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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 dangerous 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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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 ICs (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 downloaded 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 hits/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.

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 processors 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.

The 1220 logic analyser from Tektronix 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.

![Diagram](image-url)
THURLBY LA160B

20MHz, 16 channels, LED display, DC to 20MHz external clock, 2.5KHz internal clock in 16 steps, 1,999 x 16 bit word acquisition memory.

£495

THANDAR TA 2000

High performance, low-cost, portable logic analyser for development, production and field service. Can capture data across 32 channels (at 2.5MHz) and up to 100MHz (8 channels), displaying data in both timing and list formats.

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3. Different modules for timing and state analysis are required to be designed for each specific application. This concept of an analyzer constructed of different modules, known as a combined analyzer, 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 realize 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 interface method, as described in 2, is often used as a solution in low-cost instruments. An analyzer built this way can analyze 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 software-probe analyzers, decide to build-in two analyzers—one for timing and one for state analysis.

A typical analyzer 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 designated primarily for state analysis with 2MHz sample rate and 4k memory depth, but may allow selection of these same channels for a timing display format. Thus coexistence of timing and state channels is technically not unusual. However, it is unusual in low-cost analyzers 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 clarity 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 analyzer 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 analyzer 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 must 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 intermediates 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 low or data stream. Polling for 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 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, 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.

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 or 16 bytes acquisition memory. A powerful 16-bit C.P.U. with megalobytes of memory results in extremely short display up-time, 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 analyser software updates or retrofittable 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/100MHz). 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

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Tel.</th>
<th>Address</th>
</tr>
</thead>
<tbody>
<tr>
<td>Advantest (formerly TakaiKafune) instruments available from Chase Electronics Ltd, London SW14 TY</td>
<td>01-878 7748</td>
<td>Windmill Trading Estate, Luton, Beds LU1 3JK</td>
</tr>
<tr>
<td>Anritsu Europe Ltd.</td>
<td>0118 488 888</td>
<td>Thistle Road, Windmill Trading Estate, Luton, Beds LU1 3JK</td>
</tr>
<tr>
<td>Dolch Logic Instruments Ltd.</td>
<td>0207 990 990</td>
<td>4 Londen Street, Andover, Hants SP10 2PA</td>
</tr>
<tr>
<td>Fieldtech Heathrow Ltd.</td>
<td>01274 999 999</td>
<td>Hunstanton House, Bath Road, Longford, Middlesex UB7 OLL</td>
</tr>
<tr>
<td>Global Specialties Ltd.</td>
<td>01908 666 666</td>
<td>Shire Hill Ind. Estate, Suffron Walden, Essex CB11 3AQ</td>
</tr>
<tr>
<td>Gould Electronics Ltd.</td>
<td>0171 277 277</td>
<td>Office 2000, Roebuck Road, Hanwell, Ilford Essex IG6 3UE</td>
</tr>
<tr>
<td>Hewlett-Packard Ltd.</td>
<td>0346 773100</td>
<td>Nine Mile Ride, Easthampton, Wokingham, Berks RG11 3LL</td>
</tr>
<tr>
<td>Iwatsu instruments are available through TSI Instrument Services, Harlow. Essex</td>
<td>0278 29522</td>
<td>Tel: 01-357 8771</td>
</tr>
<tr>
<td>Kontron Electronics Ltd.</td>
<td>0219 793933</td>
<td>Teltonic Instruments Ltd, Maidenhead, Berks.</td>
</tr>
<tr>
<td>Kontron Electronics Ltd.</td>
<td>0269 793933</td>
<td>Teltonic Instruments Ltd, Maidenhead, Berks.</td>
</tr>
<tr>
<td>Marcon Instruments Ltd.</td>
<td>0272 992922</td>
<td>Longacres, St Albyn's, Herts AL4 OJN</td>
</tr>
<tr>
<td>Nicolet Instruments Ltd</td>
<td>0296 464646</td>
<td>Brookfield Road, Warwick CV34 5XN</td>
</tr>
<tr>
<td>Nicolet Instruments Ltd.</td>
<td>0225 494111</td>
<td>Brookfield Road, Warwick CV34 5XN</td>
</tr>
<tr>
<td>Philips Test &amp; Measurement</td>
<td>0203 358866</td>
<td>Pyle Unicord Ltd, York Street, Cambridge CB1 2PX</td>
</tr>
<tr>
<td>Racal-Dana Instruments Ltd.</td>
<td>0735 36101</td>
<td>Duke Street, Windsor, Berks SL4 15B</td>
</tr>
<tr>
<td>Rohde &amp; Schwarz UK Ltd</td>
<td>0225 358866</td>
<td>Rofeck Road, Cheixgton, Surrey KT9 1LP</td>
</tr>
<tr>
<td>Tektronix UK Ltd.</td>
<td>01-357 8771</td>
<td>4Londen Street, Andover, Hants SP10 2PA</td>
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<td>Tektronix UK Ltd.</td>
<td>01-357 8771</td>
<td>4Londen Street, Andover, Hants SP10 2PA</td>
</tr>
<tr>
<td>Thandar Electronics Ltd.</td>
<td>01274 999 999</td>
<td>London Road, St. Ives, Huntingdon, Cambridge PE17 4HJ</td>
</tr>
<tr>
<td>Thurlby Instruments Ltd.</td>
<td>01274 999 999</td>
<td>Archcliffe Road, Chesterfield, Chesterfield, Derbyshire</td>
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<td>01274 999 999</td>
<td>Archcliffe Road, Chesterfield, Chesterfield, Derbyshire</td>
</tr>
</tbody>
</table>

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 if yyy is true' has to be substituted by 'Record if xxx is true or if yyy is true.'
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.b.s. 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.

