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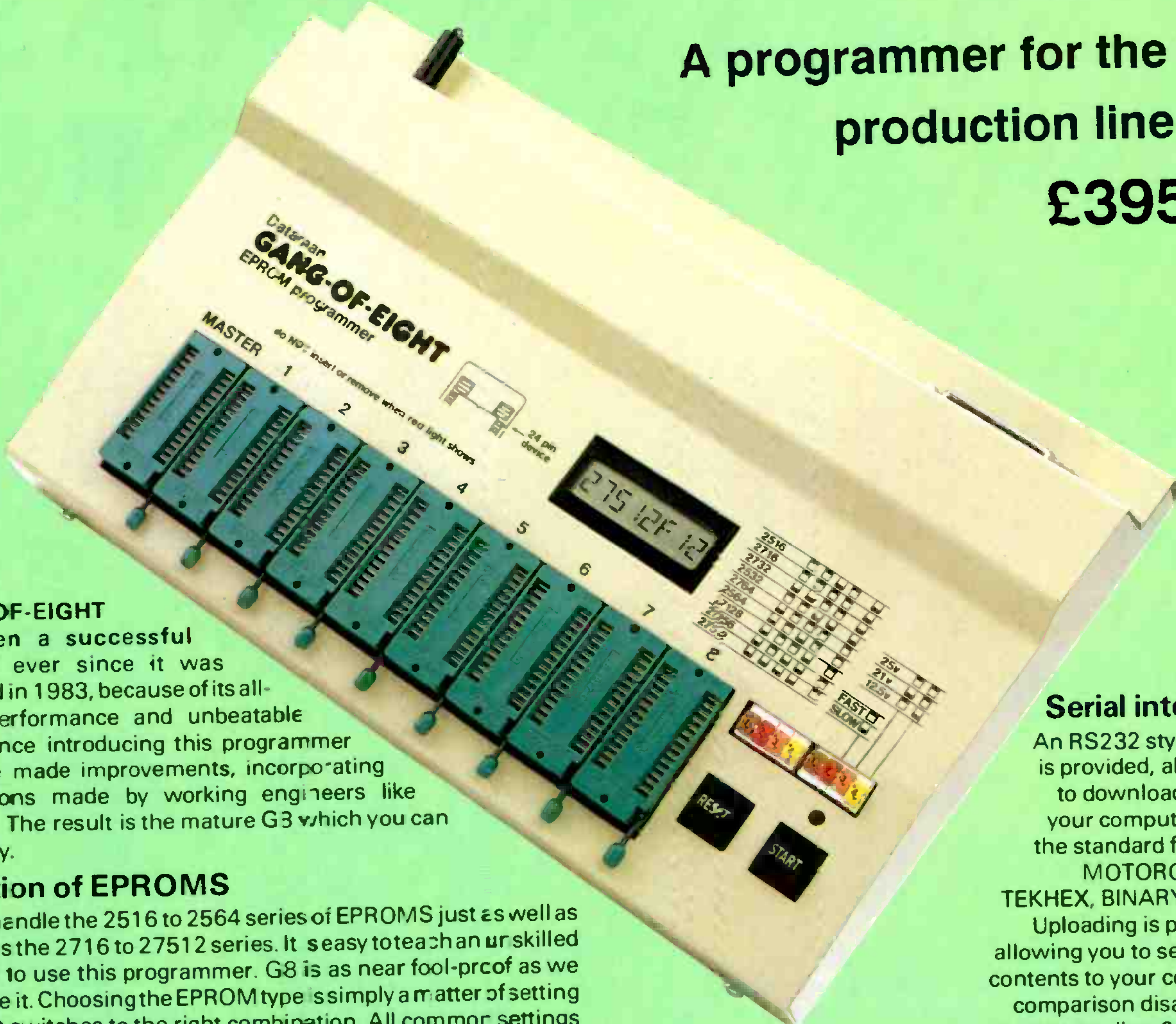

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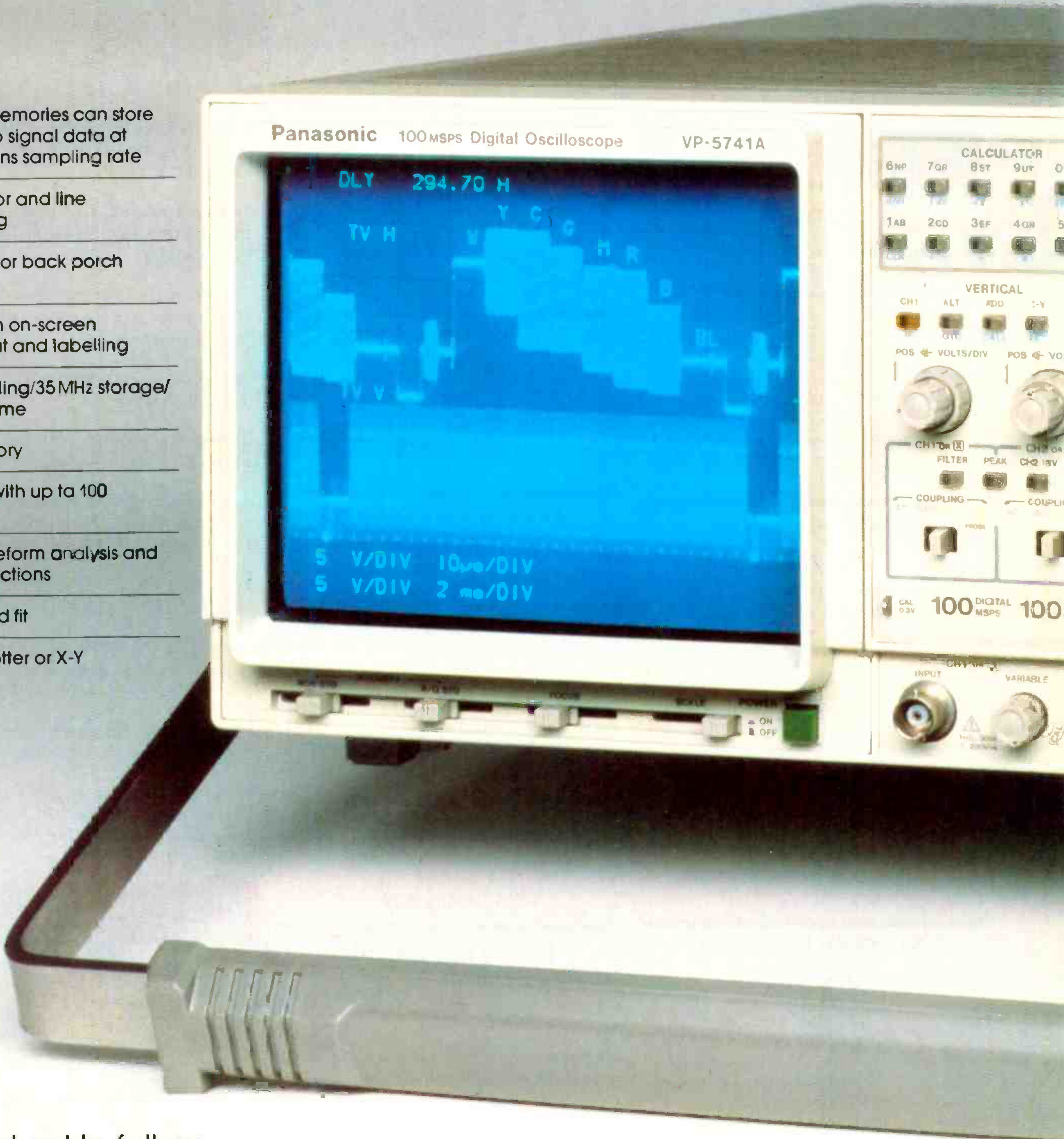

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COMMENT

Games computers play

A few weeks ago someone demonstrated an Atari game that simulated a modern high performance fighter. The graphics were fantastic, with images updated sufficiently fast to avoid the irritating flicker associated with earlier computer games. The sound effects were even better. Before long I had zoomed through the air, shot down dozens of enemy fighters and bombed numerous targets. What fun. What progress in hardware and software.

Such games are immensely enjoyable, but they cannot be viewed in isolation from the rest of society and they may have far reaching implications for all of us.

Just as the map is not the territory, a simulation is not the real thing. You can bomb villages from an Atari without seeing dead babies or getting condemned in the UN. No sane person would suppose for a minute that a games player might leave their toy and climb in to a real bomber for the sake of a little more realism. The more probable effect is that the games player might relate more strongly to military hardware and actively support its development and even use against other human beings. What is the psychological effect of such games on the player who joins the armed forces? Not very long ago a large civilian aircraft was accidentally shot down by people sitting in front of screens deep inside a ship. Is it possible that years of games playing had affected the reaction of these young men?

The fighter pilots in these computer games are not always pitted against an abstract enemy. They frequently find themselves fighting Russians. Suppose the cold war intensifies. Is it beyond the realms of possibility that those who avidly battled against Russians in the comfort of their own homes might support the party wishing to carry that battle into the Russians' homes? Already there have been reports of a game called 'Contra' in the USA, in which the player is sent to invade Nicaragua. The majority of nations (and many US citizens) regard the Contras as terrorists. In this game, a potted and highly inaccurate version of current affairs is built into the game and the user is not asked or expected to question the scenario. The player is required only to kill Nicaraguans – simulated ones, of course.

If this type of game does not disturb the average UK reader, imagine a minor variation on 'Contra'. The goal is for members of the IRA to infiltrate into Northern Ireland and to plant bombs in public places and on buses carrying British soldiers. A truly minor variation from the point of view of the player and the software writer, but imagine the outcry such a game would create in the British Press.

A more observable effect of computer games on society has been the reduction in female students studying computer science. A decade ago some courses had twenty to thirty per cent female students, while today the figure has fallen to two or three per cent. It would be unrealistic to lay all the blame for this reduction at the door of the computer game. However, ten years ago the computer was seen by girls as 'sexually neutral'. Any visitor to a computer games arcade cannot fail to see that most of the games are being played by boys. Many school teachers report that boys also monopolise computers in the classroom. If girls do not get a look-in they rapidly come to regard the computer as an alien artefact not for them.

I do not deny that computer games can be fun and it would probably be as unrealistic to ban such games as prohibition once proved in America. At the same time, the social impact of games will not go away and I do not wish my final thought as I see a blinding flash to be 'I told you so'.

Alan Clements

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A PLL for 900MHz

Applications for 900MHz RF are becoming commonplace. Siemens has brought out a low cost PLL chip pure enough for narrow band PMR and cordless phones.

by
GERT KRINGS, HEIMBERT-ULRICH IRMER and
REINHARD GREIDERER

The allocation of frequencies in the 900 MHz range for PMR and the need to keep the cost down requires a new breed of synthesizer design. Siemens claims a complete IC system solution. The system is particularly suitable for 900MHz applications although its individual components can be applied for other frequency ranges as well.

The TBB200 CMOS PLL circuit uses a digital phase and frequency sensitive detector. It has a high linearity to obtain high speed control loops and very pure oscillator signals. The output stage of the detector has been designed as a current source whose current can in addition be varied in a 1:4 ratio. A voltage doubler integrated on the chip increases the level of the detector output voltage almost to double the operating voltage. Maximum input frequency is 70MHz with an input sensitivity of 10mV. All circuit functions are selected by means of a serial I^{2}C Bus. Low current consumption, low supply voltage, and the voltage doubler make it suitable for battery operated synthesizers.

Fig. 1 shows a block circuit diagram of a system concept for the RF module of mobile telephones. The PLL circuits represent the most important component parts on which the quality of the radio section relies to a great extent. Together with a VCO, it is responsible for the synthesis of the transmitter frequency and the frequency required for mixing the incoming signal.

The electrical requirements on these synthesizers are extremely high. For a mobile radio, a frequency range up to 15MHz must be covered with a channel raster of 25kHz. In addition, the centre-range frequency may not vary more than ±2.5kHz.

The phase noise must not exceed 125dBc at a frequency ±25kHz off the carrier frequency and spectral lines in adjacent channels must be attenuated to at least 75dB. At the same time, loop response times of 10 to 20ms are required. To save current, the transmission path is turned on only when it is needed, which adds demands on the response times.

For cordless telephones, the requirements are identical with the exception of the frequency variation range, which in this case is 1MHz.

The system uses two separate PLL loops. A loop in the receiving path consisting of VCO2, a Pre-scaler T, and a dual modulus PLL circuit PLL2 generate the frequencies necessary for the mixer M2. These frequencies are also used to mix down in mixer M1 the transmission signal generated by the VCO1 oscillator into a frequency suitable for the second PLL circuit (PLL1).

Here, the TBB200 operates in single modulus mode and can process input frequencies of up to 70MHz. While the internal reference frequency is 25kHz at the receiving end corresponding to the channel raster, the reference frequency on the transmission end is 1MHz. The advantage of the resulting short settling time is the modulation of the transmission frequency with the AF signal through modulation of the reference oscillator. When changing the channel, only the PLL2 has to be reprogrammed.

Several aspects have to be considered when using a PLL circuit for applications of this type. A synthesizer represents a phase control loop consisting of a digital phase

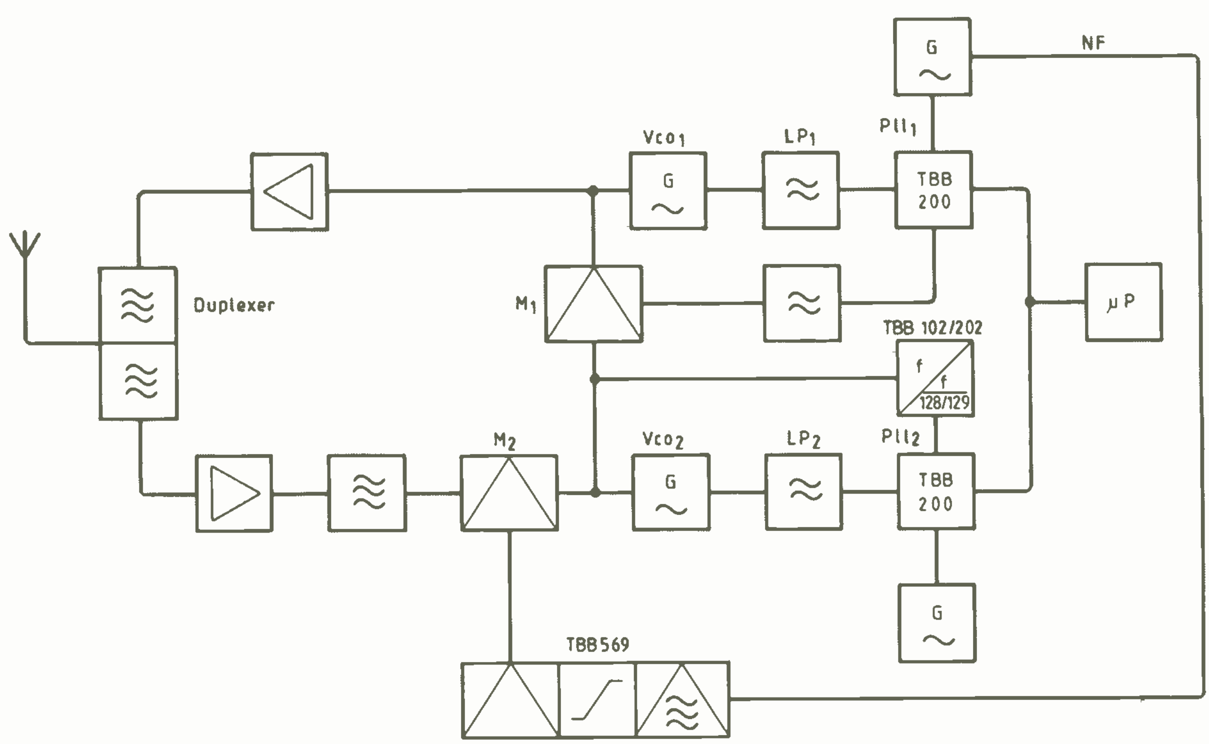


Fig.1. System block diagram with main synthesiser components in place.

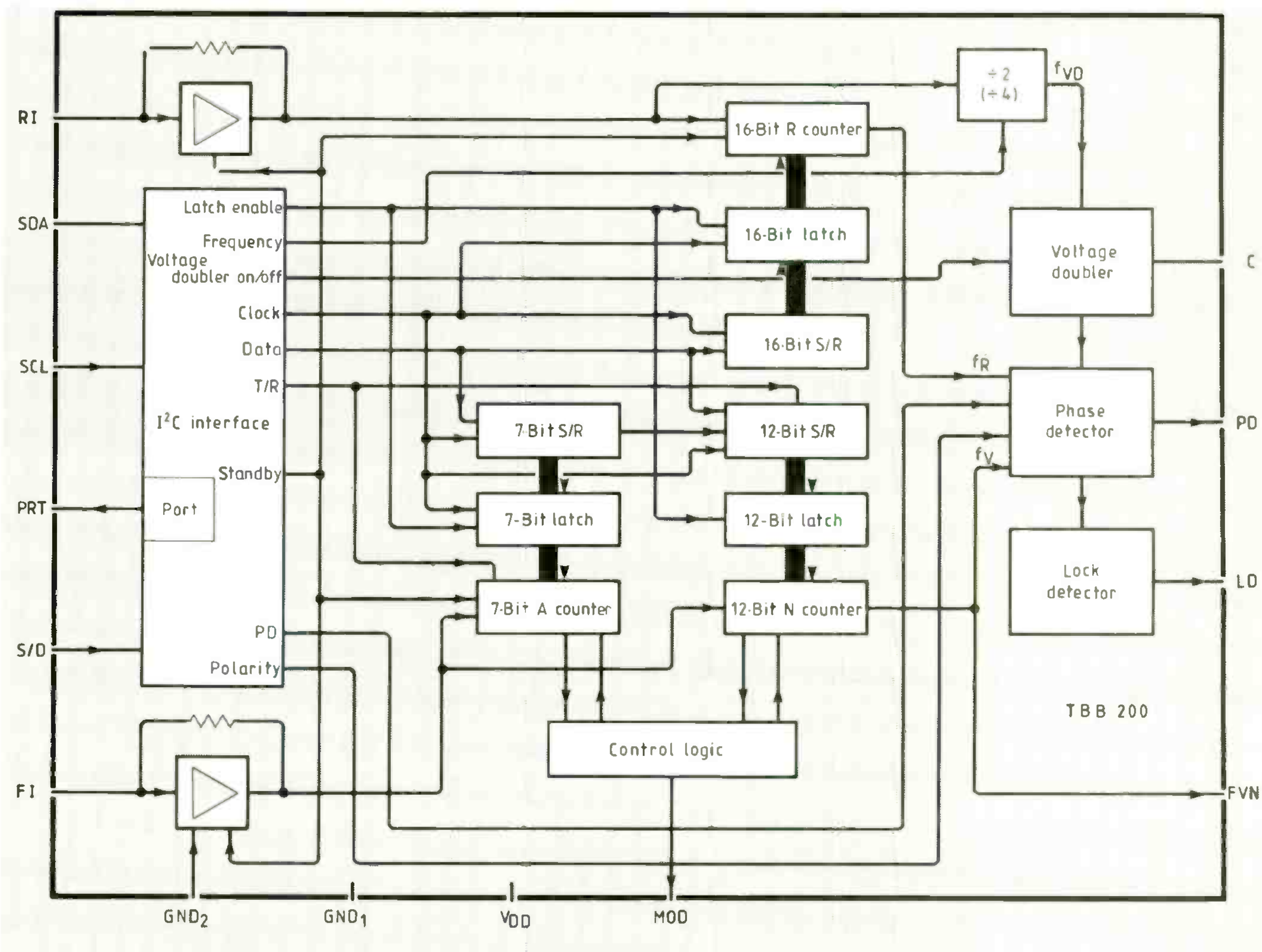


Fig.2. Architecture of the TBB200 chip.

detector, a loop filter, the oscillator to be tuned, and a pre-scaler. The phase difference between the reference frequency and the frequency to be controlled corresponds to the pulses at the phase detector output. They are smoothed by the loop filter and fed forward to the oscillator as control signals. As a result, the loop filter directly influences the spectral purity of the frequency generated and the system's response time.

The phase detector characteristics must be as linear as possible in the vicinity of the zero crossing to ensure satisfactory suppression of the spectral lines at relatively low filter time constants (that is, short response time). Another advantage is the high input sensitivity for the RF voltage coming from the VCO. A jitter-free operation of the internal PLL counter can be obtained at a lower RF level, which reduces oscillator noise. Lower RF levels also reduce interference problems.

Fig. 2 shows the TBB200 architecture. The sine or rectangular input signals at RI and FI are amplified through wideband input amplifiers and converted into rectangular signals by a limiter. Divided down by the R or N Counter, the rectangular signals control the phase detector, which in turn generates the resulting differential signal at output PD. The positive or negative pulses as a function of the phase duration are also present at the lock detect output LD in unipolar form. The locked state is derived from the pulse width. By means of the integrated voltage doubler the reference point for the phase detector output is bised of negative, resulting in a larger variation range for the VCO control voltage.

In dual modulus mode, the control signal required for switching the pre-scaler is supplied by output MOD. It changes its polarity when counter A has divided the input signal according to the set divider ratio.

To achieve low current consumption in battery operated devices, the frequency dividers and input amplifiers can be switched off independently of one another. In addition, additional external circuits can be set in stand-by state by a general purpose PRT port output.

All functions and divider ratios are set with the SDA DATA line and SCL Clock Line via the I²C Bus.

PHASE DETECTOR

The phase detector (**Fig. 3**) in TBB 200 is both phase and frequency sensitive. The capture range of a closed loop is infinite. The weighted pulse duty factor of outputs UP and DOWN is linear in the phase range $\pm 2\pi$. Limited by the real switching times of the output stages, phase differentiations in the nanosecond range can no longer be resolved with conventional circuits. The result is a dead band in the transmission characteristic curve of the phase detector in the vicinity of the zero crossing.

The locked state of a PLL system also means that the momentary control point lies at the phase zero crossing. If there is a dead band the loop is no longer closed. A deviation of the oscillator due to unavoidable leak current in the loop filter will be noticed only when the dead time zone has been exceeded. The reaction time of the control loop varies with the ratio of the VCO frequency counter. This instability leads to increased oscillator noise.

A delay circuit section VZ has been added to the TBB 200 to eliminate the dead band. This (**Fig. 3**) extends the Up and Down signals to time t_D, which is greater than or equal to the switching time of the output stage (**Fig. 4**). Through this method, these stages are simultaneously conducting for a short period.

With conventional push-pull output stages, the internal cross current is superimposed on the supply voltage. The positive and negative anti-backlash pulses are offset in time with the disadvantage that the harmonics created by these pulses are superimposed to the VCO control voltage. When using current sources as output stages, this offset in time is not necessary, since the cross current is limited to the value supplied

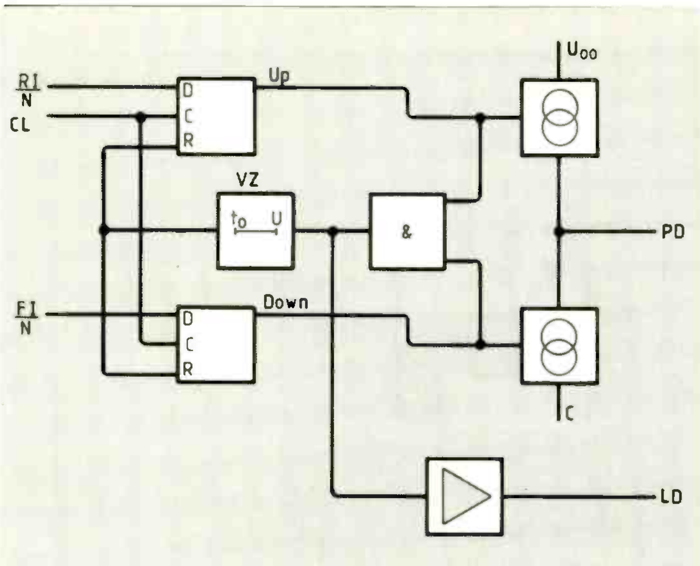


Fig.3. The phase detector circuit arrangement.

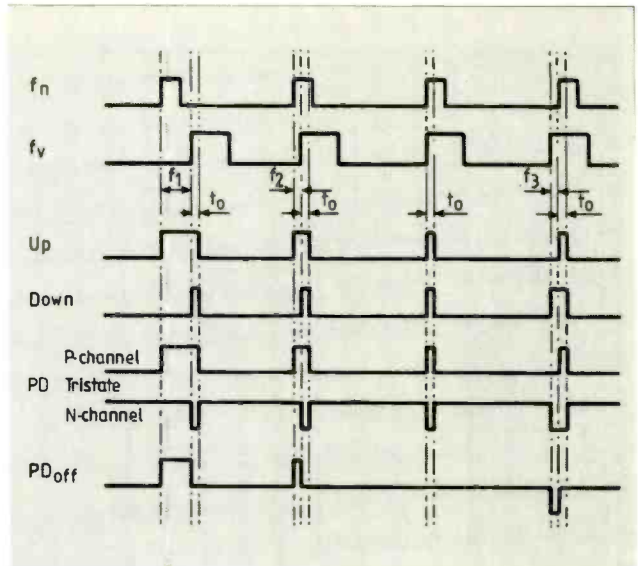


Fig.4. Timing diagram for phase detector. Note pulse overlap.

by the source to the loop filter in case of phase error.

The effects on the internal processes cannot be detected externally. By extending the time of one of the two signals, depending on the corresponding phase differentiation at the input, a pulse is generated at the output whose width is the time difference. The result is a continual linear increase of the weighted output voltage with the phase differentiation.

Use of current sources has other advantages. From the point of integration, it is easy to change the value of the superimposed current and thereby influence the gain factor of the phase detector. In this case, two current values are selected which can be set via the I^2C Bus: $I_{PD}=2.5$ mA and 0.625 mA. The 4:1 ratio does not produce any significant change in the phase angle of the control system, ensuring the stability of the control loop for the given loop filter.

