. At the same time, the devices themselves may also have an effect on other vehicles or interfere with radios, radio telephones and televisions.

To find out more about the problems and also to develop ways in which car electronics can be protected from interference, an £800,000 test chamber has been built by Gaydon Technology at its proving ground in Warwickshire.

Gaydon Technology is a subsidiary of the Rover Group and is one of the UK motor industry's major research and development companies. Its latest facility comprises a completely closed room, screened to prevent outside interference, in which whole vehicles or components are bombarded with radio signals across a well-defined frequency range to test their proper functioning under running conditions. Within the chamber is a complete motorized turntable assembly and vehicle chassis dynamometer. This unique combination allows the test vehicle to 'drive' under simulated road conditions at any position. It can rotate a full 360 degrees in either direction.

Until now, there has been no special automotive test chamber in the UK, equipped with a chassis dynamometer, allowing vehicles to be tested for malfunction under load. It is believed that the Gaydon installation is the first dedicated vehicle chamber of this type in Europe.

Quantum chips?

A healthy sign that industry and fundamental research are not so far apart comes with news of some progress in quantum mechanics from Hitachi. What they've done is adapt a technique called electron holography to demonstrate the validity of a concept known as the Aharanov-Bohm effect. This effect, postulated in 1959, predicts on the basis of quantum theory that electron beams passing either side of a magnetic field will be influenced by the field, even though they don't actually pass through it. This, of course, contradicts classical physics which says that electrons are only influenced by the direct effects of electric or magnetic fields.

Until now, it hasn't been possible to demonstrate the Aharanov-Bohm effect because of the sheer practical difficulties of limiting the extent of a magnetic field. Another difficulty is that of measuring the very tiny effect predicted.

The Hitachi engineers modified an electron holography system in which a split beam of electrons follows separate paths before being combined to produce an image on a target. Any disturbance to one beam – however tiny – produces a significant change in the image.

The really ingenious part of the exercise, however, consisted of creating a magnet with no external field. This was done by surrounding a magnetic alloy with a layer of superconducting niobium at the temperature of liquid helium (−270°C). Just to make sure that there were no residual electric fields, the whole assembly was sheathed in copper.

When this shielded magnet was brought near one of the electron beams in the holography apparatus it was found that the beam was indeed perturbed. Of course others will want to repeat the experiment just to be sure. But if such quantum effects do exist, then they aren't entirely without practical application. As chip etching techniques improves it will soon be possible to create details of micron size where quantum effects could make a significant difference. Unless such effects are understood and controlled, they could well lead to unexplained performance anomalies.

Battery on a chip

Work undertaken by Dr Brian Nevett of the Department of Physical Sciences at Brighton Polytechnic together with Dr Peter Foot, now at Thames Polytechnic, is likely to lead to a commercially viable solid-state rechargeable lithium battery. Although many lithium couples have been tested with polymer electrolytes, there have been problems either with mechanical or electrical stability of the whole system, especially the cathode.

One ideal re-chargeable cathode is nickel phosphorus trisulphide ($NiPS_3$), though up till now it has proved impractically expensive to produce. The standard method is to heat the raw elements in a vacuum at over 800°C for a week or more.

Drs Nevett and Foot, with the help of the British Technology Group, have now developed a method of producing amorphous $NiPS_3$ at room temperature and then modifying this for cathode use by a relatively short process of heat treatment. This method not only works well but the $NiPS_3$ can easily be painted on to a nickel surface to make a practical cathode.

A $NiPS_3$ cathode, together with a solid polymer electrolyte and lithium anode, forms a system with between three and five times the energy density of a lead acid accumulator. It can also be constructed in a fashion more akin to that of chip manufacture by depositing successive layers of material on a subsrate. This in turn has given the Brighton group the idea of combining a battery with a memory chip. Either the chip could be printed on the battery surface or the battery materials incorporated into the chip structure. Such a chip would then for all practical purposes be non-volatile.

Enquiries have already come from a number of interested companies.

Research Notes is written by John Wilson.

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IDC	195	325	375	—
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	0 1	0 156
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Technical details, application form and job description from the Chief Fire Officer, Devon Fire and Rescue Service HQ, Clyst St George, Exeter EX3 0NW.

Closing date 30 April 1987

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Electronics Technicians, Electricians

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EWW/5/87

Post to: **Enquiries Unit, Voluntary Service Overseas, 9 Belgrave Square, London SW1X 8PW.** (24p S.A.E. appreciated)

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Application forms and job description from:
Miss R Whiting, Unit Personnel Officer, Papworth Hospital, Papworth Everard, Cambridge CB3 8RE. Tel: (0480) 830541 ext: 334

Closing date: Friday, 8th May 1987

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PSYCHOLOGY DEPARTMENT

Electronics Technician

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Further details and informal enquiries to Mr. G. Wales (0203 523611)

Application forms from the Personnel Office, University of Warwick, Coventry CV4 7AL (0203 523685) quoting Ref. No. 36/T/86. Closing date 4th June 1987.

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Senior Telecommunications Engineer - Kenya

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The successful applicant will investigate the project and formulate logical actions and then carry out detailed planning for its execution. Close liaison with the Kenya Posts and Telecommunications is essential.

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