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THE LOGICAL CHOICE
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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 synchronizing 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 XTAL0UT. 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 CK10.

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 FOND and BACK 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 501 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 [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 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, rgn, 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...
sync signals may be selected by a bit in one of the control registers.

Bus buffering converts HD64180 signals to 8086 form. Signal 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 M.-. Paging line PAGE is a chip-select signal produced by the SC84 c.p.u. board using address lines A[15:8]. It acts as the most-significant address line of the VSDD. It is possible to think of this pin as a programmable chip select. By gating line PAGE with the data bus enable signal 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 WAIT signal with the bus-transaction signal. Other requirements are for an active high RESET and open-collector buffering on the MWR and MWR 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 IN pin is configured as a WAIT generator and the EOP 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 DOR, INP, and INR describe the configuration of the video memory to the VSDD and the ocr bit, when clear, instructs the processor to store but not to act upon the other control words being written until the ocr 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.e. 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

<table>
<thead>
<tr>
<th>Bit</th>
<th>Mnem.</th>
<th>Cond.</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>UCF</td>
<td>Clear</td>
<td>Locks out updating of all registers except VCR, and ATBA.</td>
</tr>
<tr>
<td>1</td>
<td>DEI</td>
<td>Set</td>
<td>Enables digital data o/p (rather than analogue).</td>
</tr>
<tr>
<td>2</td>
<td>SAB</td>
<td>Set</td>
<td>Memory access 3 clock cycles (slow).</td>
</tr>
<tr>
<td>3</td>
<td>DEN</td>
<td>Clear</td>
<td>Memory access 2 clock cycles.</td>
</tr>
<tr>
<td>4</td>
<td>HRS</td>
<td>Clear</td>
<td>Enables display.</td>
</tr>
<tr>
<td>5</td>
<td>DOF</td>
<td>Clear</td>
<td>Selects 4bit 16k d.rams.</td>
</tr>
<tr>
<td>6</td>
<td>DS1</td>
<td>Set</td>
<td>Selects 64kbit d.rams.</td>
</tr>
<tr>
<td>7</td>
<td>DS2</td>
<td>Set</td>
<td>Selects 256k-bit d.rams.</td>
</tr>
<tr>
<td>8-12</td>
<td>BR</td>
<td>BR</td>
<td>Blink rate in multiples of 8 frames.</td>
</tr>
<tr>
<td>13-15</td>
<td>DC</td>
<td>DC</td>
<td>Blink duty cycle in 1/16ths of blink period.</td>
</tr>
</tbody>
</table>

#### Video configuration register R1

<table>
<thead>
<tr>
<th>Bit</th>
<th>Mnem.</th>
<th>Cond.</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>PRE</td>
<td>Set</td>
<td>Selects pipeline access mode.</td>
</tr>
<tr>
<td>1</td>
<td>PSA</td>
<td>Clear</td>
<td>Halves sync generator clock rate.</td>
</tr>
<tr>
<td>2</td>
<td>RE</td>
<td>Clear</td>
<td>Allows system to read from video memory.</td>
</tr>
<tr>
<td>3</td>
<td>FAE</td>
<td>Set</td>
<td>Converts 8D7 pin to FREE ACCESS indicator.</td>
</tr>
<tr>
<td>4</td>
<td>PCE</td>
<td>Set</td>
<td>Enable priority-access mode (used only with 8D7).</td>
</tr>
<tr>
<td>5</td>
<td>EVC</td>
<td>Set</td>
<td>CKIO acts as input for separate video clock.</td>
</tr>
<tr>
<td>6</td>
<td>VP</td>
<td>Set</td>
<td>Selects European interface vertical sync.</td>
</tr>
<tr>
<td>7</td>
<td>TMS</td>
<td>Set</td>
<td>VSDD as slave in twin mode.</td>
</tr>
<tr>
<td>8</td>
<td>TMM</td>
<td>Clear</td>
<td>VSDD as master in twin mode.</td>
</tr>
<tr>
<td>9</td>
<td>BM</td>
<td>Clear</td>
<td>Combi. sync signal produced at HSYNC pin.</td>
</tr>
<tr>
<td>10</td>
<td>MAS</td>
<td>Set</td>
<td>VSDD generates sync.</td>
</tr>
<tr>
<td>11</td>
<td>INL</td>
<td>Set</td>
<td>VSDD generates interlaced display.</td>
</tr>
<tr>
<td>12-15</td>
<td>CH</td>
<td>CH</td>
<td>Char. height in display lines (0 implies 16).</td>
</tr>
</tbody>
</table>

#### Register-window base address R2

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

#### Data-window base address R3

<table>
<thead>
<tr>
<th>Bit</th>
<th>Mnem.</th>
<th>Cond.</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>3-9</td>
<td>SB</td>
<td>Clear</td>
<td>Upper 7 bits of 10bit coordinate of r.h. display edge. By specifying SB, no time is wasted in constructing non-displayable data.</td>
</tr>
<tr>
<td>10</td>
<td>DWA</td>
<td>Clear</td>
<td>Upper 5 bits of data window word address in host memory.</td>
</tr>
</tbody>
</table>

#### Data-length mask R4

Bits 11-15 of this register are DLW and form the upper five bits of a mask used to qualify which bits of a processor address must match those in the DWA for the address to be accepted as being in the data window. For example, 11000 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 BKN, 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, ODTSB, 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. They are the upper 10 bits of the colour-table word address in ram bank zero.