The advantage of controlling a filter from a current source as the output stage of the phase detector as compared to control from a voltage source is that characteristics are obtained independently of the absolute value of the control voltage. One particular characteristic is that a PLL system of the third order can be realised with only three passive components. PLL circuits with voltage output require components which are already active, which naturally increase the noise level.

VOLTAGE DOUBLER

A voltage doubler has been integrated onto the chip. This generates a negative voltage proportional to the operating voltage at Pin C, which is the reference point for the phase detector output PD and, at the same time, for the external wiring. This results in an expanded control range for the VCO.

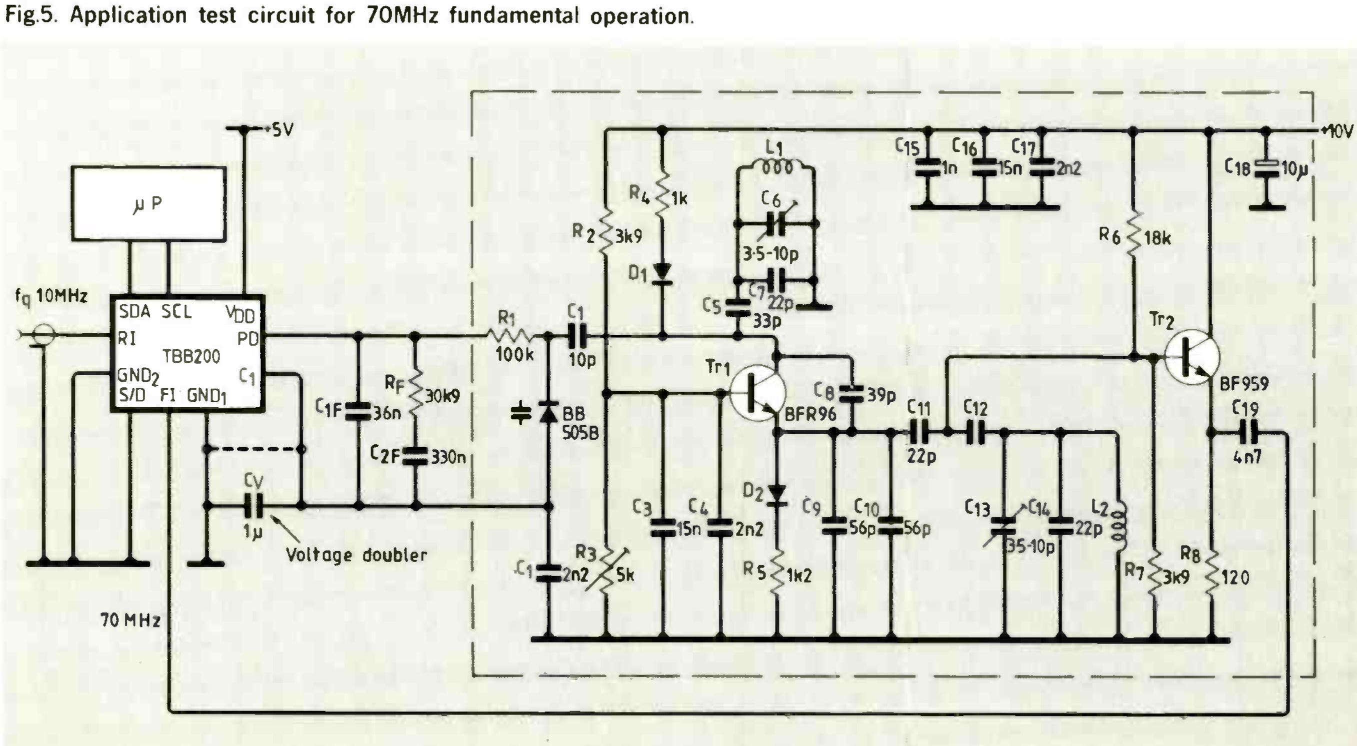
The voltage doubler consists of a push-pull circuit, which switches energy taken alternatively from two integrated load capacities to an external charge capacitor at Pin C. The clock frequency for the capacitive loading is derived from the crystal frequency divided by a factor of 2 or 4 (bus programmable).

Fig. 5 shows an example of a synthesizer for a frequency of 70MHz. The TBB 200 operates in single modulus mode without pre-scaler.

The crystal frequency at input RI is 10MHz. This frequency is divided down internally, to a reference frequency of 25kHz present at the phase detector, which corresponds to a divider ratio of 400 by the R counter. Similarly, the VCO frequency of 70MHz is brought to the same comparison value by a divider ratio of 2800 in the N counter.

The output PD is connected to the control input of the VCO via the passive loop filter,

Fig.5. Application test circuit for 70MHz fundamental operation.



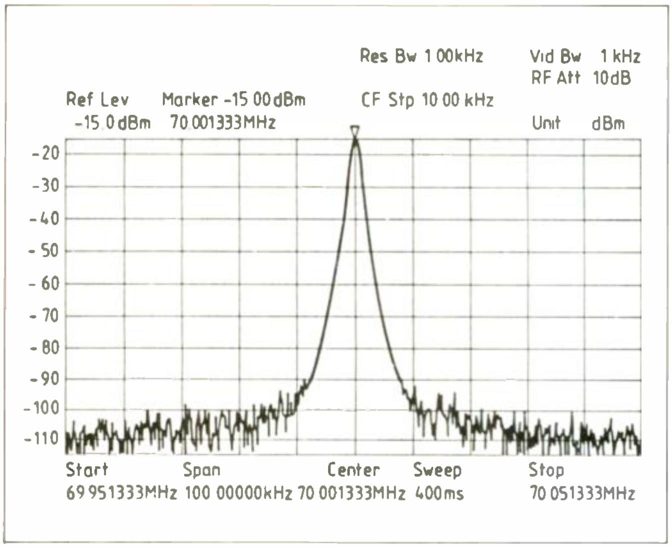


Fig.6. Synthesiser noise spectrum, open loop.

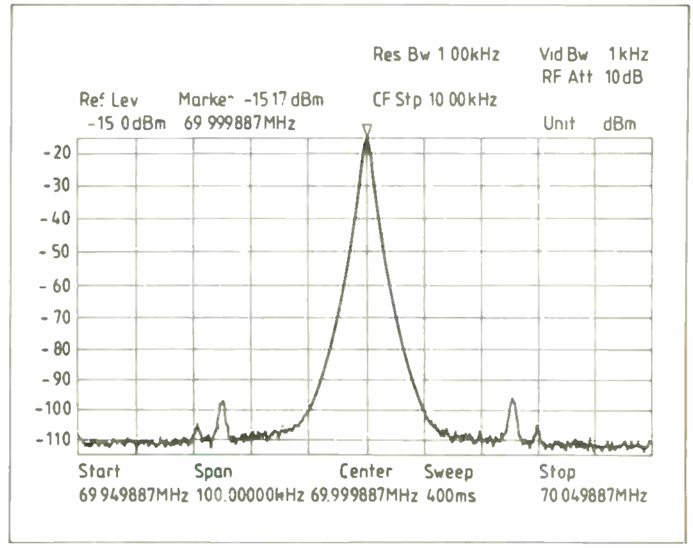


Fig.7. As Fig. 6 but with a closed control loop.

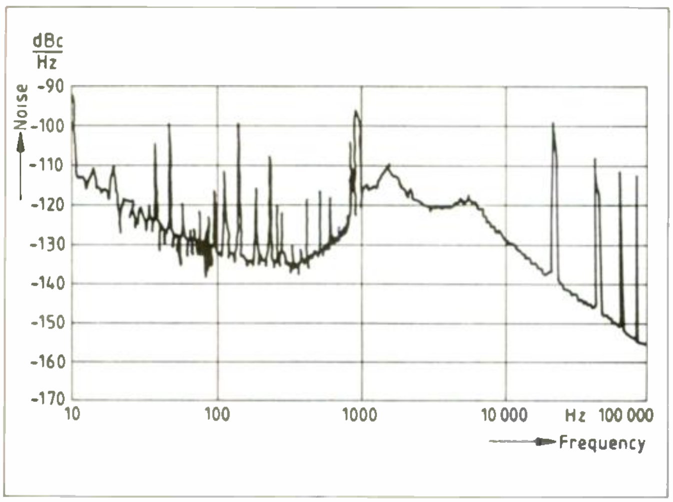


Fig.8. Close in noise characteristics.

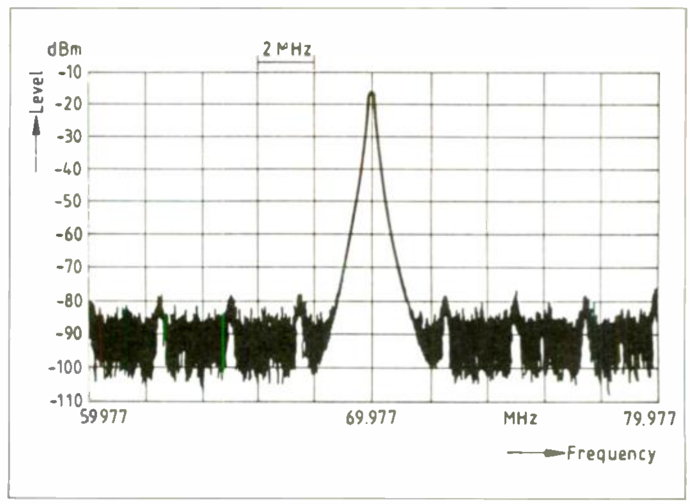


Fig.9. Noise spectrum showing effect of a divided clock.

which consists of three components. The filter time constant is determined in such a way that it produces a settling time of 15ms for a frequency jump of 25kHz, after which the actual value of the frequency is ±6% of the target value. The loop bandwidth was caculated to be 72Hz.

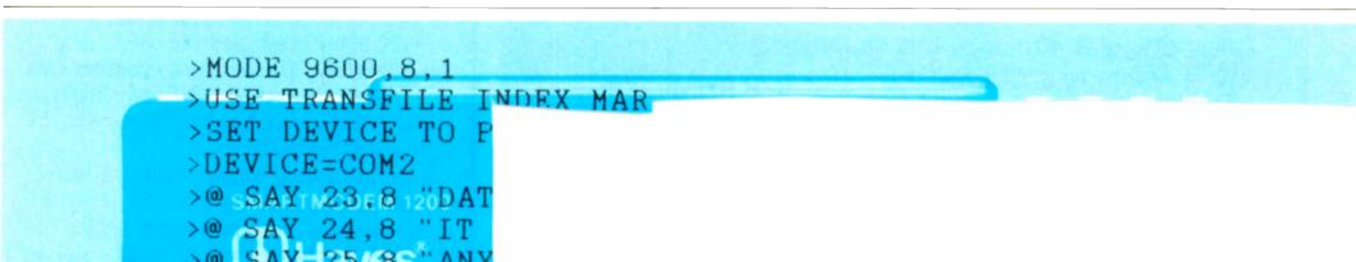
The VCO comprises a controllable Colpitts oscillator with the Tr1 transistor and a buffer stage with the Tr2 transistor. The varactor diode is coupled with the oscillator circuit L1, C6, and C7 via C2. It is grounded to RF via C1, so that the oscillator can be controlled with the voltage doubler integrated in the TBB200.

To suppress unavoidable harmonic signals, a resonant circuit L2, C13 and C14 is connected in parallel to the input of the buffer stage.

The output level of the oscillator is −15 dBm. **Fig. 6** shows the spectral characteristic of the oscillator signal at a frequency ±50kHz off the carrier frequency. In comparison to this, **Fig.7** shows the same curve, but with a closed control loop. As can be seen, the noise ratio is reduced and the spectral lines appearing in the reference frequency range are attenuated more than 80dB. **Fig.8** shows the phase noise at a frequency 10Hz to 100kHz from the carrier frequency, while **Fig. 9** presents the influence of the voltage doubler for a crystal frequency divided by four, used as clock frequency. At a range of 2.5MHz, spectral lines appear, which are attenuated about 70dB. These values depend very much on the circuitry layout.

Reference

1 Best, R.: Theorie und Anwendungen des Phase-Locked-Loop. Arau (Schweiz) AT Verlag



Multi-function multimeters

An unusual feature of the new 80 series of multimeters by Fluke is this flexible stand (below), which consists of alloy cables embedded in rubber. It can be bent over and around equipment housings, pipes or other mechanical supports, to support the instrument safely while enabling the engineer to use his hands more productively. A probe clip moulded into the plastic protective case makes it possible even to use the instrument single-handed.

Technical innovations are to be found within the case. In place of the familiar Intersil digital voltmeter chip, the 80 series has a device of Fluke's own. Besides providing enhanced accuracy, this extends the measurement capabilities into areas which other designs have been unable to reach. At the top of the range is the model 87, which can detect signal transients or glitches as short as a millisecond. It also has true rms capability.

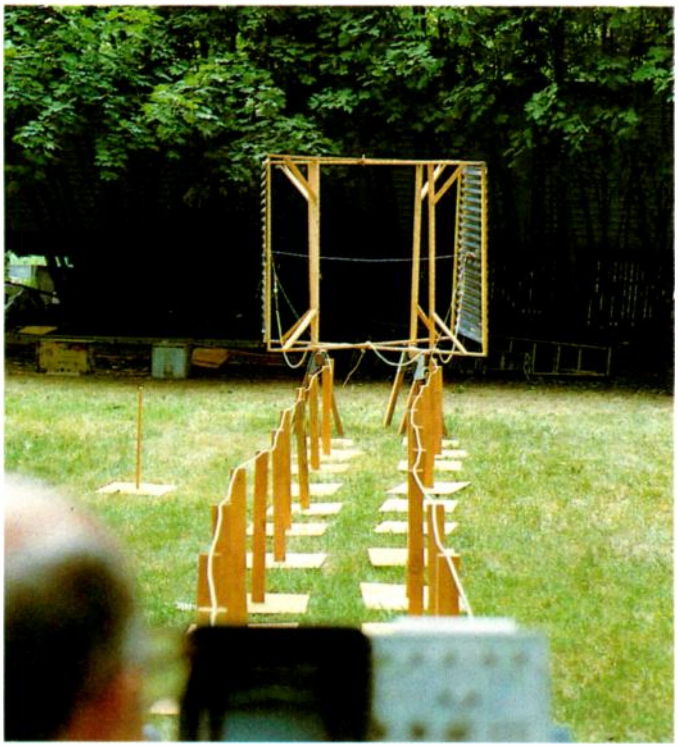
All three instruments in the series measure capacitance, frequency and duty cycle, and have touch-hold, audible min-max alert and min-max average recording facilities – which enable the user to average signals over up to 36 hours. Display is a 3¾-digit (4000 count) liquid crystal panel which includes an analogue bar-graph with a zoom feature. On the 87, a selectable 4½-digit mode is available (20 000 count), and the whole display can be back-lit. The frequency counter covers a wide range, from 0.5Hz to over 200kHz, and is optimized for trouble-shooting ac, 5V logic and 12V systems.

E.m.i. shielding ensures than the instruments work accurately even in noisy r.f. environments. Input protection against up to 1000V is provided on all ranges and an

Thirty six nanoseconds faster than light

This article is based on refined measurements made with the Obolensky electrical circuit arrangement which, in its various versions, has been around since 1977. Since then various reports on possible faster than light events with various speeds have been made.

P T PAPPAS, ALEXIS GUY OBOLENSKY



The present measurements indicate definite anisotropy of the normal velocity of light, depending on the orientation, the time of the day and the polarity of the current. Certain practically instantaneous interactions seem to have occurred beyond the available resolution of the instruments. Other signals have been observed at precisely twice the velocity of light. All the above measurements withstood the statistical analysis for an artifact effect.

In particular, the anisotropy discrepancy is a function of the travelling path, which goes to zero inverse proportionally to the separation distance. The double speed light signal is similarly delayed inverse proportionally to the distance of propagation. The coincidence and phase shifts in the dual channel fast oscilloscope change in accordance to the above effects, indicating that the observed effects are real and not an effect generated in the instruments, detectors or other media.

They suggest that certain signals can travel up to twice the speed of light. These experiments have been conducted since 1977. Similar observations and reports have been made on several occasions by Obolensky [1].

However, systematic experimentation with the parameters of the experiment and systematic numerical analysis of the results was made for the first time during August 1988 at the Technithion/Bromion laboratories at Sloatsburg, New York and are presented here. In this way the significant factors of the experiment and their relation became clear, so that the experiment is reproducible in all its versions.

The experiment employs one of the top fast oscilloscopes available in the market, the Tektronix 2764. Three effects were observed, 1) practical instantaneous interactions, 2) signals propagating at twice the speed of light and 3) anisotropic signals with respect to the direction. None of these cases were expected by the electromagnetic theory.

DESCRIPTION OF THE EQUIPMENT

The Obolensky circuit consists mainly of a symmetrical triangle circuit, as shown in **fig 1**, a battery to supply current around it, two relays to interrupt its current and few more accessories described below. Two 60Kohm resistors are placed symmetrically as shown in the figure, to limit the current so that the battery will not be short circuited and destroyed when both relays were closed. The battery was 250V, a commercial photoflash battery.

Near the two base corners, two identical mercury relays interrupt the Obolensky circuit, which when not excited are normally closed and conducting. Next to the two relays, two signal sensor coils are placed. The two coils were identical. The primary coil is actually the base wire of the triangular circuit, passing through the axis of the coil. When there is a signal through the wire, ie, a change in the current density, an induced signal, ie, an emf potential appears at the coil terminals, proportional to the current intensity change. The induced signal was impedance matched to 50 ohm, through another transformer inside the relay package and connected to a high quality 50 ohm coaxial line.

The coaxial lines from each transformer were mounted on wooden stands about 60cm above the ground and they were arranged symmetrically to each other. They were brought to the oscilloscope and connected through the 50 ohm inputs provided there. The base of the triangle, in the August 1988 experiments, was of variable lengths as well as the 50 ohm transmission lines. For the base lengths of 5,10,18, and 20ft were chosen; and for the transmission lines from 35 up to 105ft lengths were chosen. The base wire was a single commercial wire with a plastic insulation around it. At the ends of this wire and perpendicular to it, two square metal plates of 1.5×1.5 square meters were placed and made contact with the base wire,

Technithion Laboratories, 124 Route 17, Sloatsburgh, 10974 New York

as shown in the figure.

These metal sheets face one another and form the plates of a capacitor. Their function was to enhance the signals received at the oscilloscope. The whole apparatus was movable and could be placed at various orientations. In the first series of the experiments, the apparatus was placed with the base wire facing east/west and the two transmission lines going south.

THE OBSERVATIONS

While the experiment was in operation one of the two relays were excited with 12V AC at 60 Hz, transformed from the 110V mains. This caused the relay to open and close 60 times a second while the other relay remained closed. The signals received at the oscilloscope are shown on page 1164. Obviously when one relay, say relay A figure 1, is energized the event of the capacitor discharge is propagated via two routes to the dual channel oscilloscope: one short route ABF and one longer ACE route. The trigger was set near to zero level and what is shown is the events received from both transmission lines, when either the left or the right relay interrupted the circuit. One signal was always inverted inside the oscilloscope, so that the two traces did not overlap.

The first thing always to notice is the fact that two signals arrive simultaneously from each line, with no detectable time difference. These two signals with initial almost zero amplitude, both increase progressively in magnitude with time. Then a sudden enormous signal appears, almost a vertical spike, which changes the amplitude in the opposite direction. After these two events, dumped oscillations, consisting of similar spikes follow outside the range of the oscillograms, until all the signals go to zero. The signals shown in the oscillograms relate to the event which is caused by one of the relays interrupting the circuit. When the circuit is first interrupted the current still flows, due to the distributed inductance; and it charges the two capacitor metal sheets. The voltage increases between the plates and appears across the opened contacts of the relay. Due to this excessive voltage an avalanche initiates between the relay contacts and the capacitor plates discharge giving a relatively huge instantaneous current, several orders of magnitude bigger than the DC current flowing under steady conditions.

Because of the extremely weak coupling of the signal transformers on the base wire, only the violent event of the capacitor discharge is the event recorded by the oscilloscope. The event of closing again the contact of the relay corresponds to a current increase from 0 to 2mA in about 100 nanoseconds. This is a too small change compared to the capacitor discharge in less than one nanosecond resulting to a change from 2mA to several amperes and back to zero.

The obvious puzzle is what are these two simultaneous signals, related to a common cause, but via unequal paths. Numerical analysis of the data of the August 1988 experiments showed the following facts.

1. The time difference between the two spikes from each channel is proportional to the length of the base wire, the ratio of the length of the base wire over this time difference, is about equal to the expected velocity of an electromagnetic wave along an antenna, which is close to the velocity of light in vacuum.

2. This time difference relates to the direction of the triggering relay and to the polarity of the DC current in the base wire, and according to A. Obolensky, considering earlier data for a given current polarity, it varies with the time of the day; and it depends on the horizontal and vertical directions of the base wire.

3. The time delay, from the moment the two signals appear simultaneously until the first spike appears, is proportional to the transmission line length. The ratio is practically constant and slightly over twice the speed of light in vacuum.

4. Making the lengths of the transmission lines unequal, the two signals no longer arrive simultaneously, but one delays with respect to the other by the amount of time needed to travel the extra length at twice the speed of light.

With the above discoveries, the values for signal velocities along the lines, which best fit all the data are as follows:

a) Two one way Maxwellian velocities C_0 along the base of the Obolensky triangle:

$C_0 = (271 \pm 1.8) \times 10^3$ Km/sec, r.e. 0.7%, for clockwise propagation
$C_0 = (278 \pm 2.2) \times 10^3$ Km/sec, r.e. 0.8% for counter clockwise propagation.

This velocity is responsible for the relative propagation delay of the huge spikes. It is a measurement of one way velocity and not the average measurement of the go and return velocity, as it is usually the average velocity, measured in the case of light. In this way, the one way velocity is found slightly anisotropic as described above and depending on not properly understood factors such as direction and orientation. This uncertainty introduces the relative high error in the data compared to the top technology instrumentation employed in the experiments.

b) A practically instantaneous, non Maxwellian velocity C_{00}, or a higher velocity than the resolution which the oscilloscope allows to detect, along the base of the Obolensky triangle:

$$C_{00} > 100C$$

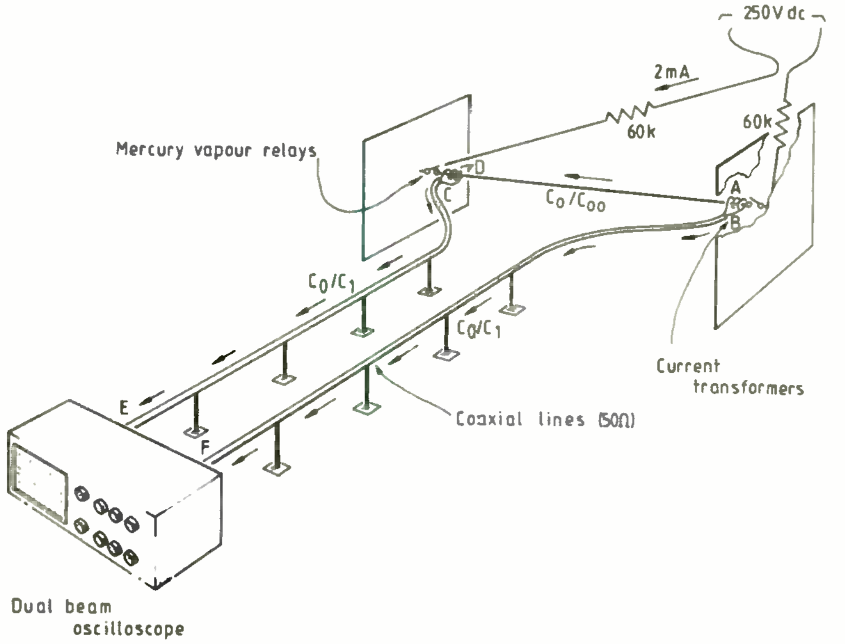


Fig.1. A.G. Obolensky's experiment. Oscilloscope is Tektronix 2764.

Table 1: 10 Velocity in the transmission lines

Trans. line length/ft	Time lapse* ns	Velocity Km/s
74.5	36	630031
39	18.8	632155
39	19.3	615696
39	19	625449.6
55.5	27.2	621792
56	28.2	608990
64.5	32.5	604723
82.5	41	613257
91.5	45	619658
108.5	53.8	614476
mean velocity 619660 Km/s		
standard deviation 2764 Km/s		

*Time lapse between the simultaneous appearance of the two arrival signals and the first spike.

Table 2: Clockwise and counterclockwise velocity

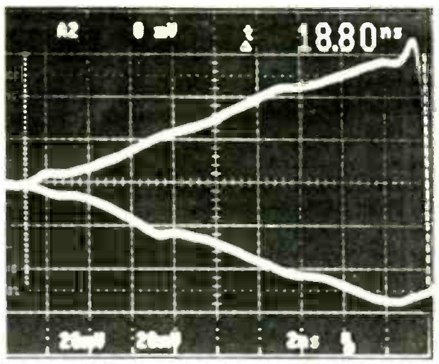
Straight line/ft	Time lapse* CW	Time lapse* CCW	Velocity ft/ns CW	Velocity ft/ns CCW
5	5.65	5.74	.8849558	.8710802
5	5.62 ns	5.78 ns	.8896798	.8650519
5	5.62	5.74	.8896798	.8710802
5	5.65	5.81	.8849558	.8598452
10	10.85	11.25	.9216589	.8888889
10	10.7	11.00	.9345794	.9090909
18	19.2	19.75	.9374999	.9113924
20	21.4	22.00	.9345794	.9090909
mean velocity Km/s			278000	271000
standard deviation Km/s			1800	2200

*Time lapse between the two successive spikes.

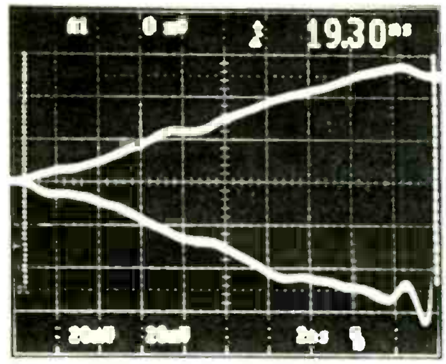
Measurements show that there might be a phenomenon – a purely electrical signal speculate the authors – that travels faster than light. It shows up here as the simultaneous arrival of a low level signal (at the origin on the left of each trace) occuring just before the relatively massive swing that you would expect to see when the relay opens.