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**ELECTRONICS & WIRELESS WORLD**

474
64-way connector
+5V
2a, 2c, 31a, 31c
wait 14c
reset 16c

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 CD 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 synchroniz-
ing 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 pro-
cessor 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 regist-

ELECTRONICS & WIRELESS WORLD
<table>
<thead>
<tr>
<th>Mode</th>
<th>Width units (pels)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 bit/pel</td>
<td>32</td>
</tr>
<tr>
<td>4 bit/pel</td>
<td>16</td>
</tr>
<tr>
<td>8 bit/pel</td>
<td>8</td>
</tr>
<tr>
<td>Normal</td>
<td>8</td>
</tr>
<tr>
<td>Falt attrub</td>
<td>8</td>
</tr>
</tbody>
</table>

Note: The mode Table position to locate the values read in the correct RAM locations. This look-up table is then constructed as Cl CO x where Cl and CO come from the object descriptor and x is fixed as 0100.

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.

When using uniform spacing, bits higher than the specified character width are ignored.

The order in which the words appear is irrelevant. At the beginning of each display frame 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.

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 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.

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

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

Joules Watt

O f 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 ideal 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 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 'loss' of the power supply by crossing off 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.

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. 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 $\mu$, $r_m$, $g_m$ and $r_\infty$ are often written as partial derivatives, where the input terminal quantities act as independent variables and the output quantities follow as dependent variables.

Thus

$$\mu = \frac{\partial v_o}{\partial i_i}$$

$$r_m = \frac{\partial i_i}{\partial v_p}$$

$$g_m = \frac{\partial i_i}{\partial v_p}$$

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 of the voltage generator, which is a controlled voltage generator. The second departure is the existence of the current generator, which is a controlled current generator. The third departure is the existence of the voltage-controlled voltage generator, which is a controlled voltage generator. The fourth departure is the existence of the current-controlled current generator, which is a controlled current generator.
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 $\mu$. But one not so obvious question, and one that is also not answered very well in the books, is the second condition $r_o > R_L$. Which voltage amplification are we talking about? Is it $v_o/v_i$, or $i_o/i_i$ because these ratios will be different in general. I have plumped for defining the ratio $v_i/v_o$ as $A_v$, the external voltage amplification, and $i_o/i_i$ as $A_i$ 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 includes the conditions $r_o > R_L$, and $r_i < R_s$. 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 $\mu$. The best voltage amplifiers must therefore have a 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 into the common-emitter 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 circuit would indicate that the common-base transistor circuit makes a good current amplifier. Unfortunately, the current "gain" $\alpha$ 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 mess - 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 into the transfer resistance $r_o$, so the device became known as a 'transistor' or 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, $r_o$. The output resistances and the type of controlled generator differ in the two cases. This could be very confusing as the same term (transfer resistance) 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 measurement, 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 any more. Tone controls in audio amplifiers carry out this kind of function. (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. This kind of functional design is 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 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 amperees 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 strewed with even more pitfalls.

**References**


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.

Fig. 4. If $h_{fe}$ is small and $1/h_{fe}$ 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.
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 imprecise 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 f/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 likening of cheap parts (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 v, while asynchronous counters clocking on the falling edge of the input signal would use signal u. Likewise, signals c and o are used for active high and active low "clear" or "reset" signals. (Resetting should be asynchronous.)

The clock is derived from a 2 MHz oscillator of standard design (Oscillator 1), and the flip-flop FF1 provides the two phase signals v and u.

No signal conditioning circuitry is shown, but will be present if necessary. On the falling edge of the input signal, flip-flop FF2 is triggered. On the next rising edge of signal v, this is detected and stored in flip-flop FF3, (which also resets FF2). Flip-flop FF3 provides signals v and u, indicating that the falling edge of the input signal has been detected, but this information is delayed for one cycle of signals v and u.

If the start of an input cycle has not been detected, and the timing counter has not overflowed (detected by flip-flop FF1), 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 these comparison are latched in FF2.

Multiplexer 1 is an octal 2-to-1 multiplexer, which may be constructed in any convenient manner. Signals v and u are both available, which means that quad And-Or gates could be used. CF1 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.c.s.

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 FF7.

The set input of FF5 and FF7 are used to ensure that the output of FF7 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 FF5).

The output of FF7 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 FF2 and FF4. Various things now happen. Signal c or o 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 is used to reset Counter 2.

The choice of latches is essentially arbitrary. In the circuit described, the latches are loaded either on the rising edge of the input or with the uninput of a 4511 c-mos latch/decoder/driver or on the rising edge of the output of FF2 (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 FF5, 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, if FF5 detects counter overflow, signal n 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 FF5 is reset, and normal operation resumes.

Finally, flip-flop FF8 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 c of FF8 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) LS1111I 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 n used as an address bit must distinguish between data corresponding to transition periods (n low) and output information (n high). The address bit corresponding to signal or a will distinguish between the bytes that go to make up the transition period data (n low) or the output data (n 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 CF1 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, FF2 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 FF7 being used as a “clock enable” input to Counter 2, the clock being derived from signal a or b.
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.

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!

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 conversa-

tion 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
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 measur 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 29th 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 labyrinth of Washington. Here Morse made a dreadful mistake. Smith has been described by many as the distinguished group below comes from a photograph in the collection of Mr Peter Mallett.

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 recognize 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.

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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.

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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.

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 building 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

\[ \frac{v_o}{v_i} = \frac{a}{A} + b \frac{v_i}{v_o} \]

(1)

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

\[ A(s) = \frac{v_o}{s} \]

where \( \omega_h \) 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

\[ \frac{v_o}{v_i} = \frac{a}{b} \frac{1}{1 - \frac{s}{\omega_h}} \]

and the d.c. gain is \( = -a/b \). For the stability of the block, the 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

\[ \frac{v_o}{v_i} = \frac{1}{1 + \frac{s}{\omega_h}} \]

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 shown in Fig. 2, whose general compensated expression for \( v_o \) is

\[ v_o = v_i + v_p = K_v v_p - K_i v_i E(s) \]

where

\[ E(s) = \frac{1 + sT_3}{1 + sT_1 + s^2 T_3} \]

\[ T = \frac{K + 1}{\omega_h} \quad \text{and} \quad T_1 = \frac{K_1 + 1}{\omega_{h1}} \]

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 experimental results were given in ref. 1.

AHMED M. SOLIMAN
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.

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

$$\phi = K \frac{\omega}{\omega_0} \quad \omega < \omega_0.$$  

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 $2\omega/\omega_0$ 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.

BUILDING BLOCK 3

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

$$\phi = K \left[ \frac{a}{K + 1} - 1 \right] \frac{\omega}{\omega_0} \quad \omega < \omega_0.$$  

Figure 7 is a generalization of Fig.2 using blocks 2 or 3 (see ref.6). The phase-lead inverting integrator 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 $3\omega/\omega_0$, which is the necessary amount for phase correction at $\omega_o$.

Another application for BB3 is in the realization of the variable-phase non-inverting integrator 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.
BUILDING BLOCK 4

The inverting building block of Fig. 110 has the transfer function

\[ \frac{V_2}{V_1} = \frac{1}{K + i[a + i + 1] + i} \]

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

\[ \phi = \left[ a + 1 + \frac{1}{K} \right] \omega_0 - \frac{\omega}{\omega_0}. \]

Block 4 can also be used to realise a phase-compensated 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.

References


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

In Fig. 14, the condition for phase compensation is \( K(1 + 1) = K(a + 1) + 1 \), the non-inverting d.c. gain \( P = K \), and the magnitude of the inverting d.c. gain \( N = K(1 + 1) \). 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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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 queuing 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 Islington, 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 mt' 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 software. It is specifically for the production of computer-aided design, 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.

The system is 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 manufacturing control.

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 support 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 EIP 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 Han-
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 playback frequency, noise amount, amplitude and output mix. Pitching is achieved 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 this field. Simultaneously, it has been involved in the development of a number of other products, including the world’s first electronic hi-hat.

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 régime. 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 Telsec data system, these have been broadcast on the IBA LBC 97.3MHz transmitter in London. The system 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 Teletext (UK) Ltd.

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

Irish 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 X.25 network management system. All eight sites are equipped with either 6001 or 6002 statistical multiplexers 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 commitment 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, a new reality, the additional West Coast satellite earth stations coming on stream shortly, and with the advent in 1980 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. We hope to launch 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 for computer assistance? 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 CICnet 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 re-launch of the 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 1010 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 34 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 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-fax/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 PSL/1223 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 Advisory 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 TEMTA, 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.
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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).

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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.

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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.

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 runaway.

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 $V_{th}$ and $V_{ce}$, related to energy consumption during the on state.

The two devices used in the comparison are:

- SGS565: SGS MOS; 400V; 6A; $R_{in} = 1\Omega$
- SGS400036: SGS; 400V; 6A (very fast switching)

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.

Fig. 2 shows the best working conditions for power mos and bipolar devices.

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.

$$V_{th} = V_{th} + \alpha \cdot (T_j - 25°C)$$

where $\alpha$ is a positive coefficient of temperature ($\alpha = 2.310^{-4} \text{°C}^{-1}$). This is a positive feedback, similar to a decrease of

Fig. 3 shows the thermal limits of bipolar and power mos devices.
V_{F1} in bipolar devices. But in a mos device, there is also a very important negative feedback: the increase of R_{th(i-case)} with temperature.

\[ R_{th(i-case)} = R_{th(i-case)25°C} \times (1 + \alpha (T - 25°C)) \]

where \( \alpha \) is the temperature coefficient \( (\alpha = 8.10^{-4} °C^{-1}) \). The effect of an increase in \( R_{th(i-case)} \) is greater than the variation in \( V_{CE} \). 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 SGS475 (400V, 12A, 0.5512). 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 \( R_{th(i-case)} \) due to an external power pulse. In fact, an increase of \( R_{th(i-case)} \) 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 \( (V_{CE} \text{ for SGS471}, V_{CE} \text{ for BUV48}) \). Results are shown in Fig. 4 and Fig. 5. SGS475 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 SGS30MA050D: four mos chips paralleled in a TO-240 package with \( I_{MAX} = 30A, V_{DSS} = 500V \) and \( R_{D(on)} = 0.25Ω \). 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.
**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 ORL

---

**Where does the bus stop?**

There’s plenty of information on terminating unidirectional digital buses but I cannot find anything on terminating 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 any 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. I 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 prospect, 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 merits 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.

Alan Morris
Cambridge

---

**Planck**

One Tedenstig (Feedback, February 1987) represents the equation

\[ H = 2\pi n, r, (a-1) \]

as demonstrating a "deep relation" between \( H \) and \( a \).

Not so, I fear. 

\[ E = h \nu_c = m_c c^2 \]

where \( \lambda = \frac{hc}{\nu_c} \) is equivalent wavelength of electron and \( \nu_c \) is equivalent frequency of electron

\[ m_c = \frac{hc}{\lambda} \]

Substituting in Tedenstig’s equation

\[ h = \frac{2\pi r, (a-1)}{\lambda} \]

- in other words, \( h \) has been crudely 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 \( h \)

\[ 2\pi r, (a-1) = \lambda \]

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

T.H. Brindley
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 \( a + b = h \) 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 constitutive 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&W, 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
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 humans make computers in which $1 + 1 = 0$, carry? Can we really expect to understand the physical universe on this basis?