Antenna distances and transmission-line lengths have been varied, and even the orientation of the set up has been altered. In each case, the phenomenon remains.

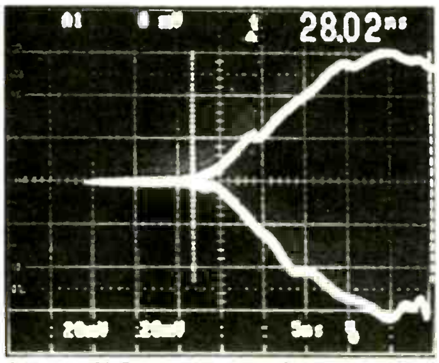
The pulse relay has picosecond rise and fall times.



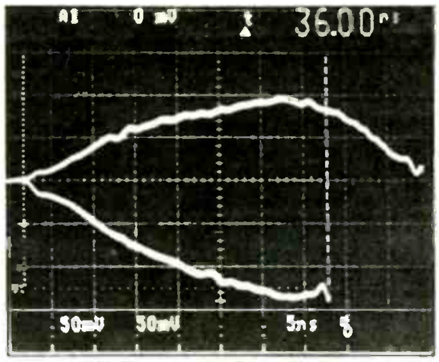
Antenna 10ft Transmission line 38.5ft
C1 = 2.074 × 10^9ft/s = 632155km/s



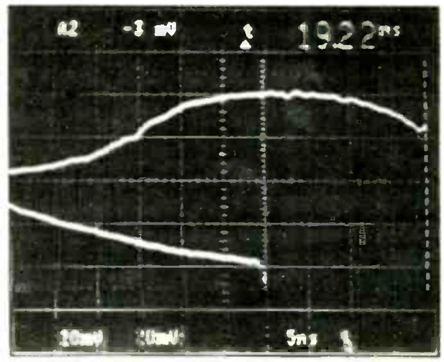
Antenna 10ft Transmission line 38.5ft
C_1 = 2.02 × 10^9ft/s = 615696km/s



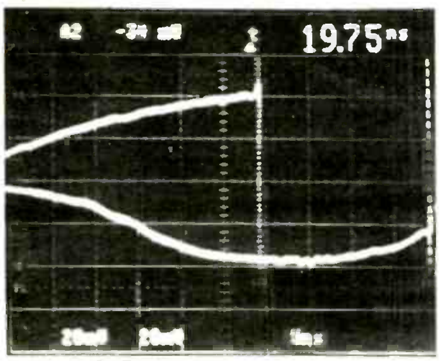
Antenna 10ft Transmission line 56ft
C_1 = 1.998 × 10^9ft/s = 608990km/s



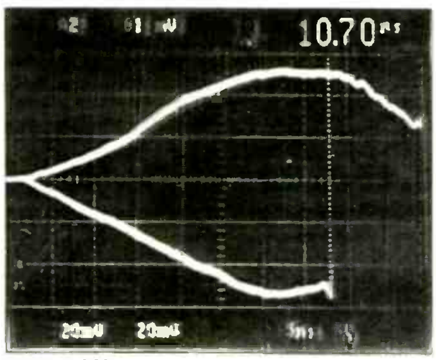
Antenna 10ft Trigger south Transmission line 74.5ft
C_1 = 2.069 × 10^9ft/s = 630.031km/s



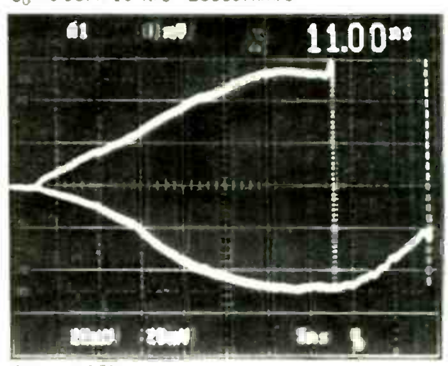
Antenna 18ft Trigger west
C_0 = 0.937 × 10^9ft/s = 285597km/s



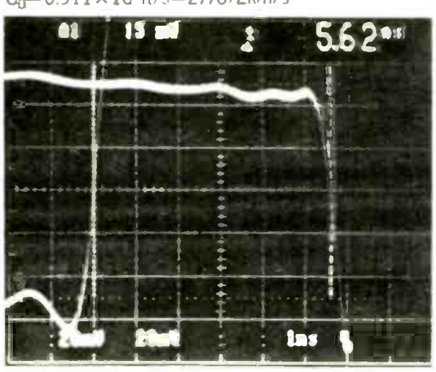
Antenna 18ft Trigger east
C_0 = 0.911 × 10^9ft/s = 277672km/s



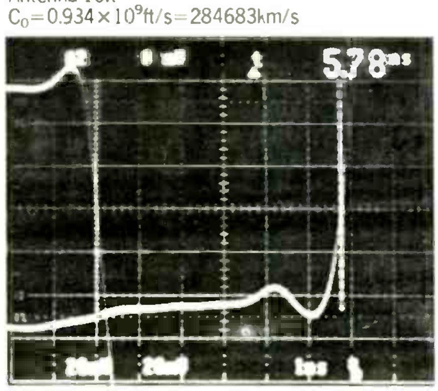
Antenna 10ft
C_0 = 0.934 × 10^9ft/s = 284683km/s



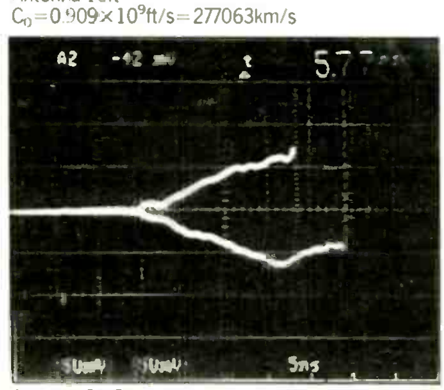
Antenna 10ft
C_0 = 0.909 × 10^9ft/s = 277063km/s



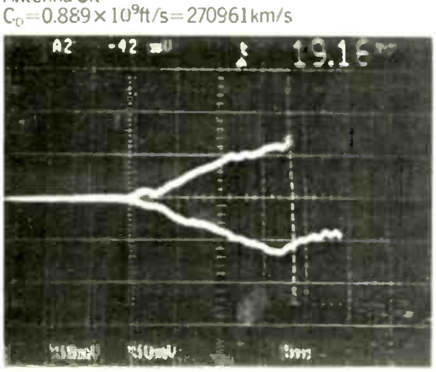
Antenna 5ft
C_0 = 0.889 × 10^9ft/s = 270961km/s



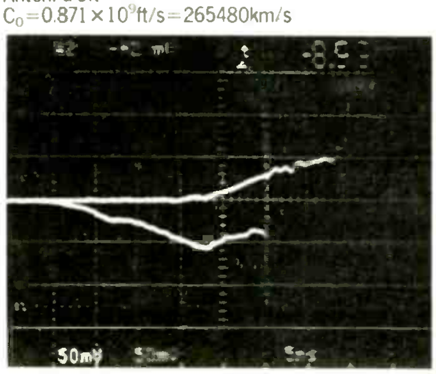
Antenna 5ft
C_0 = 0.871 × 10^9ft/s = 265480km/s



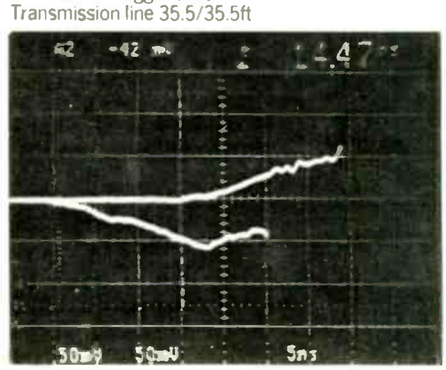
Antenna 5ft Trigger south
Transmission line 35.5/35.5ft



Antenna 5ft Trigger South



Addition line length to one leg produces expected lag



This velocity is responsible for causing no delay to the low amplitude signal, travelling the base of the Obolensky triangle and through the remote transformer down the coaxial line to the oscilloscope. This signal arrives simultaneously with the other signal travelling the shorter route, ie from the energized relay to the nearby transformer and via a coaxial line of the same length, finally to the oscilloscope. No difference is caused to the simultaneous nature of the signals, by changing the length of the base of the Obolensky triangle.

c) A Maxwellian velocity C_1 close to the velocity of light along the transmission lines, which is the expected standard propagation velocity of the coaxial lines. This velocity does not affect the relative positions of all signals for equal transmission lines. This velocity as determined from our limited data was:

$$C_1 = 200110 \text{ km-sec.}$$

This velocity is responsible for the propagation of the huge spikes along the transmission lines. Their absolute delay is affected accordingly to this velocity and to the length of the transmission lines.

d) A non Maxwellian velocity C_o, about twice the velocity of light along the transmission lines.

$$C_o = (620 \pm 2.7) \times 10^3 \text{ km/sec, r.e. } 0.4\%$$

This velocity is responsible for the propagation of the low amplitude signals at the beginning of the oscillograms. The relative appearance of these signals is proportional to this velocity and to the length difference of the transmission lines.

Similarly, the relative delay of the first spike from the beginning of its signal trace, is affected accordingly to this velocity and to the length of the transmission line it propagates.

From the above, we see that there are two modes of propagation in each line. One mode which carries most of the energy is the normal velocity of propagation mode known for these transmission lines which we call Maxwellian mode. A second non Maxwellian mode of propagation with much higher velocity than the first, carrying a low energy signal of the same event. However, it was found for the coaxial line to operate at the superluminal velocity, non Maxwellian mode, it was necessary not to be near bulky objects or the ground and not to undergo sharp bends.

This was the reason the coaxial lines were mounted on elevated wooden stands. It was found that the speed of the signals drops considerably as soon as the coaxial lines come close to the ground or to a bulky object. Analysis of this behaviour showed that the speed signal in the coaxial line is about twice the speed of light for the section between the transformer and the first section close to a bulky object or to the ground. After this section the velocity drops down to about its Maxwellian value. It seems possible that several internal and external factors determine this non Maxwellian velocity, and have to be found.

No theory available at the moment seems to explain these superluminal velocities. The fact that they carry low energy signals under special conditions, seems to be the reason that they have been unnoticed today.

REFERENCES.

1. Alexis Guy Obolensky, Proceedings of "The International Tesla Conference", Colorado Springs, 1986 and 1988.

2. Harold W. Milnes, "Faster Than Light Signals", Radio Electronics, V. 54, No 1, p.55, 1983. (This article came to our attention after writing this report).

Wu, Chu and superconductors

Alabama and Texas are at war. Fortunately, the war is currently being conducted with words as the weapons and patent applications and commercial contracts as the prizes, but it is beginning to warm up a little.

Dr Maw-Kuen Wu of the University of Alabama in Huntsville and Dr Paul Chu of the University of Houston are at odds (or, rather, their universities are) over the share of credit each of them is claiming for the discovery of yttrium-barium-copper-oxygen material which becomes superconducting at 98°K. Some of the heat in the controversy is possibly generated by the signing of an agreement between DuPont and Houston to "commercialize superconducting products and processes based on the discoveries of Dr Paul Chu", to quote the local Huntsville paper *The Huntsville Times*. Both the university and Dr Chu stand to receive substantial profits from the agreement, particularly if a patent on the material is granted.

In January 1986, Bednorz and Müller at IBM in Zürich came up with a lanthanum-barium-copper-oxygen material which superconducted at 30°K. On the publication of this work in September 1986, Dr Chu reproduced the results at Houston and mentioned the fact to Dr Wu, who had been one of Chu's students and had subsequently gone to Huntsville. A worldwide crescendo of activity ensued, with a view to increasing the superconductivity temperature, the Houston group finding transient indications of the effect at temperatures up to 100°C.

Chu, at Houston, believed that there was a real chance that a number of new materials based on the IBM work could now be made and promptly filed a patent with, reportedly, an extremely wide scope for materials which had not yet shown reproducible effects at over 77°C – the boiling temperature of nitrogen.

Seventeen days later, Dr Wu at Huntsville was able to show the effect at 93°C in a sample of Y-Ba-Cu-O material and immediately informed Dr Chu, since the two had agreed to co-operate fully on the research. A press conference was held a couple of weeks later. Chu being the senior of the two, he was accorded the major share of attention and, therefore, credit for the discovery, though he was personally meticulous in including Wu in his remarks. The down-grading of Wu's (and therefore his university's) efforts by the press has been exacerbated by the DuPont contract with Houston, but the two scientists have tried to remain aloof from the wrangling. The discoverer of the first, reproducible high-temperature superconductor will probably be recorded as Dr Chu of Houston with, at the most, a passing reference to Dr Wu. It seems strange that the two IBM researchers who started it all are rarely mentioned.

Dr K.A. Gehring of GEC Hirst Research Centre speculates on the first uses of superconductivity.

Microwave components come right at the top of the list of possible superconductor applications. There are real benefits in using superconductors in that you get dispersionless and lossless propagation of e-m waves. It enables construction of higher quality filter systems, resonators and so on and yet the fabrication technology required for these applications is not even as sophisticated or demanding as it is for active electronics. Superconducting quantum and radiation detectors present a typical early application.

Hybrid superconducting and semiconducting devices are particularly interesting. Many of the standard semiconductor devices work happily at liquid nitrogen temperature. New superconducting materials close the gap. There are now perfectly accessible operating temperatures at which both superconducting and semiconducting materials will operate simultaneously. This means that 20 or so years from now there will be a range of novel devices of which there are, as yet, no known details. The potential for the combination of these two particular types of material is immense.

Superconducting magnets is an obvious application of these materials. Where helium technology is currently used, the new superconductors could bring benefits, provided the materials problem can be overcome. The range of materials which display superconductivity at these high temperatures is now fanning out. New materials are being discovered at a comparatively rapid rate.

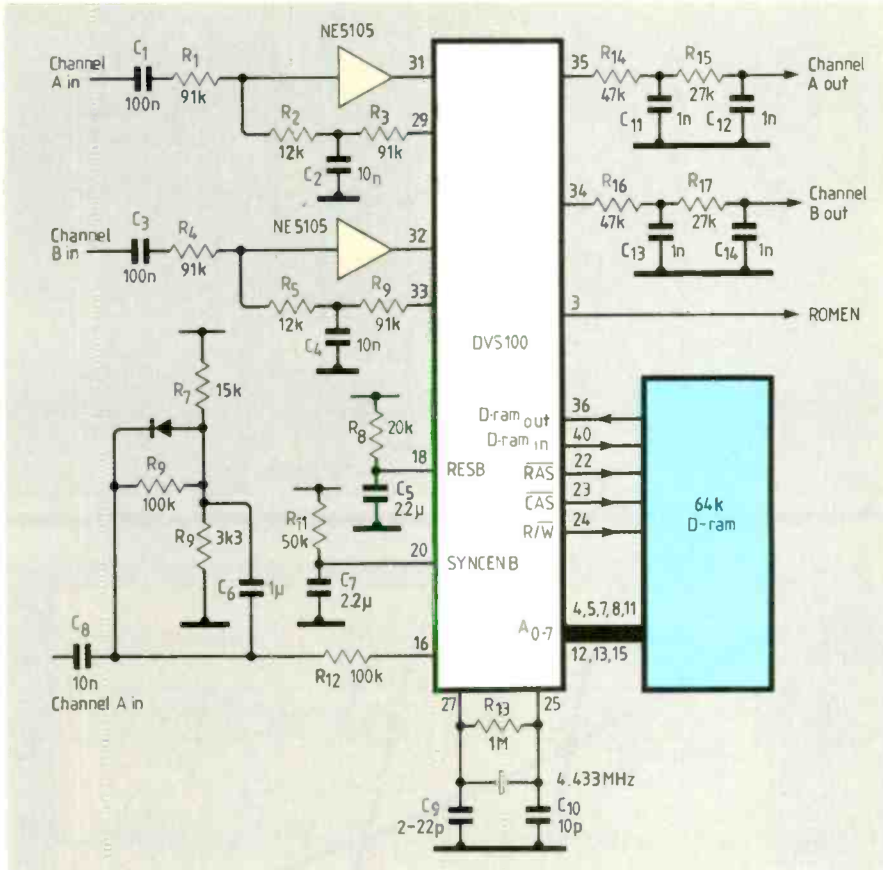
Japanese industry has a planned superconducting train. It feels confident enough to produce a model for public inspection on the platform at Tokyo railway station complete with leaflets for school children. Superconductivity has been brought to the attention of the man in the street as well as the Japanese research laboratories.

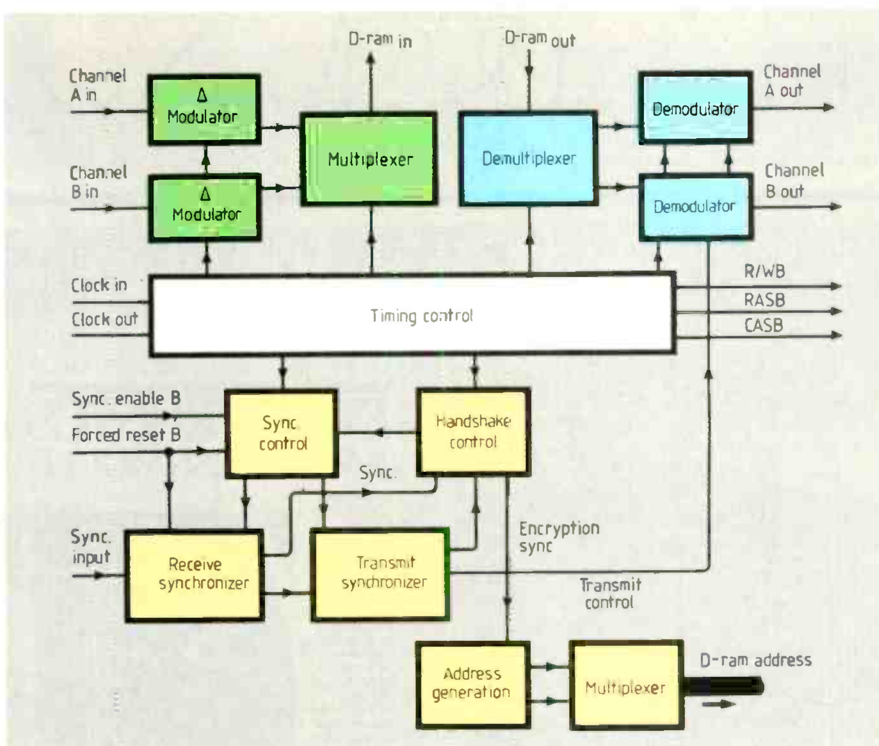
APPLICATIONS SUMMARY

C-mos speech encryption

In both the US and Europe, business users have become increasingly disenchanted with their mobile radios and cordless telephones: now that wide-band scanning receivers are available cheaply in almost every high-street, confidential call traffic can be intercepted by anyone. To combat the problem, Marconi Electronic Devices is producing a one-chip speech privacy codec suitable for use in any analogue telephony circuit.

In the DVS100, speech is converted to digital form by delta modulation; two conversion channels are included, for duplex communication. Each frame (about 100ms long) is reversed in time and then converted back to analogue for transmission. This technique scrambles the speech enough to defeat casual eavesdropping; but security can be enhanced by adding a prom and a few other components, which make it possible to transpose time segments according to a rolling key. A two-way link is required for the chips to establish synchronization: even an eavesdropper equipped with another DVS100 is unable to listen in. A data/application sheet from MEDL (numbered C751D) describes the cryptographic technique and shows sample configurations for various types of communication link. Price of the device is £24 for 1000-up.



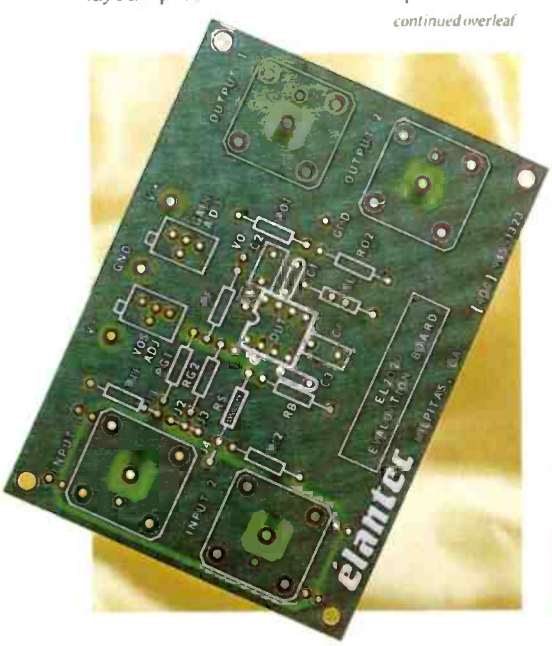


The DVS100 speech encryption chip is a low-power c-mos device suitable for use in communications handsets. Chip design was by AEP (Merseyside) Ltd.

High-speed amplifiers

Bread boarding with a 50MHz current-mode feedback amplifier can be tedious due to layout problems. Elantec has produced a

continued overleaf



ADDRESSES

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08446 8781

Marconi Electronics Devices Ltd
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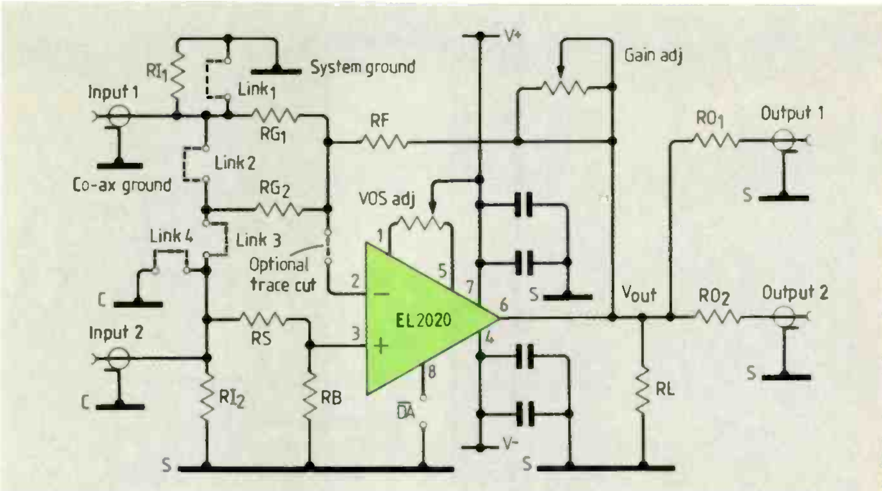
0522 500500

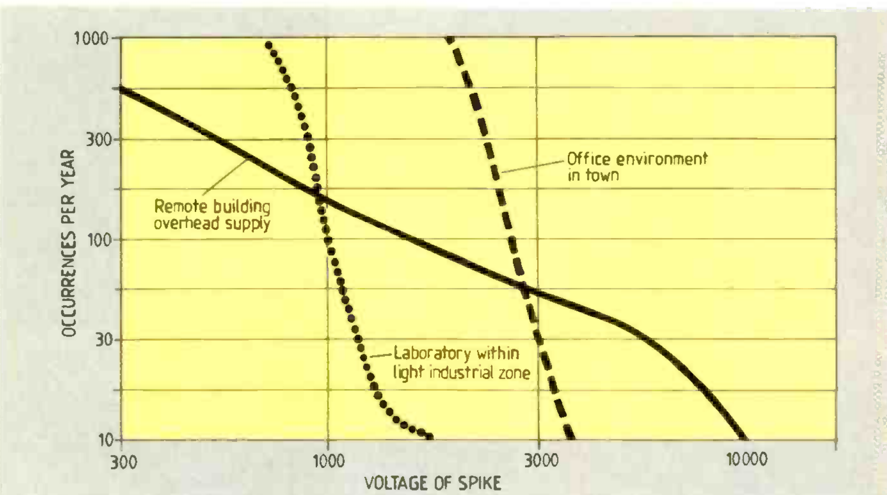
Lightning Elimination
Bandet Way
Thame
Oxon OX9 3SJ
084421 3204

APPLICATIONS SUMMARY



demonstration board that simplifies development work with their EL2020 monolithic amplifier, and five configurations that can be made up on that board are presented in "Using the EL2020 demonstration p.c. board."

This non-inverting buffer is accompanied by a times ten amplifier, an inverting buffer, a summer and a video distribution amplifier with loop-through difference input. The EL2020 is a monolithic device capable of supplying 30mA with 500V/µs slew rate.



Computer reliability

An update of "The reliable operation of computer-based systems in the office environment" is now available.

Written as an aid to "the successful computer installation in the average office environment", this note, from Lightning Elimination, is one of a set of four covering the protection of electronic systems from transients and lightning. It explains the nature of the interference problem, presents different solutions, and gives some guidance on problem solving.

In their introduction, the booklet's authors quote IBM and Bell Laboratories research indicating that 88% of mains-derived computer problems are due to spikes, about 11% are due to voltage fluctuations, and only about 0.5% are due to total power failures. This graph, based on international data taken from companies in America, Switzerland and the UK, does not include dips in the supply caused by heavy load switching.

NEXT MONTH

Working with DSP. The fast Fourier transform is one of the most universal of DSP applications. We present an overview of the possible routes to FFT and FIR filters and examine ways of implementing them. We also look at strengths and weaknesses of specific DSP chips and the algorithms with which to program them.

Realtime I/O control using the Z80 family. Organising and writing software for realtime I/O control challenges ingenuity if hold-ups are not to occur in the system. Multitasking co-routines are much faster than single task subroutines when slow peripherals are involved. Speed yours.

Practical design – an electronic frequency counter. An 8-bit processor lies at the heart of this design providing exceptional versatility and general usefulness. It offers seven digit resolution to 1GHz with a prescalar option. It will also calculate sum, difference and ratio functions.

Optically broadcast telecomms. Rather than provide point to point communications links with selected traffic to a selected route, why not send all traffic down all optical lines and pick off what you need? Optical waveguides now have the bandwidth and BT Martlesham thinks optical broadcast has real possibilities.