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 NEC1). 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 continuing work and any future development of RPC1 will be within the CCIR. In 1986 Goly 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 bits/s the potential maximum signal dropout tolerance of RPC1 thus is 21 ms (compare Kirby, Table 21). Clearly the potential of RPC1 was under-utilised, 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 pagers 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 pagers are turning out completely to RPC1 because of its many advantages. Regarding voice on the same channel, RPC1 certainly could be used since each batch lasts 1,060 seconds at 512 bits/s (or 553 ms at 1200 bits/s), which is a negligible 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 noise; 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 briefcase 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 radiopager manufacturers, or BT Radiopaging.
R.I. Tridgell Former 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 phenomena”. 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 Cooke’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 Ampere’s 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 quantitiy 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.

M.G. Wellard
Kenley
Surrey
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### VIDEO SPARES & HEADS

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### PHILIPS G9 10MM ANTI SURGE FUSES

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Radio navigation system

Design, testing and implementation of a Loran navigation system using a Dibit 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 stimuli of 1.3µs and has an internal resolution of 1µs. Theoretical, 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 LCD.

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.

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Middlesex UB7 7BX Tel: 0895 445522

Motorola
ITT Multicomponents 346 Edinburgh Avenue Slough Berkshire SL1 4TU Tel: 0753 824131

Inmos
1000 Aztec West Ammanbury Bristol BS12 6GJ Tel: 0451 616616
-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. codec/decoder. This design is part of Siliconix Applications No.3.

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

Digital switching matrixes like the one shown normally use e.c.l. or t.t.i. 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.
A n 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 IC10 and IC20 (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 IC1, a monostable which drives an 'access' LED. This has proved useful during the construction of both hardware. Data bus transceiver IC7 is enabled by any card access and provides additional protection and fanout.

Figure 5 shows the eight-bit digital output. A single octal latch IC10 latches data written to port address 1. 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 and the Schmitt triggers are fed via R510. This arrangement is highly recommended since it provides very low loading and can be connected directly to 15V CMOS 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 1 µs or so is due to R52, 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-oriented device that latches data written to port address 2 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 IC16, with its sample and hold buffer amplifier. A minimum system would comprise the address decoding (Fig.2), the D/A (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 \textsubscript{240} to around 10µs (100k samples per second). During conversion the Busy output is used to force a Hold condition on IC \textsubscript{240} 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 \textsubscript{w}. Internal circuitry then performs the conversion and data is available for reading at port v. 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 v(0), v(1), together with strobe signals st(0), st(1) 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 2.56V and for accurate reading of the applied voltage this reference may be adjusted to 2.000 volts by V\textsubscript{ref}. 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 V\textsubscript{ref} 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 \textsubscript{501} (timing diagram Fig. 1). A read cycle begins with the end-of-conversion signal v(0) which is stretched by IC \textsubscript{501} to ensure its visibility to the processor read loop. The processor then loops waiting for the first strobe (st(0)) to read the most significant b.c.d. digit, followed by strobes for the other three digits. Strobes st(1), st(2) and st(3) 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 under-range in memory undecoded.

**SIGNAL CONDITIONING**

A quad op-amp IC \textsubscript{601} (not shown) buffers and conditions the analogue signals both inward and outward. The circuits allow a scale factor

**COMPONENTS**

The interface is available fully assembled and tested at £139, or in the following kit stages:

- **Kit A**: printed circuit board with connector for address decoding circuitry of Fig. 2. £16.50.
- **Kit B**: address decoding circuitry of Fig. 2 including p.c.b. connector, and all components fully assembled and tested. £31.50.
- **Kit C**: complete interface including case, p.c.b.s, connectors, switches and interconnecting cable. £17.50.

Prices include postage and packing but please add v.a.t. at 15%. Orders or enquiries should be addressed to Placepower Ltd. Unit 24, Longs Industrial Estate, Englands Lane, Gorleston, Norfolk NR31 6BE; telephone 0493 603771.

---

**ELECTRONICS & WIRELESS WORLD**
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 wavio (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 50 s to 500 s 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 50 s to 500 s 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 interrogated 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 wav.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 wavio program and played out at whatever timebase setting is required.

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

AVAISABILITY
Driver and test routines for the interface can be supplied by the author in full source and object code on 5.25-in 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 'Copps', 8 Robinswood Drive, Ferndown, Dorset BH22 9RT, telephone 0202-87543. 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 wav.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'

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 S14 allows a.c. coupling if required.

TESTING
Physical layout of the interface is important since it must mate with 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-threads 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-threads 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 epoxy cures. Be careful not to be too generous with the epoxy, or the
connector may become a permanent feature of the computer! Wiping the Amstrad connector with a silicone-based preparation such as WD40 will prevent stray epoxy from adhering.

Begin testing with the address decoding circuit of Fig.2. Having checked it, fit it to the computer and run the program pwt. This asks for the selection of a read-data or write-data fast software loop, allowing an ordinary oscilloscope to be triggered from (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 TP31. In this case, trigger the 'scope from ![Figure 3](https://via.placeholder.com/150) (i/o request) using the voin. 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 *in*. 

**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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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

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 5 MHz could be obtained by staggering and the drive required was about 10 watts at 18 MHz.

Maximum length of the cell was limited by attenuation of the ultrasonic wavetrain to about 5 cm. The wavetrain travelled this distance in about 50 microseconds, forming an image 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 300 W 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 synchronisation 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 \((250 \times 12) + 60\), or 30 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 \((10125 \times 60) = 20\), 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).
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 500-550 Hz oscillator through a 6L6 push-pull output stage. Synchronization was achieved via the other motor (a synchronous phononic 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 Voore is a television engineer working in broadcasting.

Further reading


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. 4392361).
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VIS is based on a precision computer controlled 16 channel A-D converter, with six programmable ranges and read rates of 50k samples per second at 8 bit resolution. 25k at 12 bit.