The economics of equipment hire. The true cost of under used test equipment can be surprisingly high. Hire and leasing options look attractive for more reasons than a possible saving in money.

Caching in the chips. Cache is a way of making slow, cheap DRAM look like fast, expensive SRAM. Intel's 82385 cache controller chip intercepts data traffic destined for the main system memory and diverts it to a small, high speed SRAM. Frequently used data is always kept to hand, available to the processor without wait states. The article describes how it is done.

Spectrum analyser using fast Fourier techniques

Fast digital signal processors and analogue-to-digital converters allow the design of a spectrum analyser to handle 100kHz signals over 72dB

PAT MEEHAN AND JOHN REIDY

Spectrum analysis based on swept heterodyne techniques is the best solution for the analysis of megahertz signals. The elaborate analogue circuits needed to heterodyne and band-pass filter a complex waveform would, however, strain almost any engineer's design skills. Fortunately, designers who need to analyse lower bandwidth signals have an alternative: f.f.t techniques employing fast, digital signal processors and analogue-to-digital converters, which enable the simple construction of a spectrum analyser that handles 100kHz signals over a 72dB dynamic range.

A low-cost, high-performance spectrum analyser consists of d.s.p., an a-to-d converter, analogue circuitry, program and data memory and interface logic. The system shown in Fig. 1 uses a common data address and data bus to communicate to on-board circuitry and an external processor. This external processor can be the c.p.u. of a personal computer, which can use its c.r.t. display to plot the spectrum analysis results.

As with any data-acquisition system, a spectrum analyser's performance relies heavily on the analogue front-end circuitry. The designer must carefully select circuits that minimize harmonic distortion and spurious noise. The circuit shown in Fig. 2 employs a ninth-order, elliptic anti-aliasing filter (Fig. 3), a fast 200ns track-and-hold amplifier, a 1.5ppm/°C voltage reference and a 3μs, 12-bit a-to-d converter.

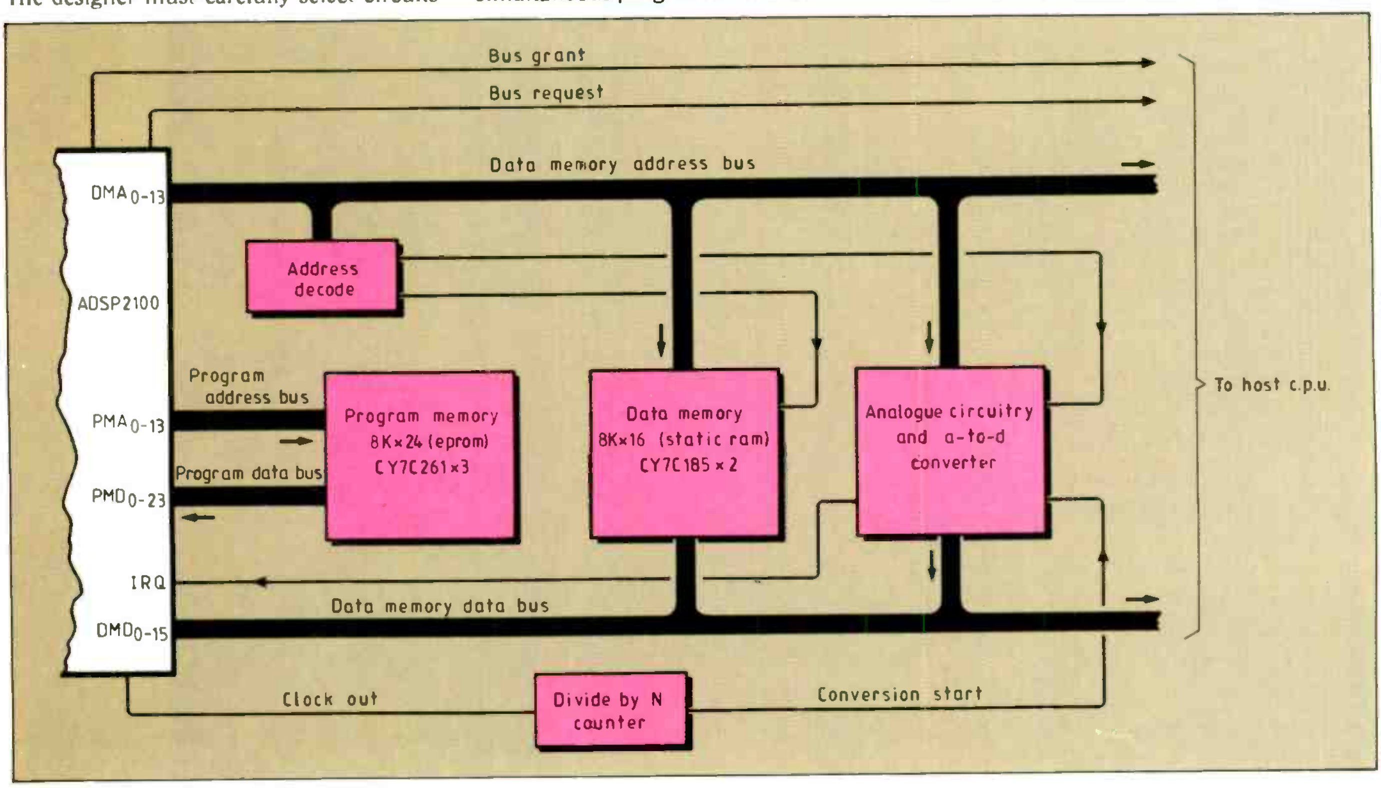
The spectrum analyser's a-to-d converter will determine its input bandwidth and dynamic range: an AD7672 has a 333kHz maximum input bandwidth and a 72dB signal-to-noise ratio. It is manufactured in c-mos and requires an external voltage reference such as the 1.5ppm/°C voltage drift AD588. The reference has force and sense terminals to ensure a high-accuracy Kelvin connection to the a-to-d converter.

The choice of track-and-hold amplifier will depend on how fast the analyser must acquire the input signal. Since the throughput rate of the spectrum analyser is 256kHz, there is only 3.9μs between successive conversions. But the converter's 3μs overhead, combined with the 100ns allotted for extra margin, leaves only 800ns for the signal acquisition. An HTC-0300 easily beats this specification with its 200ns acquisition time and 100ps aperture jitter. Furthermore, the device's 250V/μs slew rate and 8MHz signal bandwidth ensure low harmonic distortion.

Designers typically choose a switched-capacitor or active-filter circuit for the anti-aliasing function. However, the high-frequency clock used in a switched-capacitor filter injects noise into the signal, while slew rate limitations in op-amps used in an active filter introduce unwanted distortion. A passive RLC filter avoids both of these problems. The 9th order elliptic filter (Fig. 3) has a 100dB stop-band attenuation with a 0.1dB pass-band ripple. Although the phase response of the elliptic filter is not linear, its magnitude response is. Since spectrum analysis is primarily concerned with the input signal's magnitude, phase errors are not of major concern to most designers.

The cut-off frequency, which ultimately determines the upper bandwidth limit of the system, is set at 100kHz. Plotting the filter's response shows the Nyquist limit to be in the middle of the transition band which, since

Fig. 1. High-performance spectrum analyser employing a signal processor with Harvard architecture. Two-bus design improves signal throughput by permitting simultaneous program and data fetches.



this application has a 256kHz sampling frequency, is 128kHz. The filter's roll-off attenuates frequencies above 156kHz by 100dB. Because there is a deadband between 100kHz and 128kHz, any frequencies above 100kHz are discarded in the digital frequency domain. This includes any alias frequencies mirrored back into the 100 to 128kHz bandwidth.

An ADSP-2100 digital signal processing microprocessor provides all the necessary computing power for the spectrum analyser. The device can execute a single instruction in as little as 125ns – the faster ADSP-2100A has an instruction cycle time of 80ns. Its parallel design and Harvard architecture, however, permit the processor to execute more than one operation per instruction cycle. For example, in one cycle the ADSP-2100 can generate the next program address, fetch the next instruction, perform one or two data moves, update one or two address pointers, and perform one computation. This means that the it can execute a block floating-point, 1024-point f.f.t. in 12.77 milliseconds.

PROCESSOR INTERFACE

The processor-to-converter interface (Fig. 2) must include provisions for proper timing and bus isolation. The timing for the a-to-d converter and t-and-h amplifier is derived from the ADSP-2100 CLK OUT, which runs at a frequency of 8.192MHz. A counter attached to the ASDP-2100s' clock divides this signal by two to generate a 4.096MHz clock signal for the AD7672. An additional division by 16 produces a sampling frequency of 256kHz, resulting in a total input bandwidth of 128kHz.

A timer on the system board produces a CONV START pulse of 500ns duration, initiating an a-to-d conversion and triggering a "hold" for the t-and-h amplifier. Upon receipt of this pulse, the AD7672 brings its BUSY output status low. Since BUSY is Anded with CONV-START, both CS and RD remain low for the duration of the conversion. At the end of the conversion, BUSY returns high, and the system clocks data into two 74HC374 latches on the microprocessor board. The latches buffer the converter's output data, provide data-bus isolation and match the AD7672's slower read time to the fast data access of the processor. An RC delay line compensates the data set-up time after BUSY goes high, ensuring that valid data is clocked into the latches. At the end of each conversion, the AD7672 BUSY output also interrupts the ADSP-2100, indicating that new conversion results can be read.

Good printed-circuit-board layout is critical for high-accuracy results. All analogue components should be decoupled with 10μF and 0.1μF capacitors connected in parallel. Furthermore, the circuit should use a single point for analogue ground. The track-and-hold and a-to-d converter digital grounds should be the only other grounds connected to this point.

JUSTIFYING DATA

After the ADSP-2100 reads 1024 samples from the latches, it uses an f.f.t. algorithm to process the data. First, however, the 12-bit data must be aligned to the processor's 16-bit buses. The data should be left-justified as far as possible, without causing an overflow, to decrease the significance of bits lost due to truncation after fixed-point operation on the data. The extent to which data can be left-justified depends on the real and imaginary growth in the first stage of the radix-2, decimation-in-time f.f.t. An analysis of this f.f.t. routine indicates that only a 1-bit growth is possible in the first stage when the imaginary data and imaginary twiddle factors are zero. Consequently, the sign bit (m.s.b.) of the AD7672 is sign-extended by one bit. The m.s.b. of the converter, therefore, maps into the two m.s.bs of the ADSP-2100A data bus. In addition, the m.s.b. of the AD7672 must be inverted to give twos-complement format. After manipulating the data, the processor places the results into memory.

The memory for the spectrum analyser is divided into two blocks: program and data memory. Program memory stores the f.f.t. twiddle factors, the window coefficients and the processor's source code. (Twiddle factors are precalculated sin and cosine values used to speed up the f.f.t. algorithm.) The total requirement for the program memory is approximately 3072 words.

The system's data memory must have sufficient room for the a.d.c. samples, f.f.t. results and some housekeeping information. Source code for this application was written so that the f.f.t. results "over write" the sampled data as the f.f.t. progresses, produc-

SPECTRUM ANALYSIS USING THE FFT

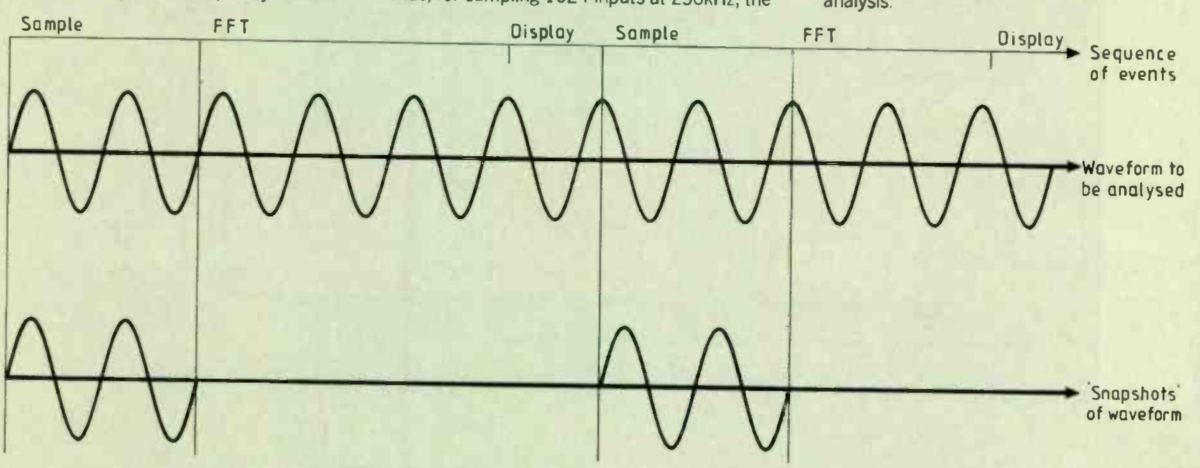
The f.f.t. algorithm, while not the only digital technique, is certainly the most popular method of measuring the power spectral density of a signal.

An f.f.t. only looks at a "snapshot" of the signal taken during the sampling interval (A). To perform a continual analysis, the f.f.t. and display routines must run in parallel with the sampling activity. But one f.f.t. still only represents the sample during N samples.

Two important considerations when using f.f.ts are the algorithm's frequency and amplitude resolution. The frequency resolution of an f.f.t. is equal to the sampling frequency divided by the number of points in the f.f.t. Obviously, lengthening the f.f.t. improves resolution, but leakage, or smearing, in the frequency domain complicates this simple calculation: unless the truncation interval is equal to an integer number of periods of the signal, the spectrum will be smeared. Although various windowing functions may be used as multipliers to reduce this smearing, all windows spread the main lobe and produce side lobes. If the signal being analysed should have any frequency components in main or side lobes, then this frequency information is effectively hidden, decreasing the effective frequency resolution of the f.f.t.

The rolloff of the antialiasing filter, instead of Nyquist criteria, places a ceiling on the input frequency. The lower frequency is limited by the fact that the system must sample at least one full period during the sampling interval. Thus, for sampling 1024 inputs at 256kHz, the minimum bandwidth is 250Hz.

The system noise floor and resolution of the a-to-d converter limits the amplitude resolution. The smallest signal to an 12-bit a-to-d converter can digitize is -72dB relative to a full scale. However, this is only true for a small signal on its own: in the presence of a larger signal, the small signal will act as a dither around the a-to-d converter's transition points. With a 12-bit converter, signals with magnitudes as low as -98dB will appear in the spectrum of a 1024 point f.f.t. Conversely, the largest signal a system can handle is the full-scale amplitude of the a-to-d converter. When the input signal exceeds the full scale, it will be clipped, creating distortion in the f.f.t. analysis.



A. Unlike swept heterodyne techniques, an f.f.t only captures a snapshot of an input waveform. It misses any occurrences that may happen between sampling periods.

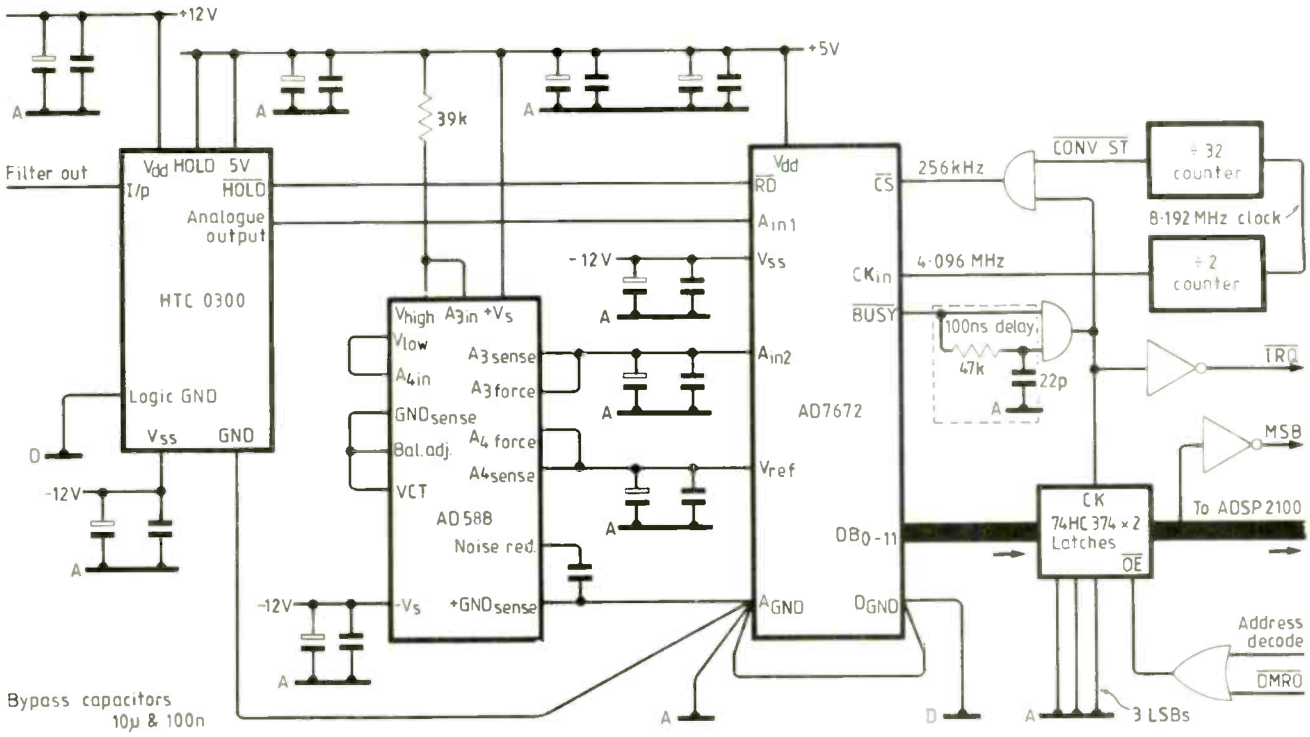


Fig. 2. **Careful design techniques must be used with the analogue circuitry in a spectrum analyser. Digital and analogue grounds must go to a common point.**

ing what is called an "in-place" f.f.t. implementation. Total data memory requirement is a mere 2068 words.

SYSTEM SOFTWARE

To develop the software for the spectrum analyser, an ADDS-2160 evaluation board hosted by an IBM PC/XT was used. Software consists of ADSP-2100 code to obtain the samples, condition them and perform the f.f.t. routine. Code for the host PC is also needed to calculate the twiddle factors and plot the log of the relative magnitudes.

Calculation of the twiddle factors (for a radix-2 decimation, in-time f.f.t.) requires the computation of N/2 cosine and N/2 sine values, where N equals the number of samples. The digital signal processor could calculate these values using a Taylor series expansion, but this lengthens the time it takes to initialize the system. A better approach is to calculate the values on the PC and then link them to the program memory at the same time as generating the source code. The Basic program listing in Table 1 calculates the twiddle factors.

Table 2 is a listing of the ADSP-2100A code necessary to read 1024 samples, window them and store them in memory in bit-reversed form. The routine automatically initializes the imaginary data to zero.

Inputs to the program are the a-to-d converter samples and the window coefficients; initial outputs are two arrays of data: INPLACECREAL and INPLACEIMAG. The former is the weighted and bit-reversed data samples, while the latter is zero. After the processor executes the f.f.t. these two arrays will contain the real and imaginary frequency data, respectively.

An interrupt-driven inner program loop complicates the normally smooth program flow. The program jumps from the WAIT-INT loop to the SERVE loop when interrupted. The software decrements the counter, AY0, before it returns to the WAIT-INT loop. A "pass" instruction recovers the condition code logic status. If register AR is zero (EQ), then the program exits the loop.

FLOATING-VERSUS FIXED -POINT ARITHMETIC

The use of floating-point calculations and coherent sampling delivers the lowest f.f.t. noise floor and offers the best frequency resolution (see box). Coherent sampling maintains an integer ratio between the input and sampling frequency, avoiding leakage in the frequency domain due to discontinuities in the time domain; f-p arithmetic minimizes truncation and overflow errors.

Combining floating-point and coherent sampling delivers low total-harmonic distortion. However, there are some harmonics that rise above the noise floor at -82dB. The antialiasing filter, track-and-hold amplifier, and impedance mismatches are the likely causes of this additional distortion. Since the a-to-d has a -72dB s.n.r., its contribution to any harmonic distortion should be below -90dB.

Coherent sampling and floating-point calculations have a number of drawbacks. Firstly, it is almost impossible to insure coherent sampling in real-world spectrum analysis. Second, floating-point requires large software overhead. Fixed point algorithms are much faster and easier to develop.

Fixed point f.f.ts require scaling of the results, which is easy to perform with the ADSP-2100's barrel shifter. The f.f.t. of a sequence tends to be significantly larger than the sequence itself, according to Parseval's theorem:

$$\sum_{n=0}^{N-1} x^2(n) = \frac{1}{N}\sum_{k=0}^{N-1} |X(k)|^2$$

TABLE 1. CALCULATION OF TWIDDLE FACTORS

```
10 REM TWIDDLE FACTORS
20 DIM REAL$(512)
30 DIM IMAG$(512)
40 FOR K = 0 TO 511
50 REAL = 32768!*COS(K*22/(7*521))
53 REAL = REAL - .55
55 REAL$(K) = HEX$(REAL)
56 IF LEN(REAL$(K)) = 1 THEN REAL$(K) = "000" + REAL($K)
57 IF LEN(REAL$(K)) = 2 THEN REAL$(K) = "00" + REAL($K)
58 IF LEN(REAL$(K)) = 3 THEN REAL$(K) = "0" + REAL($K)
60 IMAG = 32678!SIN(K*22/(7*512))
63 IMAG = IMAG - .55
65 IMAG$(K) = HEX$(IMAG)
66 IF LEN(IMAG$(K)) = 1 THEN REAL$(K) = "000" + REAL($K)
67 IF LEN(IMAG$(K)) = 2 THEN REAL$(K) = "00" + REAL($K)
68 IF LEN(IMAG$(K)) = 3 THEN REAL$(K) = "0" + REAL($K)
69 PRINT K, REAL$(K), IMAG$(K)
70 NEXT K
80 END
OK
```

TABLE 2. ADSP-2100 SAMPLING CODE

```
.MODULE SAMP_AD;
.CONST N=1024, MOD_VALUE=H#0010
.EXTERNAL INPLACEREAL, INPLACEIMAG;
.EXTERNAL WINDOW COEFFS;
.PORT AD7672
.ENTRY SAMPLES;
.ENTRY SERVE;
SAMPLES: 1CNTL=B#00000; {SET UP TRIGGERED INTERRUPTS)
AY0=N; {SET UP COUNTER}
AR=N;
I0=^INPLACEREAL; {INDEX 0 = START OF ADDRESS OF INPLACEREAL}
I5=^INPLACEIMAG;
I4=^WINDOW_COEFF;
M0=MOD_VALUE; {MODIFIER FOR BIT REVERSAL}
M5=1;
ENA BIT_REV;
IMASK=B#1000;
WAIT_INT:AR=PASS AR; {RECOVER THE CONDITION CODE}
IF EQ JUMP FINISH;
JUMP WAIT_INT;
SERVE:MX0=DM(AD7672); {MULTIPLY SAMPLE BY WINDOW COEFF AND}
      MY0=MX0*MY0(RND); {STORE IT BIT REVERSED IN INPLACEREAL}
      DM(I0,M))=MR1;
      DM(I5, M5)=0;
      AR=AY0-1;
      AY0=AR;
RTI;
FINISH: IMASK=B#0000; {DISABLE ALL INTERRUPTs}
DIS BIT_REV; {DISABLE BIT REVERSAL}
RTS;
.ENDMOD;
```

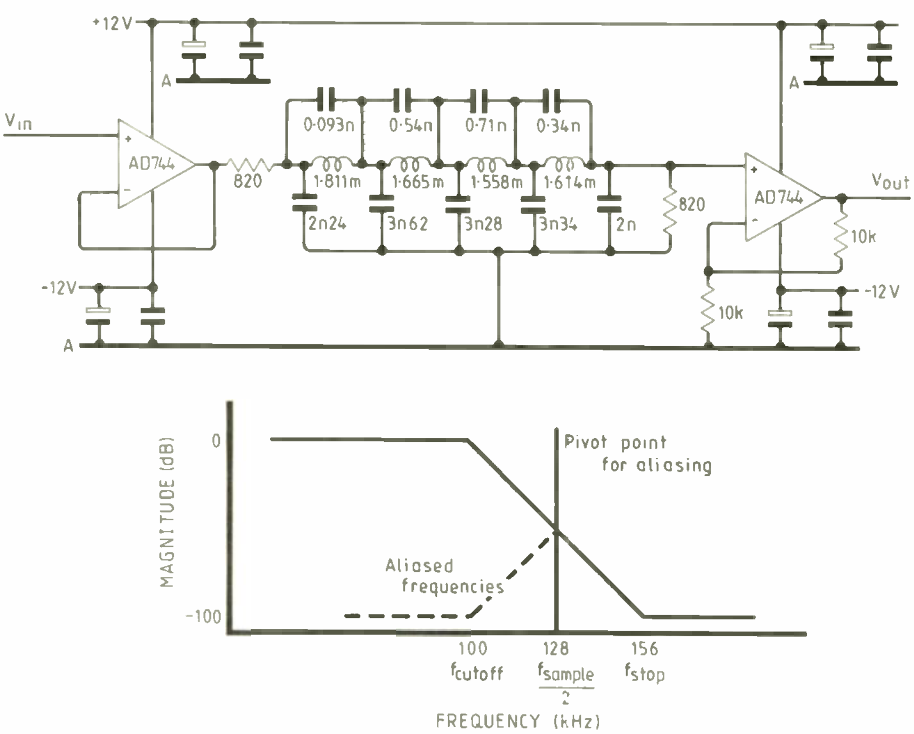


Fig 3. A ninth-order elliptic filter delivers a – 100dB stop-band attenuation and cutoff frequency of 100kHz.

The mean-square relationship between input and output is determined by the number of f.f.t. stages. An N-point f.f.t. will have $\log_2 N$ stages; therefore, for a 1024 point f.f.t., there are 10 stages. While the magnitude of a data may grow by one bit per stage, very often the real or imaginary data can grow by two bits.

There are three possible scaling techniques: unconditionally shift the magnitude one bit right at each stage; conditionally shift right each stage depending on magnitude growth; or scale the real and imaginary data by two bits and test for growth at each state. Scaling and shifting the real and imaginary arrays is the best solution, since the first method is inaccurate due to unnecessary scaling and the second devours processor overhead.

The upper and lower bounds of the signal-to-noise ratio due to round-off and scaling can be determined by two equations:

$$\frac{\text{RMS (Error)}}{\text{RMS (Signal)}} = \frac{\sqrt{n} \times 2^{-b} \times (0.3) \times \sqrt{8}}{\text{RMS (Input)}}$$

and

$$\frac{\text{RMS (Error)}}{\text{RMS (Signal)}} = (M-2.5)^{1/2} \times (0.3) \times 2^{-b}$$

where b equals the number of bits to represent the word, n equals the length of the f.f.t. and M equals the number of stages.

The program listing for the ADSP-2100 represents data as a 14-bit word at each stage, with the exception of the first stage, which is 15 bits. This gives an upper bound of 56dB and a lower bound of 86dB. The upper bound, however, is the better measure of the actual results. With a spectrally pure sinewave input and fixed-point calculations. The noise floor is greater than -80dB up to a maximum frequency of 100kHz.

BOOKS

Introduction to the 4:2:2 digital video tape recorder, by Stephen Gregory. Engineer's guide to the D1 component-coded digital recording format, covering video and audio interfaces, cassette and tape parameters, track pattern, signal processing and channel coding. A final section describes the integration of a D1 machine into two practical studio systems, ITV's experimental digital production facility and the Quantel digital production centre. Since this book emanates from Sony Broadcast, the example chosen is Sony's DVR-1000. Pentech Press (John Wiley & Sons), 200 pages, hard covers, £28.

Crash course in electronics technology, by Lou Frenzel. 'Programmed instruction' course beginning with basic concepts and devices and taking the reader by numbered stages as far as amplifers, oscillators, modulators, pulse techniques, test equipment and industrial control methods. Each chapter includes a statement of learning objectives and ends with a quiz. Other volumes in the series deal with microcomputers and digital technology: intended readership is in technical schools and industrial training. Pitman Publishing, 562 pages (A4 format), soft covers, £17.95.

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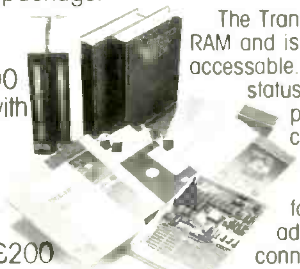

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IBC 1988

Technical developments seen and heard at broadcast engineering's biennial event, held in Brighton in September.

Inevitably, the two main talking points at the International Broadcasting Convention were direct satellite broadcasting and high-definition television, with hdtv the clear leader. Of the 15 technical sessions, during which some 100 papers were presented, no less than five were devoted wholly to advanced television systems while others – such as those on cameras – included many papers connected with hdtv. Interest in satellite systems was centred on dbs services for the UK, which are due to begin in February from the Astra satellite.

Outside the meeting halls, the focus was on what might be described as the festival fringe, with its two big hdtv events. Out of town, at the University of Sussex sports centre, was a large exhibition of 1125/60 studio equipment staged by an alliance of mainly Japanese manufacturers, and backed up by all-day showings in the Kingswest cinema of programme material recorded in the 1125/60 format. Meanwhile, down on Brighton's shingle beach, there took place in a specially-erected pavilion the first, keenly-awaited demonstrations of the rival Eureka 1250-line system, HD-MAC.

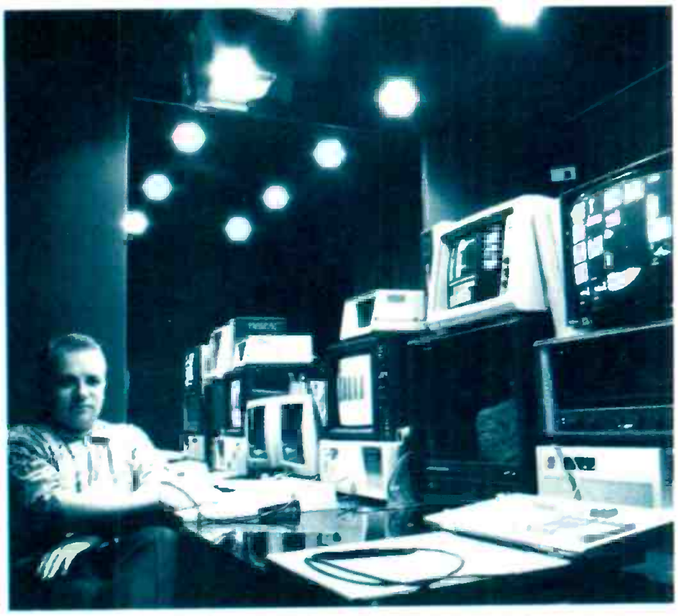
For the first time, the European consortium was showing a complete broadcasting chain, from studio picture sources to satellite transmission equipment, right through to receivers and peripherals for the home. A description of some of the technology behind the demonstrations appeared in the September issue, pages 845-850 (Eureka 95 – a world standard? by Tom Ivall).

The impetus to create a new hdtv standard arose in 1986 from a widespread feeling in Europe that the NHK 1125/60 system was fundamentally unsuited to European conditions.

Creating an alternative system in time to prevent 1125/60 from becoming established as a *de facto* standard among programme producers has meant a breathless scramble among designers and manufacturers. But although some aspects of the proposed bandwidth compression scheme were not ready for inclusion in the Eureka demonstrations, the consortium was able to show that the system worked in its entirety and indeed gave excellent results. To this writer's eye, even without the motion-compensation encoding, Eureka gave significantly better pictures than 1125/60 with its Muse encoding.

Presenting an invited paper during the technical sessions on the philosophy and practice of the Eureka hdtv proposals Pieter Boegels of the Eureka hdtv directorate described to a packed hall how far the project has progressed.

In some respects, he said, Europe had benefited from its late start in hdtv and has been able to introduce the latest technology



The trade exhibition at IBC '88 was the biggest yet, spreading from the Metropole into the Brighton Centre, the Grand Hotel and even into a windy temporary pavilion erected by the West Pier.

Somewhere among the formidable fleet of outside broadcast vans assembled on Brighton's esplanade was this one from the Travelling Matte Company, which describes it as Britain's only mobile computer graphics unit. Among its recent successes has been *Knightmare*, a children's programme for Anglia television, combining a dungeons-and-dragons fantasy theme with live action. Star of the show (top picture) was Eric the skeleton.

into the system.

Studio cameras (by BTS and Thomson) were now available and were on display in the Eureka pavilion. So was a wide range of production equipment, including vtrs, telecine and slide-scanning systems, and an HD-MAC mixer. Using the HD-MAC transmission standard, pictures could be distributed by satellite, cable, optical fibre, microwave and terrestrial links.

Work was continuing in the replay areas, he said. "We are developing some exciting new ideas in the area of hd camcorders and electronic still picture cameras – ESP. But that's another story."

Next year, said Boegels, would see the start of experimental hd transmissions and the setting up of experimental studios for making programmes. By the time of the next IBC in 1990, Eureka would be ready for adoption as a world standard. "We're on time", he said, "in fact, we're ahead of time – and if it were up to us, hdtv could start before the 1992 target date."

Inside the Eureka pavilion visitors were shown an introduction to the project in the form of the first television programme to be shot in the format, the production made by the BBC at the Open University studio centre in Milton Keynes. Pictures were displayed in the 40-seat auditorium on a large projection screen and on c.r.t. sets by a variety of manufacturers in both 16×9 and 4×3 for-

AN EXPERIMENTAL DOMESTIC VIDEO RECORDER

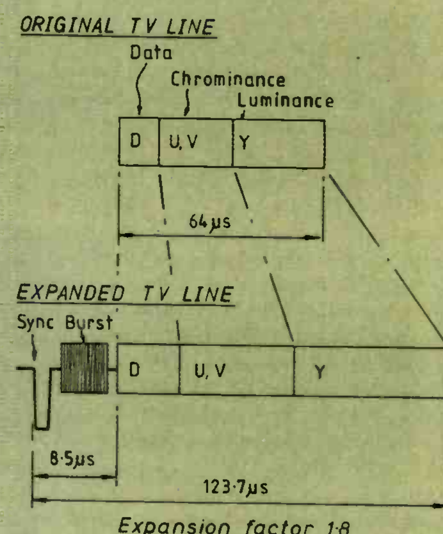
One of the experimental consumer products on show in the Eureka pavilion was a modified VHS video recorder capable of recording transparently the whole HD-MAC signal. This machine has a bandwidth of over 10MHz, four times that of a standard VHS machine. Because the recording mode is transparent, it can handle any type of video signal: the only circuits specific to signal type are the sync separator (which provides synchronization) and a stage which adds redundancy to the digital signal to protect against tape dropouts.

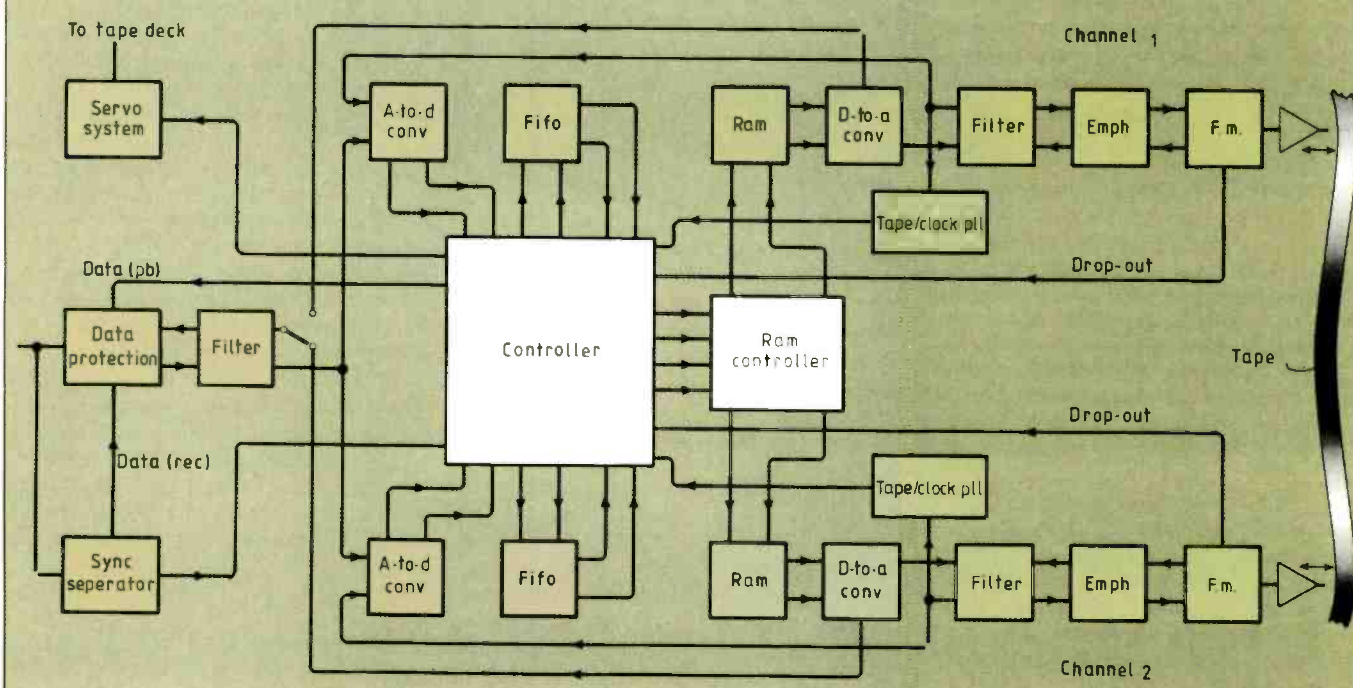
In record mode, the input signal is time-expanded by a factor of 1.8, giving two channels. These are recorded in parallel on the tape using frequency modulation, with guard-bands between. On playback, the signals are expanded and combined once more.

A residual timebase error of less than 15ns has been achieved by the digital insertion of an additional negative-going sync signal and a 2.8MHz burst, which fix an exact time relationship that can be used by the decoding circuits on replay.

To compensate for non-linearity, a test waveform (a linear ramp) is recorded on some extra lines added to the video signal. On playback, the reproduced ramp is compared with a replica of the original, and any differences are written into a look-up table in ram through which the signal passes after de-compression. Since the channel linearity changes only slowly, there is no need for rapid updating of rapid updating of the ram contents.

Unweighted video signal-to-noise ratio is 42dB and playing time is 65 minutes.





mats. Pictures were originated at 1250 lines, 50 fields, progressive scan: a compression ratio of 4:1 is required to make this signal format match the MAC channel.

Providing the pictures were three outside broadcast vans plus a large amount of associated equipment, including an optical fibre link and satellite transmission simulators. In the neighbouring exhibition area, further equipment was available for display and demonstration.

1125/60

Another fibre link, this time provided by British Telecom, was used by the 1125/60 manufacturers to demonstrate two-way live hdtv pictures over the 75km between Brighton and the SVC Television studio in Wardour Street, London. To preserve studio picture quality, a bandwidth in excess of 1GHz is required; and BT achieved this by transmitting chrominance and luminance separately on a pair of 565Mbit/s lines.

The pictures were of excellent quality; though it is fair to say that it would have been hard for them to be otherwise, given the availability of gigabits of link capacity. Getting good pictures through a standard satellite channel is a much more impressive trick. However, the winners here were undoubtedly the telephone users of Brighton, who were to gain the use of the new fibre as soon as the IBC demonstrations were over.

Introducing the 1125/60 exhibition, Bill Connolly, the group's technical spokesman, said that a clear separation needed to be drawn between the requirements for production and transmission of h.d.tv. Referring to moves in the US towards a 1050-line advanced television system, he pointed out that 19 standards were still under consideration there. The 1125/60 system was available here and now.

And indeed the association was showing equipment by some 29 manufacturers – certain of whom, like Quantel, also had a foot in the Eureka camp. Among this equipment was a pair of cinema-size projection displays, by Eidophor of Switzerland and General Electric of the US; a Panasonic 135-inch diagonal front-projection set and a 54-inch back-projection set by Hitachi; a real-time h.d.tv 35mm laser film recorder by the Japanese manufacturer NAC (not to be confused with NEC); an electron-beam recorder by Sony suitable for archiving (it could record a bandwidth of 46MHz, laying down RGB triplets of pictures on black-and-white film); and a Sony standards converter giving an output in PAL or SECAM, the first such device to use motion-compensation for reduced flicker.

Also shown was an analogue h.d. video recorder by Sony, which used 25mm tape and gave a playing time of 63 minutes with 20MHz luminance bandwidth. Timebase correction of up to five horizontal periods was built in. Still more remarkable was a digital vtr which used 25mm metal particle tape and gave a total recorded data rate of 1.188Gbit/s. Tape speed was 805mm/s, drum speed 7200 rev/min and video sampling rate was 74MHz (eight bits) giving 30MHz luminance bandwidth and 15MHz each for R-Y and B-Y. Eight digital audio channels, using the 48kHz, 16 bit consumer format, were also included on the tape, together with time-code and cue tracks.

A 1250 line hdtv picture looks more like a 35mm slide presentation than a raster scan image. Vertical scanning at 100Hz eliminates present-day flicker problems.

VIDEO TECHNIQUES

An interesting look into the future of video technology came in a presentation by M. Morizono, deputy president of Sony and the man responsible for the introduction of the U-Matic vcr. Referring to the proliferation of vcrs in both consumer and professional spheres, he urged industry, manufacturers and users not to allow a diversity of formats; this would create severe problems. To some it must have looked as though his plea had come a little too late. Ideally, he said, a single vcr format (presumably digital) would be capable of covering all applications, and such a machine should be developed in the long-term future. Meanwhile, vcrs for electronic news gathering needed to become lighter, smaller, more rugged and reliable, and lower in power consumption.

Turning to the field of image processing, Mr Morizono showed some fascinating recorded examples of recent work by his company. The first illustrated the interim results from an experimental real-time picture manipulator using high-speed parallel processing. It began with a still image of a girl's face. By placing a cursor over selected areas, the operator pulled the image forward into three dimensions, like a mask, as could be seen when the image was tumbled and spun about itself. As the mask rotated, the girl's face could be seen inside-out and on the back of it. Contours could be exaggerated too – guffaws rose from the audience when the cursor landed on the unfortunate model's nose and drew it out to Pinocchio-like proportions.

Another image computer newly developed by Sony was capable of deleting movement from an image. One one screen, a toy train was seen trundling around a figure-of-eight loop of track. On the other screen, only the track and scenery were visible; though, after Mr Morizono had drawn attention to it, it was possible to see at times the faintest suggestion of the train's moving shadow.

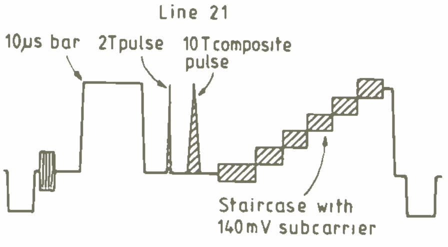
The computer could execute the same trick in reverse, showing only the moving portion of the picture. This took the form of a black screen containing nothing but the image of the locomotive, plus whatever lay in its shadow – it looked as if it were illuminated by a single spotlight.

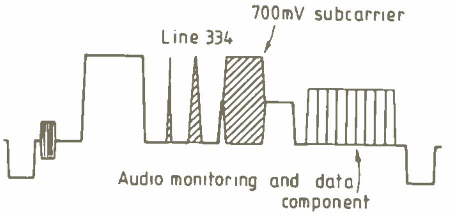
MEASUREMENT TECHNOLOGY

Despite the arrival on the consumer scene of teletext receivers equipped with "full Level One facilities" (i.e. Fastext, with its page-linking feature) and with memory stores for as many as 80 pages, pressure for shorter access times has continued. At the broadcaster's end, this had meant inserting teletext on more lines per field. Since the field blanking interval cannot be increased, broadcasters have had to consider moving some of the test and other signals they currently radiate during this period, to make way for more teletext.

A paper by C.R. Spicer and R.P. Hubbard of the BBC described an economical method of telescoping three lines' worth of test signals into one. Up to now, lines 19/332 have been used for insertion test signals (pulse and bar, staircase waveforms etc. for the monitoring and automatic control of the national network) and line 21/334 has been used (by both BBC and ITV) for distributing text information about the network for presentation and other purposes.

The new signal, which appears on line 21/334, includes the subcarrier component and staircase during the even field only (334); in the odd field (21) are a colour-bar waveform and eight bytes of data. At the end of line 334 is a data component consisting of a four-bit clock run-in followed by eight bytes of data. Clock rate is 5MHz, locked to line frequency. Five of the bytes are for communications; one is reserved for synchronization and housekeeping, and the remainder are for audio monitoring.





This last enables the network operator to ensure that the sound signal accompanying the picture is the correct one and is at the correct level. The insertion test equipment measures the peaks of the programme sound and transmits them in coded form using the two bytes. At each monitoring point, these are checked for an acceptable match. Tests showed that the experimental equipment could detect differences in modulation level as small as 0.25dB.

DIGITAL AUDIO

IBC was very much dominated by television technology, but a technical session on digital audio produced information on recent developments in the digital radio broadcasting scheme which is being developed as one of the European Eureka projects. Presentations by Paul Ratliff of the BBC Research Department, Daniel Pommier of the French research centre CCETT, and by Ch. Weck and Gunther Theile of the Institut für Rundfunktechnik in West Germany described the coding methods under consideration for this new service.

The aim is to provide a universal radio service capable of reception on fixed sets or on the move, and which is free of the drawbacks of present-day fm broadcasting. Besides the tuning problems so discouraging to listeners, these include multi-path distortion and signal cancellation in built-up

Having largely won the battle of lightweight, portable cameras, charged-coupled image sensors are staging a take-over of general-purpose studio cameras, as in the LDK900 from BTS. Three matched ccds are used, as against just one in cameras for the consumer market. Ccds give noise-free pictures in poor light and do not suffer from the lag which afflict tube cameras; but experts say ccd pictures are still marginally inferior when viewed on a studio monitor. However, Plumbicons and their equivalents continue to hold a monopoly in hdtv: high-resolution ccds are still some years off.

areas. Through a spread-spectrum technique assisted by the creative use of multi-path signals, the scheme promises to provide a bus containing up to 16 digital stereo signals which listeners would select on an uncomplicated fixed-tuned receiver simply by pushing buttons.

New source coding methods make it possible for a stereo programme to be digitally coded, together with an associated data channel, at a gross rate of about 250Kbit/s. One possible transmission format consists of a comb of 448 mutually overlapping carriers spaced 15.625kHz apart (television line frequency), giving a total bandwidth of 7MHz. Using a technique known as convolution-coded orthogonal frequency-division multiplex, cofdm, this yields a useful data rate of 5.8Mbit/s. A feature of this system is that the transmitted spectrum resembles Gaussian noise, which means that its potential for interfering with analogue radiotelephony services is 25dB lower over a 4kHz bandwidth than for other types of signal.

In answer to a question later from the DTI, Paul Ratliff explained that because of the signal's television-like characteristics, it could be transmitted on a conventional uhf television channel. Unfortunately, the carefully-planned uhf spectrum in the UK was heavily occupied already (and will be still more so if the Government's plans for a Channel 5 and Channel 6 are put into effect). A problem would arise with the frequency offsets employed by the broadcasters to reduce co-channel interference. It would be impossible to maintain a half-line offset to all potential interferers. For national services a single block band would be needed, for which satellite distribution would be attractive. A minimum requirement of 4-8MHz was being looked for, ideally all over Europe; the service could not be interleaved with the existing fm services.

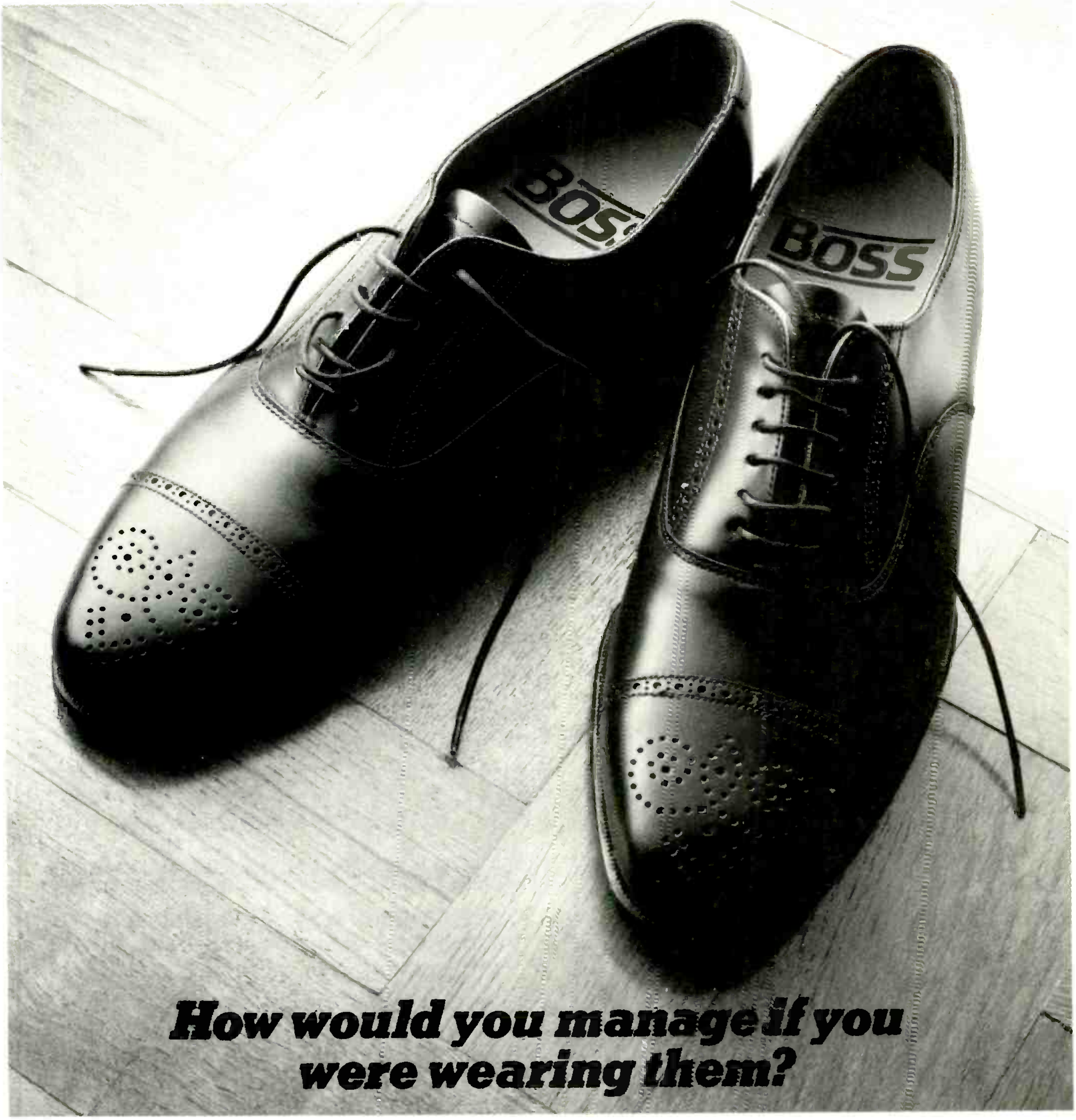
The system's tolerance of multi-path was due to the provision of a guard-period after each symbol to allow for delayed reflections. Shadows in the satellite coverage could therefore be filled by terrestrial repeater stations operating on the same frequency. Another possibility would be a ground-based network provided by transmitters sited on a triangular lattice pattern. Provided that receivers were not subjected to long-delayed, strong signals, they would be unaffected.