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Generating high voltages for laboratory experiments has always been a challenging task, from both a technical and 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 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 1 μs). 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 1 μs, 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 com-
promise 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 the arc can easily jump from a hot electrode to a person’s face or metal eyeglasses. It is best to avoid all such dangers.

**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. 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, filamentary 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 the 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 on 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.

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 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...
nechanism 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 occur 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 10M11 would easily break down during operation.

Connections to the capacitors are made by forming the flexible 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
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 hifilar 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.

**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 trigger gap.

An earthed wire can be dangled from the ceiling to within a few inches of the top 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 charge 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.

**IMPROVEMENT**

For an improved generator, the resistors on the interstage couplers could be reduced to 1MΩ or, for example, 3.2kΩ 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.

**References**


Edward Richlev 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 Aerox Corporation at their Palo Alto Research Center in California. He also holds an advanced-class amateur radio license, K6RZ.
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<td>10kHz-50kHz</td>
<td>0.005%</td>
<td>1600V, 1200 Va</td>
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<td>1600V, 1200 Va</td>
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<td>0.005%</td>
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<td>0.005%</td>
<td>1600V, 1200 Va</td>
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**TYPICAL PERFORMANCES**

- **Line output transformers**: 0.005% over 10kHz to 50kHz
- **Multi primary transformers**: 0.005% over 10kHz to 50kHz
- **General purpose transformers**: 0.005% over 10kHz to 50kHz

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**IN VIEW OF THE EXTREMELY RAPID CHANGE**
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 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 eirp.s in different channels ranging from 26 dBW to 39 dBW. Thirdly the spacecraft arrives on station. For Skynet-4 comsat. (Courtesy IERE)

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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 inter-modulation products result. Mr Jones mentioned that with two frequency access of equal amplitude, giving a total power just saturating the transponder, the 3rd-order product is only 12dB below the main access levels. Larger numbers of access 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-multiplexing, of course, but there are means frequencies of 30 GHz by BAe/Marconi. Of course, e.h.f. frequency accesses of equal amplitude, giving a total power just saturating the transponder, the 3rd-order product is only 12dB below the main access levels. Larger numbers of access give a complexity of intermodulation levels.

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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 bands at 12.5 and 18.1 GHz.

The repeater used in both spacecraft is manufactured by two members of the Euro-satellite 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 broadband 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 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 f.e.t 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 sends 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 t.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_12 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 Hall.
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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 known 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 19200 baud, and this limits the image update rate.

**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 S1, and the data rate by S2.

Command decoder IC4 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 means of the scan and read latches which are combined in IC17d and buffered by IC1 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 Lk1 on the board.

The clock controller consists of an s-s latch, IC29a, and IC29b, to control the enable.
ing of the address counters and the basic/scan generator; the latter is synchronized to the falling edge of the clock by flip-flop IC10b. The \( \text{ras} \) and \( \text{cas} \) signals are derived from the clock by making use of delays in the associated gates of IC21, IC22 and the buffer register 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 IC13 and IC14, 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 IC15 and IC16, which are also jointly responsible for providing addresses for the on-board static memory IC7. 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 IC15 is used as the \( \text{ras} \) signal. The m.s.b. of IC11 is synchronized to the clock by means of IC17, and it then becomes the \( \text{cas} \) signal, responsible for terminating the scan or read macro-tasks. M.s.b.s of the addresses are derived from the row and column select latches, IC18, rather than the counters, to allow quadrant selection by means of the command decoder. Gating by IC15 and IC23 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 IC19, in conjunction with IC20, compensates for this automatically: but it is also necessary to feed the \( \text{vcc} \) pin of the IS32 to ensure that the photosites are appropriately initialized. The bit-stream is then formatted in bytes by shift register IC8, whose parallel outputs are presented to the data bus of the byte-wide static ram IC7, after buffering by IC3, which is enabled only during the scan sequence to avoid bus clashes with the memory output drivers. A transceiver device was chosen for IC3, 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 IC24. This monostable is enabled only during the scan sequence, and is triggered by the \( \text{ras} \) 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 IC21 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 IC20 and IC21 is required to provide pulses to be used as a byte write-enable (\( \text{we} \)) for the static ram during scan sequences, and as a transmit buffer register load (\( \text{treb} \)) 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 \( \text{we} \) or \( \text{we} \) by the gates IC21b and IC22b, and IC1b, under the control of the Read and Scan outputs respectively of IC20. The role of IC20, is to prevent the generation of either of these signals when the \( \text{ras} \) 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, S1; IC20n and IC20m are responsible for de-bouncing the switch. These sources are combined in IC21b whose direct output, called \( \text{fax} \), is used to initialize the board so that it is awaiting commands from the host, whilst the inverted output \( \text{con} \) 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 \( \text{ct} \) signal is negated and the address counters, basic/scan generator, exposure delay generator, data-packing shift register, byte-wide buffer and \( \text{ras} \) signal are all enabled. The address counters increment from a cleared state and thus \( \text{ras} \) 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 counter returns to zero \( \text{ras} \) 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.
The column counter is incremented, ready for the entire initialize-expose-interrogate sequence to begin again at the next column of the sensor-link. This action continues until 128 logically consecutive columns have been accessed. Completion of the last column causes the m.s.b. of IC1 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 CTS. However, the row address counter increments through 128 states without generating TUR signals because of the inhibiting action of the low CTS line.

During the next 128 counts CTS is high and a TUR 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 (TBE) signal to prevent another byte being loaded before transmission of the current one is complete. The negated TBE inhibits the clock until the uart is ready to send more data, which it will indicate by asserting TAE, thus allowing the clock to re-start. Eight clock periods later the next static ram address will be set up. TUR 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 IC1 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.