The first demonstrations of this system were given to broadcasters attending an EBU meeting in Geneva three weeks before IBC. An experimental transmitter had been set up on a television tower, simulating a satellite-delivered service. Delegates were able to sample the system during car rides around the city. No interruptions to the service were experienced under bridges or behind buildings and no changes in reception quality were reported: all rated reception quality as "excellent".

An advantage of cofdm was that it could work with satellite signals nearly 7dB weaker than were necessary for standard fm. Receiving antennas for the service could include flat plane types stuck to car or lorry roofs; and for portable sets, a small pointable helix – though some members of the audience were evidently unhappy with the latter idea. A receiver for the service could be with us as a consumer product by the early 1990s, said Ratliff: "By the next IBC I hope you will experience its sunrise."

Details of the IBC programme are available from IEE Conference Services, 01-240 1871.

Further reports from IBC appear in this month's Satellite Systems, Radio Broadcast and Television Broadcast columns.



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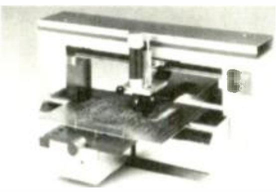
NEW PRODUCTS

Save time on prototype p.c.bs

An easy-to-use system which cuts the time and costs of prototype and producing small batches of circuit boards has been introduced by Seaward.

Single or double sided boards of any size up to 14in² are produced directly and automatically from the output of a p.c.b. cad system. The Boardmaker is a precision x, y outline milling system, which by cutting and drilling standard p.c.b.



copper clad material can produce a medium density board measuring 2 × 3in in 15min without using hazardous chemicals. The system interfaces with any IBM or compatible providing a standard photoplot output file. It comes complete with an initial 30min hotline installation assistance. Seaward Electronic Ltd, Bracken Hill, South West Industrial Estate, Peterlee, County Durham SR8 2JJ. Tel: 091 586 3511.

Training system for electronics teaching

A system for teaching electricity and electronics from basic to advanced levels has been developed by Lab-Volt Systems.

The Fault Assists Circuit Training System (FACTS) consists of a base work station, training modules, and courseware. The modules used to perform experiments are interchangeable and contain components identical to those used in industry. The base work station features circuit modification and fault insertion switches to develop trouble shooting skills. Lab-Volt Systems, PO Box 686, Farmingdale, New Jersey 07727, USA. Tel: 201 938 2000.

Board tester for rent

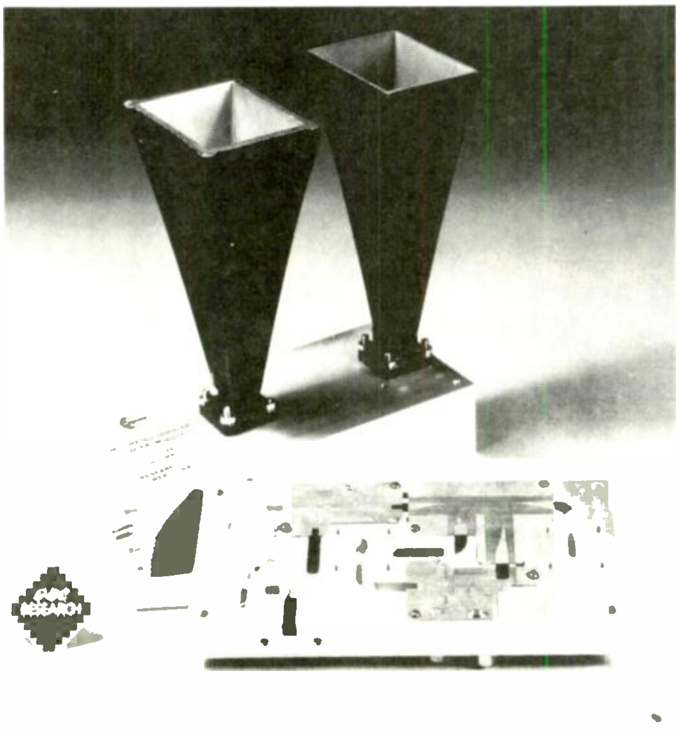
An advanced test unit designed for bench and field testing of electronic circuit boards is available for rent through Rentech.

The Boardwizard is software driven, being controlled by an IBM PC/XT/AT or compatible. Its own device library may be extended to test and isolate faults on existing boards, as well as future products. It is capable of diagnosing device problems down to component level. Rentech, Hamilton Rentals (UK) Ltd, Hamilton House, North Circular Road, London NW10 7UB. Tel: 01-961 6777.

Doppler radar module for mm measurements

A unit produced by the GEC-Marconi research centre generates Doppler waves by which the velocity of gun shells travelling at up to 100m/s can be measured with an accuracy of 0.2%.

Centred within a single unit is a temperature stabilized v.c.o., buffering iso circulator, transmit inhibit switch, l.o. coupler and receiver mixer. A dual waveguide horn antenna which directly interfaces with the module is also available. The unit performs the function of a modulated transmitter and a homodyne receiver. GEC Marconi Research Centre, West Hanningfield Road, Great Baddown, Chelmsford, Essex CM2 8HN. Tel: 0245 73331.



Consistent bonding of adhesives

Popular makes of surface mount adhesive, such as Loctite, Amicon and Ablebond etc. can be cured in the new Flexicure conveyor oven range introduced by Hedinair.

P.c.bs are carried through zones of controlled heating and/or u.v. radiation by a vibration free mesh belt conveyor, with vernier set variable speed drive and tacho speed stabilisation. For processing boards with underside leads or components, a variable width edge support conveyor is available. Belt sizes extend from 150 to 600mm wide. The length is made to suit the required output, normally between 2 and 4m. Hedinair Ltd, PO Box 71, Chadwell Heath, Romford, Essex RM6 6QW. Tel: 01-590 2090.

Microwave measurements on oscilloscope

A microwave frequency trigger for Hewlett Packard's high frequency digitizing oscilloscope provides true event triggering to 18GHz. This allows microwave frequency measurements that were previously impossible using countdown synchronizers, which are limited to continuous wave applications.

The HP 54118A trigger, with independent control of arming and triggering levels, is claimed to be the first microwave device to define a trigger by level and slope. Thus digital oscilloscope microwave measurements are extended to include pulsed r.f., pulses and non sinusoidal inputs. Microwave applications include testing and debugging of non linear devices, lightwave-communications systems and radar systems and components. True event triggering, independent of input signal frequency is achieved via a thin-film dual tunnel diode circuit. Hewlett Packard Ltd, Eskdale Road, Winnersh Triangle, Wokingham, Berks RG11 5DZ. Tel: 0734 696622.

Piezoelectric rubber in sheet form

A piezoelectric rubber material distributed by Quantelec is available in sheet form as well as coaxial cable.

The composite material is made by dispersing small particles of piezoelectric ceramic through a synthetic rubber matrix. The piezoelectric layer is sandwiched between two sheets of conductive rubber, to which connection is made. Two versions are available: a single and a double layer configuration. Flying leads can be attached to the outer layers at the factory. Quantelec Ltd, 50 Market Square, Whitney, Oxon OX8 6AL. Tel: 0993 776488.

Enhanced graphics

Two monolithic video digital to analogue converters provide performance upgrades for the IBM Personal System/2 and compatible systems.

Analogue Devices supply the 6-bit and 8-bit devices with identical package and pinout for hardware compatibility. Software is upwardly compatible between them. Applications include high-resolution colour graphics, image processing and desktop publishing. 256 colours are available at any time for the total palette. Analog Devices, Station Avenue, Walton-on-Thames, Surrey KT2 1PF. Tel: 0932 232222.

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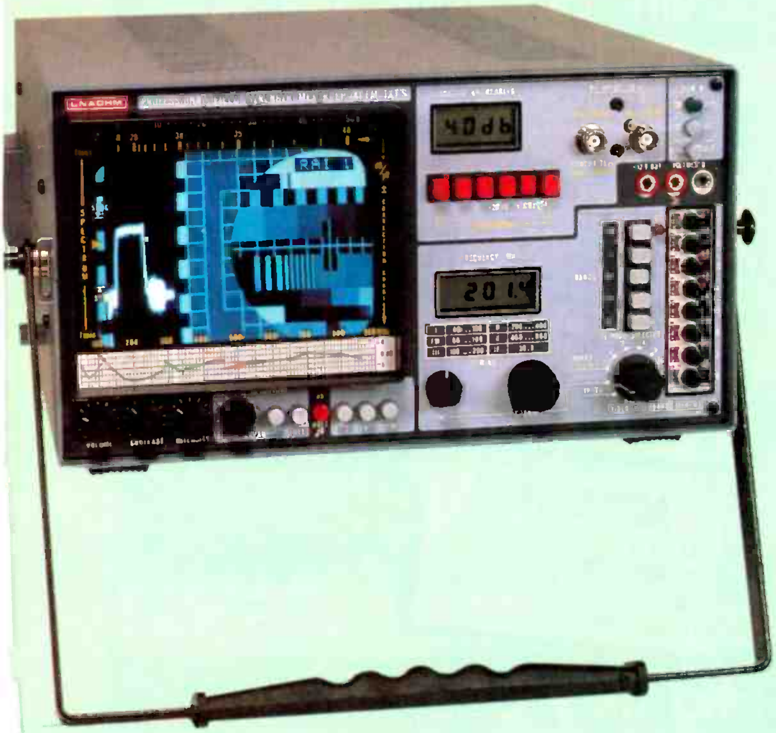

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Frequency Range:	Continuously adjustable via a geared-down vernier as follows: IF 38.9MHz Band I 46 to 106MHz FM Band 88 to 108MHz Band III 106 to 290MHz Band H 290 to 460MHz Band U 460 to 860MHz
Frequency Reading:	TV Bands — 4 digit counter with 100KHz resolution FM Band — 5 digit counter with 10KHz resolution Reading Accuracy: reference Xtal +/−1 digit.
Function: TV Monitor	NORMAL: picture only ZOOM : 2 to 1 horizontal magnification of picture : picture + line sync pulse (with chromaburst if TV signal is coded for colour)
Panorama:	panoramic display of the frequency spectrum within the selected band and of tuning marker.
Panorama Expansion:	Adjustable expansion of a portion of the spectrum around the tuned frequency.
Analogue Measurement:	20 to 40dB. Static measurement of received signal. Scale calibrated in dBuV (at top of picture tube) to rms value of signal level.
DC/AC Voltmeter:	5 to 50V.
Measurement Range:	20 to 130dBuV in ten 10dB attenuation steps for all bands; −60 to 130dBuV in nine 10dB steps for IF.
Measurement Indication:	ANALOGUE: brightness stripe against calibrated scale superimposed on picture tube. The stripe length is proportional to the sync peak of the video signal.
Video Output:	BNC connector. 1Vpp max on 75 ohm.
DC Output:	+12V/50mA max. Power supply source for boosters & converter.
TV Receiver:	tunes in and displays CCIR system I TV signals. Other standards upon request.
Additional Features:	(1) Video input 75 Ohm. (2) 12V input for external car battery. (3) Output connector for stereo earphones.
Price:	**£1344.00** exc. VAT and Carriage.

UNAOHM FSM5987 T.V. FIELD STRENGTH METER

INPUT

Sensitivity:	from 20dBuV to 110dBuV (−40dBmV to 50dBmV) or 10uV to 0.3V, in eight 10dB steps.
Reading:	dB reading proportional to peak value for video signals; proportional to mean value for AM or FM sound signals. For both signals scale calibrated to rms value and expressed in dBuV. Two more scales are available: volt from 0 to 50, and ohm from 0 to 2000 ohm. Battery status is also provided.
Accuracy:	+/− 3dB for bands I & III +/− 6dB for bands H & IV/V
Impedance:	75 ohm unbalanced; DC component blocked up to 100V.

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Range:	46 to 860 MHz as follows: Band I 46 to 106MHz; III 106 to 206MHz; H 206 to 460MHz; IV/V 460 to 860 MHz
Reading:	4 digit LCD readout. 100KHz resolution.
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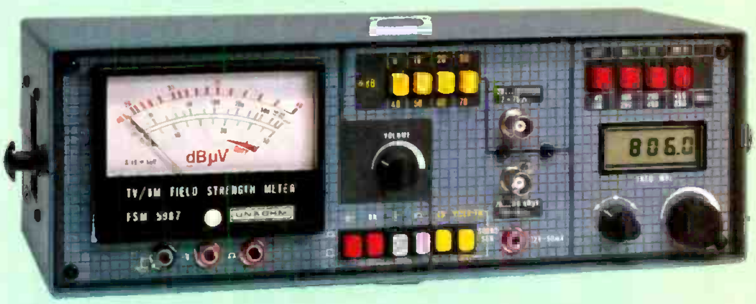

UNAOHM EH 1000 TELETEXT AND VIDEO ANALYZER

Function:	Eye Pattern: display of RF and video-frequency teletext signals by means of eye pattern diagrams both in linear representation and lissajous figures (0 and X). Line selection: display of video signals and line by line selection. Measurement of modulation depth. Teletext: monitoring of teletext pages.
RF Input:	Freq. Range: 45 to 860MHz. Frequency synthesis, 99 channel recall facility, 50KHz resolution, 30 channel digital memory. Level: 40 to 120dBuV; attenuator continuously adjustable. Indication of the minimum level for a correct operation of the instrument. Impedance: 75 ohm. Connector type: BNC.
Video Frequency Input:	Minimum Voltage: 1Vpp. Impedance: 75 ohm or 10K ohm in case of a through-signal. Connector type: BNC.
Teletext Input:	Voltage: 1Vpp/75 ohm.
Teletext Clock Input:	Voltage: 1Vpp/75 ohm. Measurement: Aperture of eye pattern: linear or Lissajous figures, selectable. Indication: directly on the picture tube. A calibrated scale shows percentage of eye pattern aperture. Error: the instrument introduces an error of ⩽5% with video input and 20% with RF input. Jitter on regen'd clock: ⩽25ns. Line selector: Selection of any TV line between the 2nd and the 625th scanning cycle by means of a 3 digit thumbwheel switch.
Oscilloscope:	VERTICAL CHANNEL: Sensitivity: 0.5 to 2Vpp/cm. Frequency Response: DC to 10MHz. Rise time: pre & overshoot ⩽2%. Input Coupling: AC. Input impedance: 75 ohm/50pF. TIME BASE: Sweep Range: 20 to 10ms (1.1/2 frames); 32; 64/192us (1/2; 1; 3 lines). Linearity: +/−3%. Horizontal Width: 10 divisions; x5 magnification.
Price:	**£1670.20** exc. VAT and Carriage.

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ENTER 14 ON REPLY CARD

The v.s.w.r. enigma

The standard explanation of standing waves contains a fallacy, in that power does not go anywhere – it is a rate, not an EM wave.

P.B. BUCHAN

Among the many chapters and articles written in books and journals that deal with transmission lines, it is rare to find a lucid and factual explanation of the phenomenon of standing waves. Standing waves exist, there is no doubt, but are of no consequence to some and anathema to others. What is clear is that there is a misunderstanding about how they occur, what they are and whether or not something should be done to avoid their presence.

A study of standing waves can be fascinating and, with care, reveals that they are not what most texts suggest. The greater understanding gained from the study will give confidence in deciding what steps, in certain circumstances, should be taken to avoid or eliminate them.

Reading, which admittedly has not been exhaustive but nevertheless has been fairly wide, reveals that except for two articles[1,2], the stock explanation is that some of the forward power is not absorbed by the load and is reflected back to the generator, (the suggestion is still to be found that this reflected power is absorbed by the generator on return[3]) from where it is sent once more back to the load where a little more is absorbed, the remainder again returning to the generator end. This to-and-fro journey continues until the power is finally used up or radiated. The standing wave pattern, it is said, is caused by the adding and subtracting of the power due to the in and out of phase components as it journeys along the length of the transmission line.

The misunderstanding here is that power has direction which, by definition, it does not. Power is the *rate* at which energy is expended. What is actually propagated along a transmission line is a plane electromagnetic (EM) wave[4,5], constrained to follow the path taken by the line. An EM wave has electric and magnetic components which are perpendicular to each other and will be familiar to the radio amateur[6].

The wave possesses energy; potential energy in the electric field and kinetic energy in the magnetic field. Travelling through space or along a transmission line, there is an exact balance between electric and magnetic fields. Half the energy is in the electric field, the other half in the magnetic field.

If the wave enters a different medium, there is an immediate redistribution of energy. Since no energy can be added to the wave as it enters the new medium; the only way a new balance can take place is for some of the impingeing energy to be rejected. This does indeed take place and the rejected energy is seen as a reflected wave. Study of light waves show the same behaviour and; of course, light waves are an exact analogy of radio waves.

To illustrate this argument in more detail; a practical transmission line will be described which has dimensions and characteristics giving the line a high v.s.w.r. The line will have a generator at one end and a load at the other and will be looked at under steady-state conditions, calculating the various input and output impedances, the value of voltage and current and the distribution of energy throughout the length. The line will be considered to have no loss and be of such a length that allows relatively straightforward figures and calculations. I hope it will become clear that there is no power dissipation of any kind except in the load, and no power in the standing wave.

A suitable length for ease of calculation is one half wave. At a frequency of 3.5 MHz (λ = 85.7m), the line length will be 42.9m. Terminating the line in a 50Ω non-reactive load at the receiving end and with a generator of 100V, 50Ω output impedance at the sending end describes a long but perfectly practical transmission line. A line composed of conductors 1mm in diameter, spaced 75mm between centres has a surge impedance of 600Ω. Capacitance of the line will be 5.5pFm^{-1} and inductance 2.0 Hm^{-1}. Figure 1 shows such a line.

Looking through the calculated results shows

$$Z_s = Z_0 \frac{Z_r + jZ_0 \tan\beta s}{Z_0 + jZ_r \tan\beta s} \text{ ohms}$$

where $\beta = 2\pi/\lambda = 0.0733$ radians; $\tan\beta s = 0$.

Therefore $$Z_s = 600\frac{50+j0}{600+j0} = 50\angle 0^\circ \text{ ohms}$$

$$E_s = E_g \frac{Z_s}{Z_g + Z_s} \text{ volts}$$
$$= 50\angle 0^\circ \text{ volts}$$

and $$I_s = \frac{E_g}{Z_g + Z_s} = 1.0\angle 0^\circ\text{A}.$$

The line obeys the theoretical characteristics of a half-wave line by having an output impedance the same value as the load. At the receiving end, Z_R = $Z_L = 50\angle 0^\circ$ ohms. The calculated voltage is

$$E_r = E_s\cos\beta x - jI_s Z_0 \sin\beta x$$

where x = s = 42.9m.

$$E_r = -50\angle 0^\circ \text{ volts}$$

and the current I_s = -1.0/0°$_\lambda$ – 1.0∠0°A. In addition to these parameters there is the calculated forward voltage E^+ which is

$$E^+ = \frac{E_r}{2Z_r}(Z_r - Z_0)_e^{+j\beta d}$$

where $e^{+j\beta d} = \cos\beta d + j\sin\beta d$.
$E^+ = -325\angle 0^\circ$ volts

The reflected voltage is

$$E^- = \frac{E_r}{2Z_r}(Z_r - Z_0)_e^{-j\beta d}$$
$$= 275\angle 0^\circ \text{ volts}$$

I^+ and I^- are $-0.542\angle 0^\circ$A and $0.485\angle 0^\circ$A. Interesting manipulation with these numbers shows for instance that $E^+ + E^- = E_r$ or that $I^+ - I^- = I_r$. The v.s.w.r. indicates that E_{max} must be 600V somewhere along

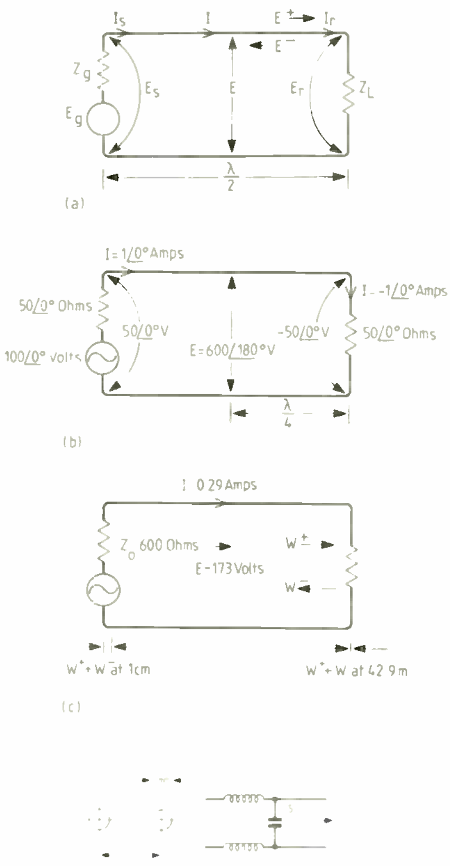

Fig. 1. Showing the 600Ω line with the various voltages, currents, and impedances along the line.

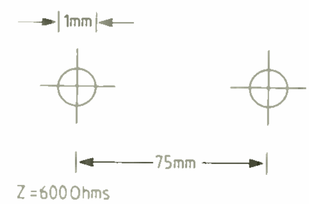

Fig. 2. Some of the calculated voltages, currents, and impedances found along the line under steady state conditions.

the line and perhaps it will be no surprise to find that at a quarter wave along the line $E^+ + E^- = 600V$.

$$E_{\lambda/4} = E_s\cos\beta x - jI_sZ_0\sin\beta x$$
$$= E_s(0) - j1.0\angle 0^\circ \times 600 \times 1$$
$$= 600\angle -90^\circ \text{ volts}$$

The current, of course, is affected by the s.w.r., but instead of being twelve times greater it becomes only one twelfth of I, which has been shown to be 1A. It has been assumed that the reader has instinctively noted that the v.s.w.r. is 12.

An important factor which has not been mentioned is the coefficient of reflection. For this line it is 0.846, indicating that about 85% of the energy is reflected. How, then, can 50W be dissipated in the load? It is the energy to which attention should be turned to understand what is happening.

Consider the energy arriving at the load

$$W_E^+ = ½Cx(E^+)^2$$
$$= 12.5\mu J$$

and the energy reflected

$$W_E^- = ½Cx(E^-)^2$$
$$= 8.92\mu J$$

This is the energy in the electric field, the energy in the magnetic field being exactly the same since it has the same forward and reflected values. The difference between the forward electric field energy and the reflected energy is 3.6microjoules; the difference between the forward magnetic field energy and the reflected energy is the same.

Since the energy was calculated using the forward and reflected voltages and currents, it is a simple matter to discover what voltages and currents are associated with 3.6 microjoules (electric) and 3.6 microjoules (magnetic).

The answer is that the electric field voltage is

$$\sqrt{\frac{2W}{Cx}} = 175 \text{ volts}$$

$$\sqrt{\frac{2W}{Lx}} = 0.29A$$

It is no coincidence that this is the voltage and current that would be found on a 600ohm line feeding a load that is dissipating 50W! The fact is that wherever the energy is calculated on this line, the voltage in the electric field will be 175V and the current 0.29A in the magnetic field.

Calculate the energy at points along the line and it will be clear that as the distance increases from the generator so does the energy. Increasing with the energy is the passage of time. Take the energy and the time together at 1cm along the line from the generator: the energy is 0.82 nanojoules (electric) and 0.82 nanojoules (magnetic), elapsed time is 29 picoseconds and dividing energy by time gives the rate of flow of energy, i.e. 25 joules per second or, for total energy, 50 joules per second. Try again at the receiving end of the line, where elapsed time is 0.143 microseconds, total energy 7.15 microjoules and, once again 50 joules per second. This clearly shows a flow of energy from generator to load of 50 joules per second. The load is dissipating 50W! One way

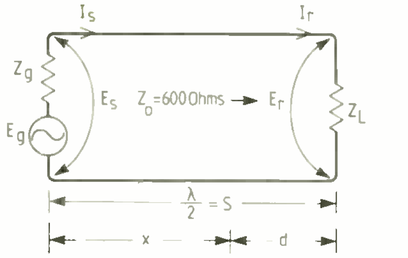

Fig. 3. The line showing voltages and currents that would be present on a 600 ohm line feeding a load that was dissipating 50W; also the points at which the energies were calculated.

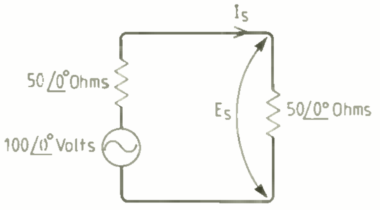

Fig. 4. Indicates the mechanical features of the line and the distribution of inductance and capacitance.

of visualizing this is to imagine a tube or column of energy moving from the generator to the load surrounded by a pulsating exterior which has no forward or reverse movement, i.e. a standing or stationary wave. The amplitude of the stationary wave is, of course, dependent upon the v.s.w.r., and, incidentally, the frequency of the pulsation is twice that of the frequency in use[7].

This, then, describes a transmission line with a fairly high v.s.w.r. If full output power were used (400W) 1,200V would be found at a quarter wave along the line, enough to be an embarrassment in certain circumstances. However, in theory the v.s.w.r. should not present any real problems on an open line of this type. In practice, problems do occur because of imbalance of line voltage and currents causing the line to radiate, possibly causing interference to domestic equipment, and sometimes preventing the antenna performing at its best.

Please note that this article describes a transmission line carrying energy where sufficient time has passed for the line conditions to have reached a steady state.

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Biosensors for diagnosis

A consortium formed by Plessey, Cambridge University and Fisons has started work on the development of biosensors, which are electronic/biological devices for the detection and analysis of biochemicals. There is a huge potential market for such devices in diagnostics and analysis.

Biosensors consist of a thin film of protein on the surface of a substrate. The film interacts in a known way with the biochemical of interest, its electrical, optical or mechanical characteristics being changed by the interaction. Depending on the type of property modification undergone, the microelectronic device on the substrate will then convert the information to an electrical signal for further processing. Examples of properties that might be affected by an interaction are conductivity, capacitance, optical absorption or refraction, or density, which could be detected by a change in vibration characteristics. The substrate could even be of several types to detect and analyse multiple biochemicals simultaneously, a capability needed in the detection of specific bacteria, viruses or antibodies.

The obvious application of such devices is in the medical field, where rapid analysis of body fluids could be carried out by a GP, the sensor in this case forming part of a small instrument for signal analysis, computation and display; in such an application, the biosensor itself would be cheap enough to be a disposable element. Other uses envisaged by the consortium lie in the food industry, the biotechnology sector and for the detection of explosives and gases.

A five-year programme of research is receiving support from the Department of Trade and Industry, the goal being the development of a sensor for multiple chemicals in the analysis of blood. It is expected, though, that simpler devices will emerge during the research.

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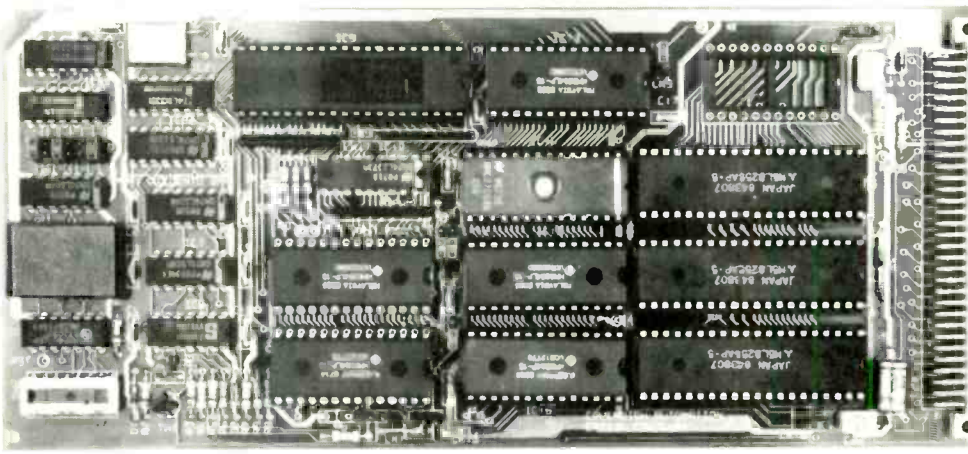

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FEEDBACK

The Catt Anomaly

I was surprised to learn (EWW August 1988) that my solution to Ivor Catt's anomaly (March 1988) does not satisfy Gauss's Law, especially as I derived it from Gauss's Law. Alan Robinson (October 1988) has already supplied the explanation: electrons flow to and from the external circuit at exactly the rate required to provide the charge Gauss requires.

My original point was that the electrons entering or leaving do not need to dash at the speed of light to charge the conductor (was this not the original 'anomaly'?) but simply nudge the existing electrons into place with a very low drift velocity. Ivor Catt is correct in believing that in a capacitor the charging process takes place in a wave, as in a transmission line, but not that this disposes of displacement current, as I will explain.

The charging of the line requires a current to flow in each conductor from the external connection point as far as the TEM wave, but no current ahead of the wave (as Alan Robinson so clearly describes). This current leads to a transverse magnetic field behind the wave, but no magnetic field ahead of the wave. Indeed, the TEM wave forms an edge to both the electric and magnetic fields. It can be shown from Ampere's Law that wherever a transverse magnetic field comes to such an edge there must be a current.

The two conductors provide the necessary currents at the top and bottom, but what about the identical magnetic field edge in the wave itself? According to Ampere, we should find a current here. Ivor Catt's explanation of the charging of a capactior is in direct violation of Ampere's Law.

I hate to say it, but this was precisely why Maxwell's 'invented' displacement current. By conventional theory, the displacement current flowing down the wavefront is exactly equal to the current flowing out along one conductor and back along the other – in fact, it completes the circuit: what could be more logical? Ivor Catt and colleagues (WW March 1979, p67) thought that such a current would lead to a magnetic field ahead of the wave, but this is not correct, and comes from a simplistic view based on magnetic fields circulating round currents in wires.

In the same article, they also confused displacement current with displacement current density, which in a perfect step wave has become infinite. Hence my original question needs repeating: can a perfect step exist?

John Matthews
Exeter

Mr Matthews very sensibly points out in a covering letter that Ivor Catt's original article was in the December 1978 issue making this train of correspondence 10 years old. He adds "Should this not be celebrated in some way?"

Yes. Correspondence closed.

Post inventive depression

I read with interest and sympathy Heinz Lipschutz's *cri de coeur*, 'Confessions of a Frustrated Inventor', in your March issue, as have a number of your correspondents who have similarly encountered the dead hand of administrative apathy.

However, there is another side to this coin, which is equally unsettling, which is that of uncomprehending enthusiasm. Let us suppose, for example, that one works for a large organisation, and one is seized with an idea for some worthwhile technical improvement, and the nature of this idea is such that its effect can be visualised by those in charge, who respond with enthusiasm and decree its instant adoption.

Now, the implementation of most technical ideas in industry implies the construction of some purpose-built hardware, and in most large organisations, those who will design and construct this hardware are likely to be remote from the original inventor. It is also quite probable that, for reasons of inadequate seniority, or of departmental isolation, the original inventor may not even be able to attend the numerous committee meetings which decide the nature of the actions to be taken and supervise their progress, or even be informed of their decisions.

Human inquisitiveness being what it is, the inventor may nevertheless keep a close eye on what is actually being done, in his name, and may be alarmed to see the extent to which has idea has been transformed in its implementation. This alarm will arise as much from the visible costs of construction as from the predictable failure of the resulting hardware to bring about the desired result, since the odium accruing to the inventor of a failed idea is proportional to the time and cost involved in its realisation.

This sad state of affairs arises from two causes: firstly, that most people like to incorporate something 'of themselves' in what is being done – indeed they cannot lose by this, since if it turns out well, they can claim the credit, while if it doesn't, they can keep quiet. It is unlikely, therefore, that those who have the task of transforming the idea into reality will be content to leave the original scheme intact. Secondly, it is quite probable that the persons in whose hands the work now lies may not even understand the theoretical background behind the basic intention, and so fail to see that seemingly innocuous changes may be destructive in their effect.

The mental agony of the unfrustrated inventor, watching the gestation of this costly 'white elephant' is not likely to be lessened by the impending 'told you so's' of the defenders of the status quo, or the likely jubilation of his professional rivals.

There are times, indeed, when the inventor, in this situation, is likely to wish, wholeheartedly, that he had kept his ideas to himself.

J.L. Linsley Hood
Taunton
Somerset

Magnetic Wagner

Thomas Boag wrote an interesting letter in the July issue making a wonderful analogy between Wagner's music and electromagnetic theory. This prompted several readers to contact Mr Boag with assertions of their own. Mr Boag sent in a very detailed response which, regrettably, we do not have room for. However we are happy to send on a copy of his letter by request.

Battery breakdown

Recently I had a problem with a NiCad cell failure. It's capacity decreased rapidly over a few weeks giving a shorter and shorter service time. Eventually it had zero volts and current. I couldn't understand why one should fail while all the others (including much older ones) are still going fine.

Re-reading the articles by R. Cooper (May, June 1985) the diagnosis was probably crystal-whisker shorting out the cell. So as a last ditch effort before dumping it in the bin I temporarily shorted the cell across a 1A current limiting supply set for an initial 'shock' charge at 6v. A couple of attempts and the cell was restored after a 15sec burst of charging and able to give out more than 1A current – the needle went off the maximum scale of the meter.

I suppose I should point out that this technique is hazardous and NOT recommended in ordinary circumstances.

FEEDBACK

After restoration I put it back in the normal trickle charger overnight to see if the internal discharge was still significant. The cell is still alright holding its charge and current capacity after a week. This leads me to wonder if it would be desirable to include a small charged reservoir capacitance for each cell in the charger unit to give each a burst of current to break down any crystal-whisker growths on every charge-discharge cycle.

There are a lot of fancy charging units on the market that give *repetitive* bursts while charging. Is such complexity really necessary? Or is the reasoning based upon electronically induced cavitation in the electrolyte to speed up chemical recombination in charging?

R.S. Ratcliffe
27 Shackleton Spring
Stevenage
Herts

Aural imagination

Mr Self's article about subjectivism in audio was a most interesting and enjoyable piece for me to read, for it puts into words what I have thought for some time. The comment I would like to add is to do with why 'subjectivists' hear differences between technically identical equipment. Mr Self touches on the subject in his article and I think it lies at the heart of the problem.

The dispute seems to have built up over the years between people who hear differences in audio equipment and those who claim you can't hear any differences because the equipment in question measures perfectly. The 'objectivists' explain their test procedures till they are blue in the face but don't explain why people will hear differences. The subjectivists are forced to resort to claiming that there must be unknown audio phenomena at work, processes that are not covered with the existing measurement techniques, and conclude that their ears are more sensitive and reliable than test equipment. The objectivists' reply seems to be more testing, such as comparing output to input waveforms, but people still report hearing differences in equipment.

I, personally, would not dispute that listeners can hear differences between technically similar equipment; where I would take them to task is in their reaction of blaming the equipment and not allowing for the biggest variable in the audio chain, themselves. They tend to treat their ears as infallible instruments without applying the same scepticism to their hearing as they do to the equipment they are auditioning. Subjectivists pride themselves on examining and exploring the subtle and unconsidered interactions in audio equipment but all this examination of minutiae halts as the sound enters the ear. There is no consideration of how the brain analyses sound and to what factors unconnected with sound affect how we interpret what we hear and influence our perceptions. The human senses can be very misleading and have proved an unreliable foundation for the sciences. The 'scientific method' has developed over the centuries to allow for human fallibility, so making it possible to distinguish between real phenomena and human desires. Scientific methods, such as double-blind testing, may be long winded and lack the glamour of subjective assessment but they do help side-step the problem of the unreliability of the listener. Whatever method is used to assess audio equipment, an approach that allows for all outside influences on the sound, whether they happen in the electrical, physical or biological domain, would be preferable.

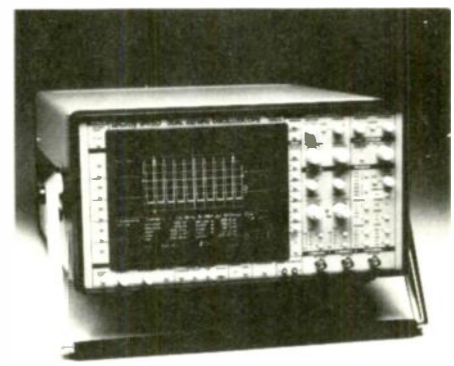
D.L.Chell
Bramcote
Beeston
Nottingham

Fast, flexible digital storage oscilloscope

With five processors to handle signal acquisition and display, this portable digital oscilloscope by LeCroy (model 9450) is so fast that it responds to its controls like an analogue one. Replotting the screen takes it no appreciable time at all.

Two Texas d.s.p. chips, one per channel, give the instrument a bandwidth of 350MHz; but it can sample repetitive signals at equivalent rates of up to 10 gigasamples per second, using eight-bit flash a-to-ds. Associated with each channel is 50K-word of non-volatile memory, which enables the instrument to record over extended periods of time and to provide horizontal trace expansion of up to 1000 times, so that the user can capture very short-lived events and examine them in detail. Total memory of the instrument is 300K by 16 bits. Rival oscilloscope designs have mostly been based on c.c.d. memories, which give less flexibility.

The large-screen display is created in vector mode by a gate-array processor developed by LeCroy. To plot a line on the screen, this processor must calculate not only the start and end points, but also the plotting speed necessary to give the required brightness. Screen resolution is 4096 by 4096 pixels – a substantial refinement over the average workstation, which gives about 1000×1000. Other Asics in the 9500 include one for histogramming.



Up to 1000 times trace expansion is possible with the 9450. Triggering modes, which can be complex, are displayed graphically at the bottom of the screen. The whole display can be dumped direct to a printer or plotter.

Around the edge of the trace display is an area reserved for text. This can be used to display and update automatic measurements of the signal. A special feature of the instrument is its variety of triggering modes: trigger decisions can be based on signal duration or pulse pattern as well as voltage level. It is possible to trigger on, for example, a brief low-level spike submerged in a signal of much larger amplitude. Repetitive signals can be averaged to recover them from noise (at speeds up to 20 000 points per second), and the trigger modes also work with averaged signals.

Other functions of the instrument are handled by a 68020 microprocessor running at 35MHz, with a 68881 floating-point coprocessor. Also among the oscilloscope's features are automatic set-up, an auto-calibration routine, menu-driven waveform processing functions, and remote control via GPIB or RS-232 links. Promised for later is an optional FFT analysis module.

The 9450 is designed and manufactured in Geneva; price is about £13000. It is LeCroy's second d.s.o.; until recently, the company had confined itself to producing specialized instrumentation for high-energy physics, much of it for sale to the European research centre CERN, which is also in Geneva. Further details from LeCroy Ltd. 28 Blacklands Way, Abingdon Business Park, Abingdon, Oxfordshire OX14 1DY; tel: 0235-33114.

Multiprocessor systems

In his fifth article, Alan Clements talks further about devices related to linking microprocessors.

Last month's article discussed gaining access to the VMEbus. In this final article I will first explain how the VMEbus is released, then detail the 68000 family interrupt requester.

Once the 68175 bus controller has gained control of the VMEbus, it retains control until it is explicitly removed from bus mastership. The 68175 controller asserts its $\overline{\text{BBSY}}$ output to indicate its continued bus mastership. When the controller active-high bus release input, BREL, is asserted, control of the bus will be passed to a new master.

If BREL is asserted during a bus cycle by the current bus master (i.e. the 68175's local master), the bus-busy output, $\overline{\text{BBSY}}$, is negated to permit bus arbitration. When the current bus access by the local bus master is complete, the 68175 releases the bus by negating $\overline{\text{ADDEN}}$, $\overline{\text{AS}}$ and STBEN. At this point, the local master can regain mastership of the VMEbus only by asserting $\overline{\text{OFFBD}}$ and requesting bus mastership.

68154 INTERRUPT REQUESTER

The interrupt requester sits between devices that generate interrupts and the VMEbus. Before I came across the 68154 to be described here, I found it difficult to understand why there might be a need for a special interrupt requester. After all, you signal an interrupt request by asserting one of the VMEbus's seven interrupt request lines and then provide a vector during the IACK cycle.

Like many of today's complex peripherals, the 68154 interrupt generator has more facilities than are necessary for a minimal application and saves several t.t.l. logic i.cs. Figure 15 shows how the 68154 interfaces to the VMEbus.

For the purpose of this discussion, assume that the 68154 has been programmed to generate an interrupt request by setting up the interrupt-request register R1. The 68154 is interfaced to the interrupt sub-bus of the VMEbus with a minimum of additional logic, Fig. 15. Seven interrupt-request lines from the 68154 are buffered onto the VMEbus by open-collector buffers. When the VMEbus interrupt acknowledge line, $\overline{\text{IACK}}$, is asserted, an interrupt-acknowledge message is passed along the VMEbus $\overline{\text{IACKOUT}}$ $\overline{\text{IACKIN}}$ daisy-chain. The 68154 responds to an IACK cycle initiated from the VMEbus when the following conditions have been satisfied:

- $\overline{\text{IACK}}$ is asserted to indicate that an IACK cycle is in effect.
- $\overline{\text{IACKIN}}$ is asserted to indicate that no other interrupt requester located closer to slot 1 has intercepted the interrupt acknowledge.
- $\overline{\text{DS}_0}$ is asserted.
- The 3bit code on A_{1-3} reflects the level of the interrupt request put out by the 68154. That is, if the VMEbus is acknowledging a, say, level 6 interrupt request and the 68154 has requested a level 4 interrupt, the 58154 does not respond.

If these conditions are not all met, the 68154 passes $\overline{\text{IACKIN}}$ to $\overline{\text{IACKOUT}}$ and sends the interrupt request down the VMEbus. However, if the conditions are met, the 68154 does not assert $\overline{\text{IACKOUT}}$ and begins its response to the IACK cycle. The 68154 first clears the appropriate interrupt request bit of its interrupt request register, R1, Fig. 16.

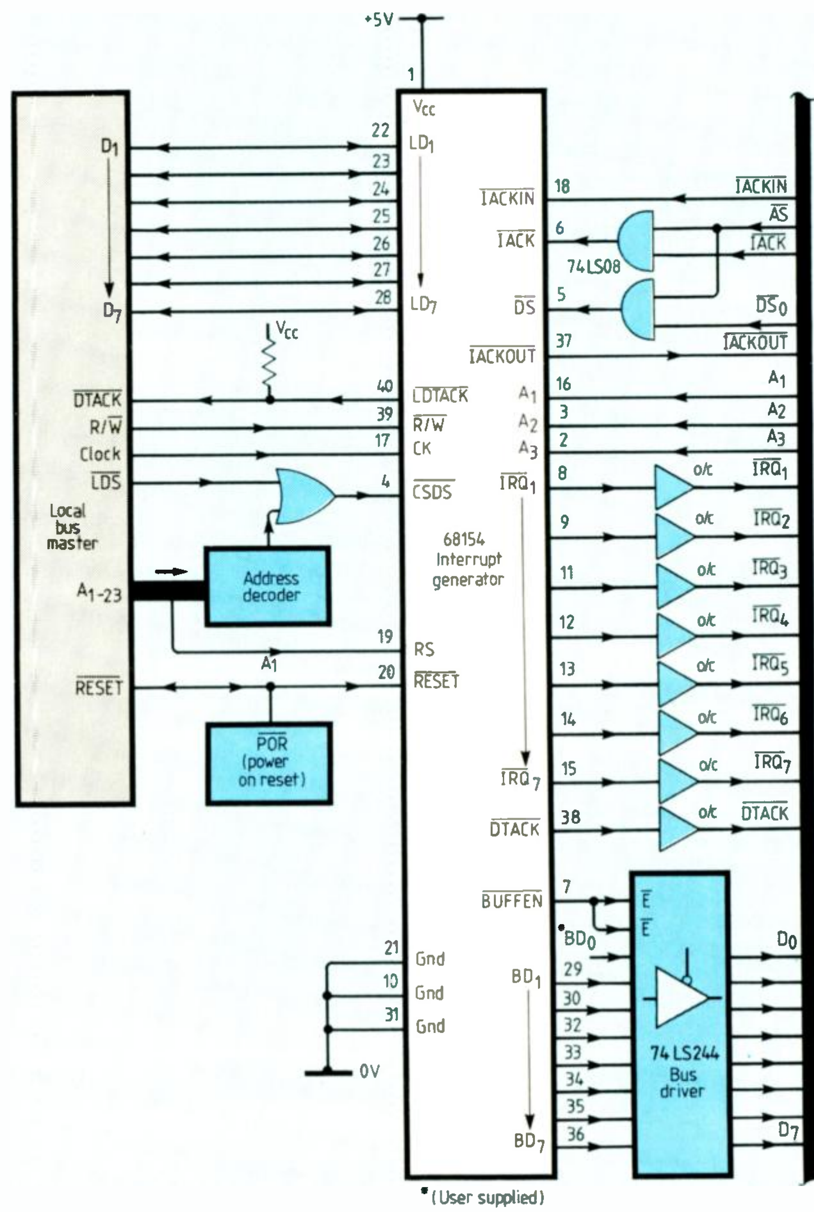


Fig. 15. Connecting the 68154 to the VMEbus.

Buffer-enable output, $\overline{\text{BUFFEN}}$, from the 68154 is asserted to enable the 74LS244 three-state buffers. These buffers put the interrupt vector on pins BD1 to BD7 onto the VMEbus to provide the status/identification byte required during as IACK cycle. $\overline{\text{DTACK}}$ is asserted by the 68154 to complete the acknowledge cycle.

Note that the 68154 supplies a seven bit interrupt vector. Bit D_0 is not supplied by the 68154 — that bit is left to user-supplied logic, Fig. 15. Timing of the 68154's interrupt-acknowledge cycle is shown in Fig. 17.

The local master side of the 68154 is as unexceptional as its VMEbus interface. It interfaces to the local bus master just like any other memory-mapped peripheral with an asynchronous bus interface through its seven data lines (remember that the 68154 does not make use of D_0).

When power is initially applied to the local master, its power-on-reset circuit asserts the 68154's $\overline{\text{RESET}}$ input. A reset operation forces all $\overline{\text{IRQ}}$ outputs plus $\overline{\text{IACKOUT}}$ high and resets the interrupt request and interrupt vector registers.

Before the 68154 is able to handle interrupt requests, it must be set up by loading its interrupt vector register, R0, with the high-order five bits of the interrupt vector. When the 68154 responds to an interrupt-acknowledge cycle, it loads the high order five bits of R0 onto the data bus and places the interrupt-request level (i.e. 1 to 7) on the low-order three bits of the data bus. For example, if the interrupt vector is 10011 and the interrupt level is five, the vector 10011101 is supplied during the interrupt-acknowledge cycle. Bit 2 of the interrupt vector register clears all interrupt requests when set and bit 1 enables all interrupt requests when set.

The interrupt-request register, R1, is used to request interrupts. Loading bit i of R1 asserts IRQ_i. Suppose we wish to generate interrupt requests at levels IRQ_4 and IRQ_6 and that the interrupt vector number is 65 (i.e. interrupt-vector table entry of 260). Code for this is as follows.

```
LEA      INT GEN, AO      AO points to the
                          68154
MOVE     #65, (A0)        Set up lowest
                          interrupt-vector
                          number
BSET.B   #1, (AO)         Enable the
                          interrupts
MOVE.B #%01010000,2(A)
               Request interrupts on levels 4 & 6
```

Once the registers have been set up, the 68154 requests an interrupt by asserting the appropriate $\overline{\text{IRQ}_i}$ line of the VMEbus and then automatically supplying the interrupt vector during the subsequent IACK cycle.

68155 INTERRUPT HANDLER

It is, perhaps, misleading to call the 68155 an interrupt handler since interrupts are really handled by a processor executing a software routine. It would have been better to call it an interrupt prioritizer or an interrupt filter.

The 68155 handles up to 14 interrupts, seven of which may come from the VMEbus and six from a local source (i.e. devices on the same board as the 678155 and its slave processor) plus a non-maskable interrupt that may be from a local or a VMEbus source. Figure 18 shows how the 68155 interrupt handler interfaces to the VMEbus, the local master (assumed to be a 68000 c.p.u.) and the local interrupt sources.

The interface between the 68155 and the VMEbus consists of nine lines, $\overline{\text{IRQ}_{1-7}}$, $\overline{\text{NMI}}$ and $\overline{\text{IACK}}$ (which is derived from the 68155's $\overline{\text{BIACK}}$ output). The $\overline{\text{NMI}}$ (non-maskable interrupt request) is the highest priority interrupt handled by the 68155 and can be connected to the VMEbus's $\overline{\text{AC-FAIL}}$ line or to some other interrupt source that must be non-maskable.

Essentially, the 68155 detects an interrupt request on the VMEbus by one of $\overline{\text{IRQ}_{1-7}}$ asserted and asserts $\overline{\text{BIACK}}$ (bus interrupt acknowledge) to indicate that the interrupt request has been accepted.

Figure 19 provides the timing diagram of a VMEbus interrupt-acknowledge sequence. The 68155 passes on the interrupt request from the VMEbus (or from a local source) to the local master via its encoded interrupt request inputs $\overline{\text{IPL}_{0-2}}$ which are connected to the corresponding inputs of the local 68000 interrupt handler. Table 2 provides details of the 68155's interrupt level encoding scheme. The $\overline{\text{BIACK}}$ output from the 68155 is buffered onto the VMEbus by a tristate gate, Fig. 18.

Before the 68155 can take part in an interrupt-acknowledge cycle, it must first take control of the VMEbus. By connecting $\overline{\text{BIACK}}$ from the 68155 to the $\overline{\text{OFFBD}}$ input of a 68175 bus controller, a bus request to the VMEbus is automatically made at the start of an interrupt acknowledge cycle. When the 68175 bus controller grants use of the VMEbus, its $\overline{\text{ADDEN}}$ output enables the $\overline{\text{BIACK}}$ bus driver.

In addition to interrupts originating from the VMEbus, the 68155 can deal with six levels of interrupt from local interrupt sources. Local-interrupt $\overline{\text{LRQ}_6}$ has the highest priority and $\overline{\text{LRQ}_1}$ the lowest.

R0 Interrupt vector number register, accessed when RS=0

R1 Interrupt request register, accessed when RS=1

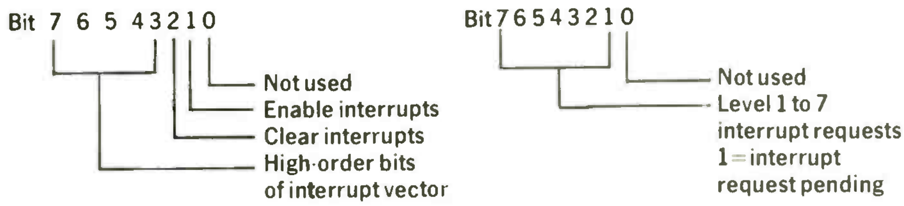
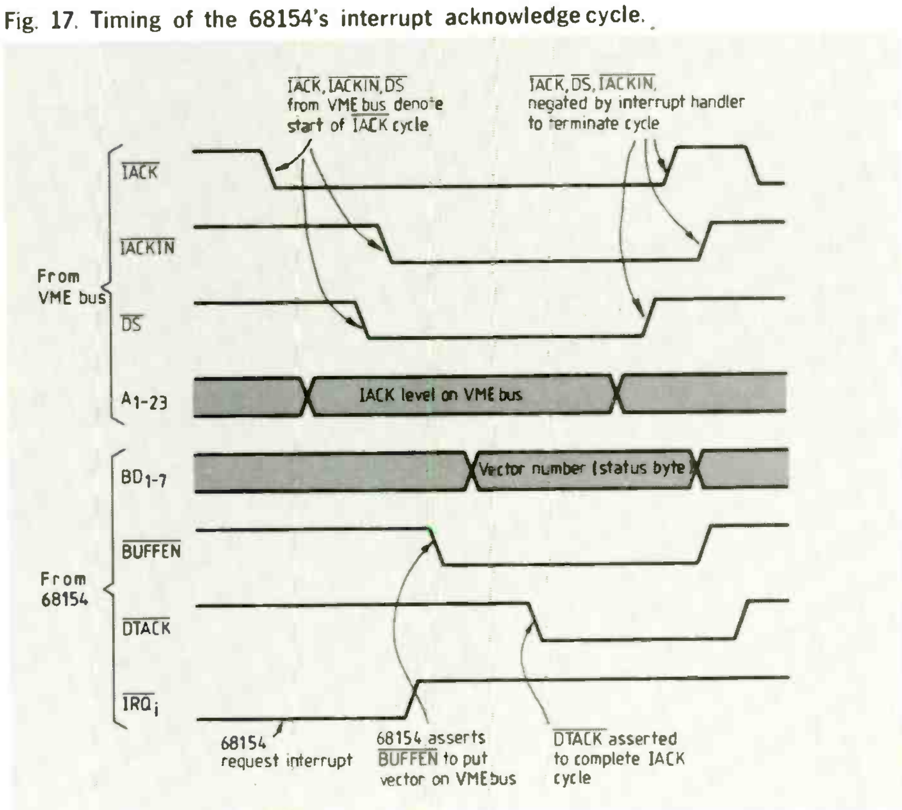


Fig. 16. The 68154's registers.