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### 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 Bransby’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 coprocessors; 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 68881 has eight general purpose registers for 32-bit single, 64-bit double and 80-bit 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 (32-bit), single-precision binary real (32-bit), double-precision binary real (64-bit) extended-precision binary real...
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 conversion takes 29μsec. (Three instructions) and Cartesian to polar translation takes 39μsec. (Six instructions).

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

<table>
<thead>
<tr>
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<td>FSIN</td>
<td>Sine</td>
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<td>Log x</td>
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<tr>
<td>FLOG2</td>
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<td>Log base 10</td>
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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 root simply involves multiplying the register value by itself (FMUL RFP2, RFP2); 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 (R=arctan(X/Y)) 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 numbers and extended-precision real numbers without using the main a.l.u. A finite state machine (the communication-dialogue sequencer) was 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 bus control logic.

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

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(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, π, 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 - FSINOS. Obtained 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
value contained at effective address <EA>.

For each microcode instruction there is a nanorom
FP4 and puts the result in FP4. Next is a
and the contents of floating-point register
application between the double-precision
This code performs a floating-point multi-

FP1,FP2,FP3 = floating-point registers
sequence:
operand interface register and communica-
EA = effective address and
FMOVE.X FP1,FP2

improves performance consider this code
real numbers and extended real numbers is
the 68882. Logic required to do simple
conversion -control unit has been added to
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 communica-
dialogue sequencer.

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

FMOVE X FP1,FP3
FADDP FP1,FP2,FP3

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 barrel! shift
register, a scientific and mathematical con-
stant rom and the eight floating point

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.

Fig.5. Due to the new 68882 hardware
features all instructions execute slightly
faster. In addition, FMOVE X, FP1 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 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-
operation to the processor). Multiply instruc-
tions 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 instruc-
tion executes instantaneously. This was a
bottleneck with the 68881 as the registers
are not dual ported.

Code sequence in Fig.5 shows the per-
formance 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 dis-
cussed in the next article.

David Burns and David Jones are applica-
tions engineers at Motorola's East Kilbride
plant.
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 LCD 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 ‘noise’ 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 7HU. Tel: 0843 582864.

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.’

NEXT MONTH

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.
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 polarity of the pulses, allowing a change in logic level without having to change cables.

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 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.

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.

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.

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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 I.C. 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 Engehr (UK) Ltd., PO Box 33, Basingstoke, RG21 3JR. Tel: 0256 24299.

Programmable logic
An integrated circuit from Mullard can be configured to be pin-compatible with 19 different standard logic devices. PL153 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.

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 S04 3NB. Tel: 0702 869922.

Eeprom and eprom combined
A high-density, non-volatile, electrically erasable, 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 201ns, and the write time of 2ms/byte is claimed to be five times faster than in other eeproms. This makes the Seeq 48128 especially suitable for 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 S04 3NB. Tel: 0702 869922.

Logic cell array
Claimed to bridge the gap between field-programmable logic and gate arrays, 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 program and 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, 3 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-IIFBC 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 and 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 get an improved Article 17; and those which were to be included ab initio in the improved Article 17 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.

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 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 1988, or 1994 in the case of the 9015kHz 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 the new system, and it is therefore recommended that a further WARC be convened not later than 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 relying on the fact that a planning system might imply a future WARC to be convened not later than 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 procedures.

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 will have been reviewed by a future WARC.

The crystal ball is clouded. Will ITU member states contribute the necessary funds? And will any 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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How good is good enough?

The European delegates to the CCEM 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.t.v. 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-MAC. Yet conform to the loose definition of h.d.t.v. 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 committees. It will clearly take time to reach consensus views but some of the early work was aired recently at the 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 frequency allocations 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 10-Hz display. Intercarrier techniques introduce degradations, yet remain an unrivalled method of limiting transmission bandwidth. A major requirement for 1250 or 1125-line standard would be an electronic camera with adequate performance on a system having a luminance bandwidth of 25 to 30 MHz, still a difficult undertaking.

Some engineers believe that countries in ETV Region 1 (Europe and Africa) should think instead of putting "true" h.d.t.v. 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 hands 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.t.v. 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.t.v. 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 twisting and changing the aspect ratio to 1250 or 1125 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 1966 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 line 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 subsampling 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 3 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.t.v. standards converter. The Japanese NHSEE 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 format 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 Edward 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 not more than 2 inches deep. To qualify, designers need to come up with their design within the next four years.

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, not only for limited applications, from thronnic 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 sub-systems based on thronnic 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 damage if pointed at the sun.

In 1975 Bell Laboratories produced a c.c.d. black-and-white camera with 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 BCC4 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 3/4-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.t.v. with its need for over 1 million 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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ELECTRONICS & WIRELESS WORLD
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 in terms of providing 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 including simulcasting altogether... If the BBC retained v.h.f./f.m. networks, m.f./f.m. 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 m.f./f.m. frequencies will be available for local (community) use.

At present the BBC has four national m.f./f.m. networks, plus the high-power External Services m.f. channel which attracts about 4 per cent share of the U.K. audience. The 1987 BBC Handbook lists 26 Radio 1, 21 Radio 2, 21 Radio 3, 12 Radio 4, 6 Radio Wales, 5 Radio Scotland and 3 Radio Ulster m.f./f.m. 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, the 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./f.m. 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 cover 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 deal of co-channel 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 Cellular and Vodafone cellular radio networks with now over 150,000 subscribers has run ahead of most predictions. Their growth is proving a near match of 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 desktop telephones. In practice, calls get lost when hills intervene between the vehicles and the base station and there can be a good deal of "dropping" 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 PATHAWER.
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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.h.w. 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.h.w. 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 quit their hobby activities restricted by increasing family or business responsibilities and let the 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 call sign 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.

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 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 unceded 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.

Data privacy

Legislative procedures in one’s own country always seem tortuous and opaque—those of other countries just plain un-fathomable. 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 defeated 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 online 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, cryptanalysis 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.

Radio Broadcast was compiled by PAT HAWKER.
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 (hems); 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 700Å 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 Technolog

ogy 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 Aharonov-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 Aharonov-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 the image produces a significant change in the image.

The really ingenious part of the experiment, 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 improve 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 Nevet 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 rechargeable cathode is nickel phosphorus trisulphide (NiPS3), 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.

Dr Nevet and Foot, with the help of the British Technology Group, have now developed a method of producing amorphous NiPS3, 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 NiPS3 can easily be painted on to a nickel surface to make a practical cathode.

A NiPS3 cathode, together with a solid polymer electrolyte and lithium anode, forms a system with two very different energy densities 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 substrate. 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 be useful in a number of 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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The Service is seeking a self motivated, suitably experienced and qualified person to be responsible for the management of the communications system involving liaison with British Telecom and the Home Office Directorate of Telecommunications as principal suppliers (OnC/ HNC Electrical and Electronic Engineering or C and G Telecommunications of MI Electrical and Electronic Incorporated Engineers etc).

Technical details, application form and job description from the Chief Fire Officer, Devon Fire and Rescue Service HQ, Clyst St George, Exeter EX3 ONW.

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Senior Radio Technician & Switching Technician Kiribati

Kiribati, formerly the Gilbert Islands, became independent within the Commonwealth in 1979. The 33 Islands within the group enjoy a pleasant climate with trade winds holding the temperature to a steady 80ºF-85ºF. There is a small expatriate community and several social clubs, but you should be able to organise your own entertainment and intellectual stimulation.

Senior Radio Technician - Reporting to the Director of Telecoms and the Commissioner of Police you will be responsible for the operation of the police radio network which consists of Pye Telecoms VHF and UHF fixed and mobile equipment. This will involve installation and maintenance of HF communications equipment and servicing solar powered non-directional beacons on outer islands, and training of local staff.

Aged 25-50 you should hold a C&G final Telecoms Certificate and have servicing experience of HF, VHF and UHF radio equipment, terminal and voice frequency telegraphic AOR equipment, transmitters of up to 10 kw and aerial systems. Some time spent at technical management level is essential. Local salary is in the range Australian Dollars 4,514-6,544 pa, plus a tax free supplement, payable by ODA, in the range £12,904-£15,888 pa.

Switching Technician - You will be responsible for installing and maintaining public manual and automatic exchanges including power supplies (50V rectifiers and 7.5 KVA diesel standby generators and control systems). You will also supervise and train local staff on installing and maintaining the exchanges and subscribers' telephones and PABX switchboards. A recognised certificate apprenticeship in telephony is essential as is a supervisory management qualification or proven ability and three years experience as a Technical Officer.

Aged 25-50 you should hold a fourth year C&G or equivalent certificate and have at least five years experience of digital switching equipment. Local salary is in the range Australian Dollars 3,598-4,809 pa, plus a tax free supplement, payable by ODA, in the range £11,784-£14,868 pa.

Senior Telephony Training Officer Solomon Islands

The Solomon Islands, which became independent in 1978, comprises a double row of mountainous islands covering 240,000 square nautical miles. Situated in the South Pacific, they offer a warm and temperate climate. Population is around 219,000 and the capital, Honiara, is located on the island of Guadalcanal.

You will be in charge of the Islands' Telephony Training School which is part of the Telecommunications Training Centre. This will involve you in formal practical and theoretical classroom training of trainee and qualified technicians on telecommunications and specialised equipment courses; producing syllabus timetables; assessing students for employment and promotion; day to day administration of the school; and the design of training literature and course materials.

A recognised certificate/apprenticeship in telephony is essential as is a supervisory/management qualification or proven ability and three years experience as a Technical Officer in Telephony Training. Local salary is in the range Solomon Island Dollars 8,316-9,126 pa, plus a tax free supplement, payable by ODA, in the range £10,550-£12,500 pa.

Applicants for all posts should be British Citizens. The first two appointments are on contract to the Government of Kiribati for periods of 21 to 27 months. The third appointment is on contract to the Solomon Islands Government for a period of 2 years.

For all posts terminal gratuities of 25% of local salaries are payable and other benefits normally include free passages, children's education allowances and subsidised accommodation.

For an application form, please write, quoting ref. AH369 /RA/EWW, stating post concerned, to: Appointments Officer, Overseas Development Administration, Room 351, Abercrombie House, Eaglesham Road, EAST KILBRIDE, Glasgow G76 6EA.

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Applicants should be British citizens aged 35-55 who are already Senior Professional Telecommunications Engineers with a degree in Telecommunication Engineering or equivalent and should be IEE members with wide experience in the planning, design and execution of telecommunications projects. A knowledge of telephone networks, exchanges, cable, ship to shore radio and radar is required.

The appointment is on contract to ODA, on loan to the Government of Kenya, for a period of two years. Salary (UK taxable) is in the range £18,000 to £34,600 pa depending on qualifications and experience and will include an element in lieu of superannuation. A tax free Foreign Service Allowance, currently in the range £540 to £2,445 pa, is also payable.

The post is wholly financed by the British Government under Britain's programme of Aid to the developing countries. Other benefits normally include paid leave, free family passages, children's education allowances, free accommodation and medical attention.

For an application form, please write, quoting ref. AH387/SL/EE/W, stating post concerned, to: Appointments Officer, Overseas Development Administration, Room 361, Abercrombie House, Eaglesham Road, EAST KILBRIDE, Glasgow G75 6EA.

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