Table 2. 68155 interrupt priority.

Interrupt request level	Interrupt priority level outputs IPL_2	IPL_1	IPL_0
$\overline{\text{NMI}}$, $\overline{\text{IRQ}_7}$	0	0	0
$\overline{\text{LRQ}_6}$, $\overline{\text{IRQ}_6}$	0	0	1
$\overline{\text{LRQ}_5}$, $\overline{\text{IRQ}_5}$	0	1	0
$\overline{\text{LRQ}_4}$, $\overline{\text{IRQ}_4}$	0	1	1
$\overline{\text{LRQ}_3}$, $\overline{\text{IRQ}_3}$	1	0	0
$\overline{\text{LRQ}_2}$, $\overline{\text{IRQ}_2}$	1	0	1
$\overline{\text{LRQ}_1}$, $\overline{\text{IRQ}_1}$	1	1	0
none	1	1	1

Fig. 17. Timing of the 68154's interrupt acknowledge cycle.



A local interrupt is acknowledged by the local c.p.u. asserting the $\overline{IACKDS}$ input to the 68155. A glance at the circuit of Fig. 18 demonstrates that $\overline{IACKDS}$ is generated in the conventional way by the local 68000 setting $FC_{0\text{-}2}$ to 1,1,1 and asserting $\overline{LDS}$. The 68155 responds by reading the $\overline{IACK}$ level from the 68000 on its $A_{1\text{-}3}$ inputs to determine the level of the current interrupt. If a local interrupt has the highest current priority, the 68155 will respond in one of two ways.

If the 68155 is operating in its vectored mode, it asserts its local interrupt-acknowledge output, $\overline{LIACK}$, places an interrupt vector number on its data bus for the 68000 to read and then asserts $\overline{LDTACK}$ to complete the bus cycle. However, if the 68155 has been programmed to permit a local device to issue the interrupt vector number, the 68155 asserts only $\overline{LIACK}$ and leaves the local device to complete the interrupt acknowledge cycle (by providing its own vector and asserting $\overline{LDTACK}$).

Note once more the versatility of modern interface components — the 68155 permits devices with their own interrupt vector number registers to respond to interrupt-acknowledge cycles, or the 68155 is able to supply a vector number for interfaces unable to supply their own. Figure 20 provides timing diagrams for a local interrupt-acknowledge cycle in both the vectored mode and the non-vectored mode.

68155 PROGRAMMING MODEL

Register structure of the 68155 interrupt handler is rather more complex than that of

Table 3. 68155 register set.

Base	A_3	A_2	A_1	Register	Name	Type
+0	0	0	0	R0	Pointer register	write only
+2	0	0	1	R1	Control registers	read/write
+4	0	1	0	R2	LRQ vector	read/write
+6	0	1	1	R3	LRQ mask	read/write
+8	1	0	0	R4	LRQ status	read only
+10	1	0	1	R5	IRQ mask	read/write
+12	1	1	0	R6	IRQ status	read only
+14	1	1	1	R7	Last interrupt-acknowledge	read only

68155 registers

REGISTER R2 provides the associated interrupt-vector number for interrupts on the local master side of the 68155. The five most-significant bits of R2 are loaded with the user-supplied vector. During a local interrupt-acknowledge cycle, the interrupt vector number supplied by the 68155 consists of the five bits loaded into R2 plus three bits that indicate the level of the interrupt (001 = $\overline{LRQ_1}$, 010 = $\overline{LRQ_2}$ ... 110 = $\overline{LRQ_6}$, 111 = NMI). For example, if R2 is loaded with 10101xxx (x = don't care), the interrupt vector number supplied by a local interrupt on level 3 is 10101011.

REGISTER R3 enables or disables (masks) the local interrupt sources. Loading bit i of R3 with 1 enables $\overline{LRQ_i}$. Note that bit zero of R3 has a special function. When bit 0 of R3 is set to 1, it allows the 68155 to supply a NMI vector during an interrupt-acknowledge cycle initiated by a non-maskable interrupt.

REGISTER R4 is a read-only local interrupt-pending register, whose contects are determined by the 68155. A logical one in bit i of R4 indicates that a local interrupt on $\overline{LRQ_i}$ is pending (i.e. awaiting service).

REGISTERS R5 AND R6 are the VMEbus side equivalent of the local interrupt side register R3 and R4. Bits 1 to 7 of R5 permit the programmer to enable interrupt-request levels $\overline{IRQ}_{1\text{-}7}$ respectively. Bit zero both R5 and R6 is not used. Register R6 is an interrupt-pending register for the VMEbus side of the 68155.

REGISTER R7 indicates the last interrupt acknowledged. The local c.p.u. may read R7 to determine which level of interrupt the 68155 last acknowledged. How the bits of R7 are decoded is shown below. R7 may be used by the operating system to implement various forms of interrupt prioritization.

Decoding R7 (last interrupt acknowledge).

Bits 3	2	1	0	Last interrupt
0	0	0	0	None
0	0	0	1	$\overline{IRQ_1}$
0	0	1	0	$\overline{IRQ_2}$
⋮				
0	0	1	1	$\overline{IRQ_6}$
0	1	1	1	$\overline{IRQ_7}$
1	0	0	0	None
1	0	0	1	$\overline{LRQ_1}$
1	0	1	0	$\overline{LRQ_2}$
⋮				
1	1	0	1	$\overline{LRQ_5}$
1	1	1	0	$\overline{LRQ_6}$
1	1	1	1	NMI

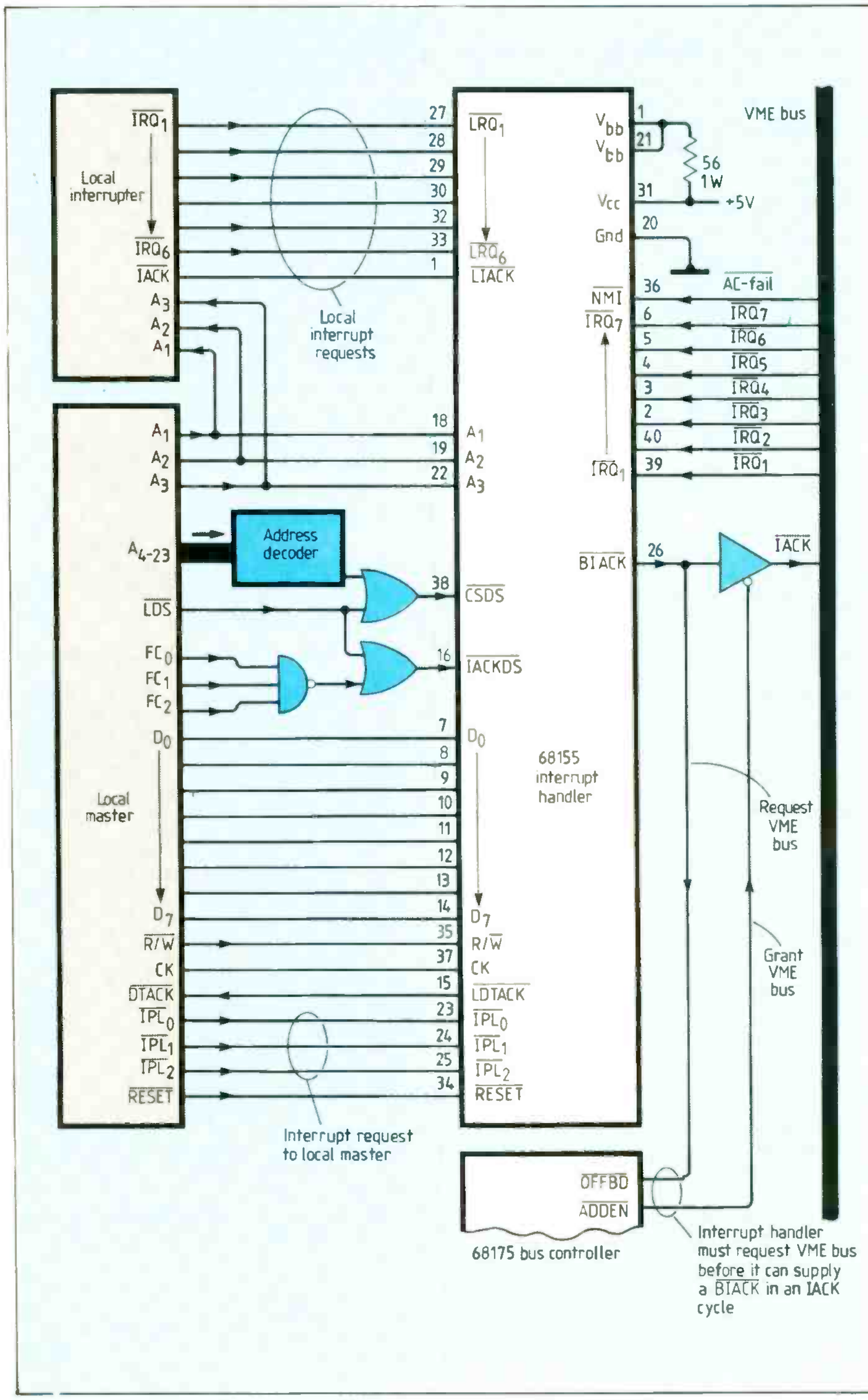


Fig. 18. Interfacing the 68155 to VMEbus.

its 68154 and 68175 companions. The local master accesses the 68155's register set exactly like any other memory-mapped peripheral by asserting the 68155 $\overline{CSDS}$ input and executing an asynchronous bus cycle, Fig. 18. Register selection is made with the aid of A_{1-3} from the local master — but that is not the whole story. The 68155 has eight addressable registers as defined in Table 3.

In Table 3, the thirteen registers are listed in terms of their base address offset from the point at which the 68155 is memory mapped, the address lines that select the register, the register number (R0-R7), the register name and whether the register is read-write or read-only.

The more numerate of you will have noticed that I said that there are 13 registers, but only eight are listed in Table 3. The reason is simple — there are six different R1s (i.e. control registers). Register R0 is loaded with the address of the current control register in R1. To select control register i (where i = 1 to 6), R1 is loaded with 001 to 110, respectively. Only one of the control registers is visible at a time.

To simplify notation, we can refer to R1 as CR_1 to CR_6, so that, for example, CR_2 is the same as R1 when R0 is loaded with 2. I hate register sets. Fathoming them out is even worse than learning irregular verbs in a foreign language. Perhaps a better approach to learning what register does what, is to ask what do you want this peripheral to do, and then look for the registers that perform that task.

Since the 68155 responds to interrupt requests, most of its registers are responsible for defining how the requests are detected. In the case of the 68155, you have to consider two classes of register: those that deal with the VMEbus and those that deal with the local bus. Control register R1 holds six 3bit values, one for each of the local interrupt request inputs. The programmer sets up each of the six values in R1 by first setting the pointer register, R0, and then loading the appropriate 3bit interrupt control value in R1.

Table 4 defines the way in which the bits of the 68155's registers are interpreted. The three lower-order bits of R1 determine the active state of the $\overline{LIRQ_i}$ input, whether the $\overline{LIRQ_i}$ is level or edge sensitive and whether that level is to respond with an interrupt vector number during on interrupt-acknowledge cycle. For example, loading control-register 2 (CR_2) with 00000111 means that the local interrupt level 2 ($LIRQ_2$) is programmed as a positive edge sensitive interrupt that issues an interrupt vector number during an interrupt-acknowledge cycle.

Further register functions are shown in the panel.

PROGRAMMING THE 68155

Like almost all peripherals, the 68155 is initialized during the reset phase. However, it can be reprogrammed at any time to modify the interrupt-service levels or interrupt vector numbers.

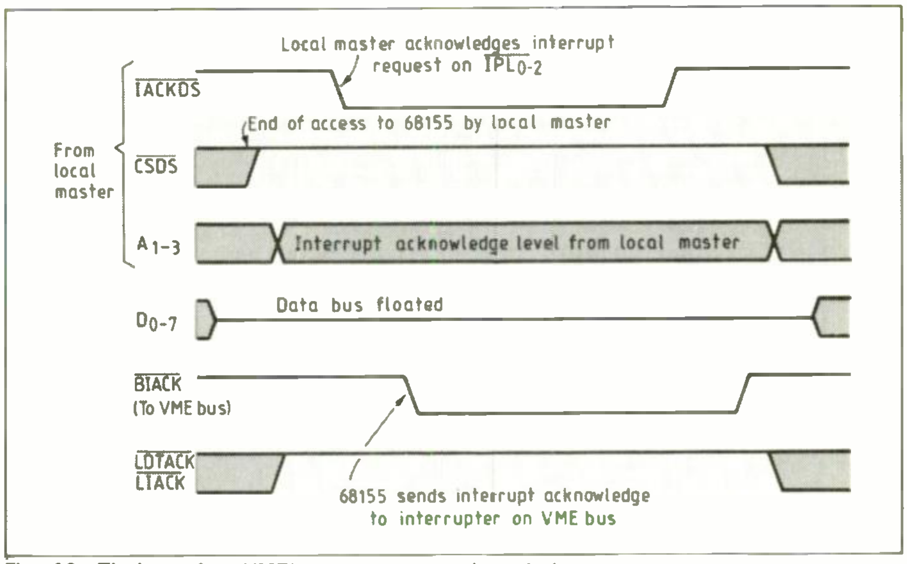


Fig. 19. Timing of a VMEbus interrupt ackrowledge sequence.

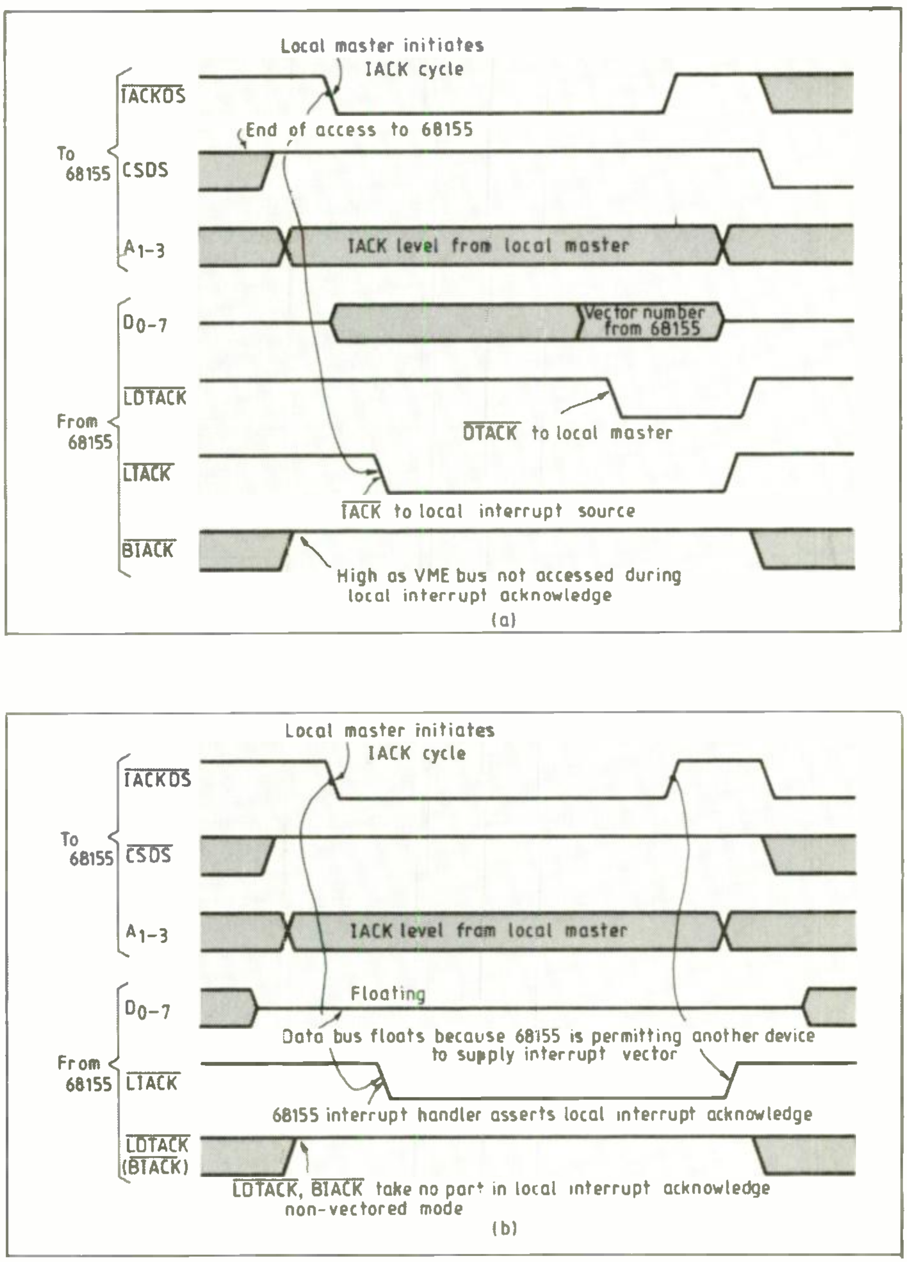


Fig. 20. Timing diagrams for the 68155 local interrupt acknowledge cycle, with (a) showing vectored mode and (b) showing non-vectored mode.

Table 4. Structure of the 68155 registers.

Register	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
R0	x	x	x	x	x	B_2	B_1	B_0
						← CR1-CR6 pointer →		
R1	x	x	x	x	x	AS_i	EL_i	VE_i
R2	LRQ_7	LRQ_6	LRQ_5	LRQ_4	LRQ_3	LRQ_2	LRQ_1	LRQ_0
	← LRQ vector output →					← LRQ level →		
R3	NMIM	LRQ_6M	LRQ_5M	LRQ_4M	LRQ_3M	LRQ_2M	LRQ_1M	NMIE
		← LRQ mask →						
R4	$\overline{LRQ_7}$	$\overline{LRQ_6}$	$\overline{LRQ_5}$	$\overline{LRQ_4}$	$\overline{LRQ_3}$	$\overline{LRQ_2}$	$\overline{LRQ_1}$	0
	← local interrupt status 1 = interrupt pending →							
R5	$\overline{IRQ_7}$	$\overline{IRQ_6}$	$\overline{IRQ_5}$	$\overline{IRQ_4}$	$\overline{IRQ_3}$	$\overline{IRQ_2}$	$\overline{IRQ_1}$	0
	← IRQ mask IRQ_i = 1 = interrupt enabled →							
R6	$\overline{IRQ_7}$	$\overline{IRQ_6}$	$\overline{IRQ_5}$	$\overline{IRQ_4}$	$\overline{IRQ_3}$	$\overline{IRQ_2}$	$\overline{IRQ_1}$	0
	← IRQ status IRQ_i = 1 = interrupt pending →							
R7	x	x	x	x	LRA_3	LRA_2	LRA_1	LRA_0
					← Last interrupt acknowledge →			

x = bit not used

Consider a system that supports three local interrupt sources, $\overline{NMI}$, $\overline{LRQ_5}$ and $\overline{LRQ_2}$, and is designed to respond to VMEbus interrupts $\overline{IRQ_{2-6}}$ inclusive. Signal $\overline{LRQ_5}$ is to be triggered by a positive edge and $\overline{LRQ_2}$ by a negative level. The local interrupt vector number is $9C_{16}$. Code for such a system might be as follows:

```
INT__BASE  EQU  $800000        Base address of 68155
R0         EQU  0              Pointer register
R1         EQU  2              Control registers
R2         EQU  4              LRQ vector register
R3         EQU  6              LRQ mask register
R5         EQU  10             IRQ mask register

LEA INT__BASE,A0               A0 points to 68155
MOVE.B  #5,0(A0)               Set pointer to select control reg 5
MOVE.B  #%111,R1(A0)           LRQ5 is positive-edge sensitive
MOVE.B  #2,R0(A0)              Set pointer to select control reg 2
MOVE.B  #%001,R1(A0)           LRQ2 is negative level sensitive
MOVE.B  #$9C,R2(A0)            Set local interrupt-vector number
MOVE.B  #%00100100,R3(A0)      Enable LRQ2 and LRQ5
MOVE.B  #%01111100,R5(A0)      Enable IRQ2 to IRQ6
```

SUMMARY

Multiple microprocessor systems offer increased computational throughput, but at a price. The penalty for multiprocessing is the cost of the buses over which the individual microprocessors communicate with each other and the loss of efficiency due to bus contention when more than one device wishes to access the same bus at the same time.

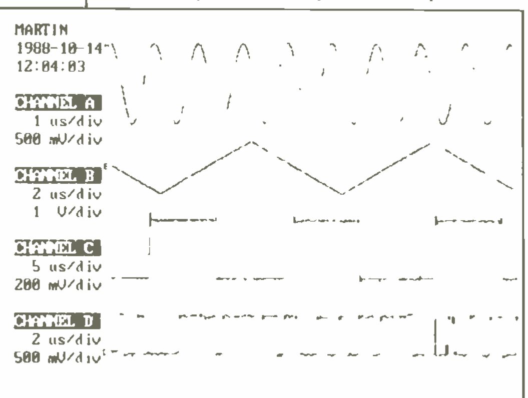
In this set of articles I have looked at two particular ways of implementing multiple microprocessors systems. One uses multiport memory that allows microprocessors to communicate with each other via a common block of memory which each may access. The other way of coupling microprocessors involves a common bus. Bus-based multiprocessor systems are, in many ways, easy to design because all they require is an arbitration mechanism that allows a microprocessor to request a bus access to use the bus and then to hand over the bus to another user. One particular bus, the VMEbus, dominates the 68000 world.

MULTIPROCESSING ARTICLES IN THIS SERIES

Digital storage oscilloscope on a PC-compatible card

In production environments, more and more emphasis is being placed on customized end products and just-in-time manufacture. As a result, test equipment for more flexible manufacturing processes also needs to be more flexible, and it follows that operators using the equipment also need to be more highly skilled.

A storage oscilloscope that can potentially be set up using, say, a bar-code label on the end product to be tested would save time and money, and allow unskilled operators to carry out the testing.



Recently, automation company Contax started distributing a digital oscilloscope card that plugs into the IBM PC and can therefore be configured and read automatically. Being a supplier and writer of computer-integrated-manufacturing software, Contax is capable of either linking the oscilloscope routines directly into cim software, or of providing device drivers so that customers can patch the d.s.o. into their own systems.

Software supplied with the card provides 'front-panel' functions, waveform filing routines and waveform analysis features like differentiation/integration, least-square fitting and f.f.t. All the features normally found on a d.s.o. are present, plus some extra ones like a 'pull-down' d.v.m. and counter.

SPECIFICATIONS

Hardware	
Single-channel sampling	40MHz
Dual-channel sampling	20MHz
Total on-board memory	256Kbyte
Bandwidth	20MHz
Trigger source	Ch. A, Ch. B, Ext, Keyboard
Trigger mode	Mid-, post-, or pre-trigger
Time base	10ns to 10s/div
Software	
Functions	+, −, ×, ÷, d.v.m., counter, F.f.t., differentiation, integration
Zoom/pan steps (horiz.)	1, 2, 5
Cursors	ΔV, ΔT
Scrolling	Independent on all four channels
Curve fitting	Spline fit, least-square fit, envelope

CIRCUIT IDEAS

Improved limit detector

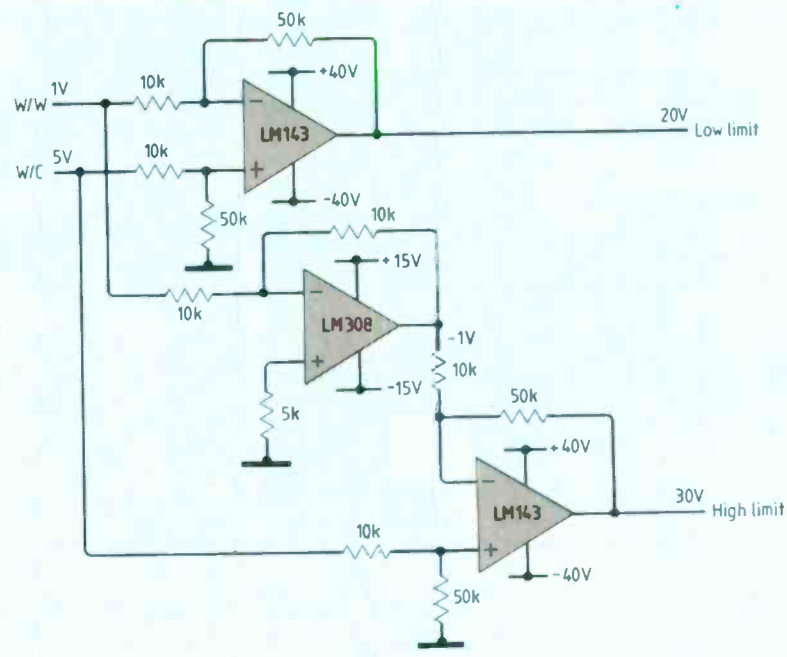
Standard two op-amp limit generators produce upper and lower-limit voltages from window-centre and window-width inputs. For example, a centre input of 3V and a width input of 1V produce upper and lower limit voltages of 4V and 2V respectively.

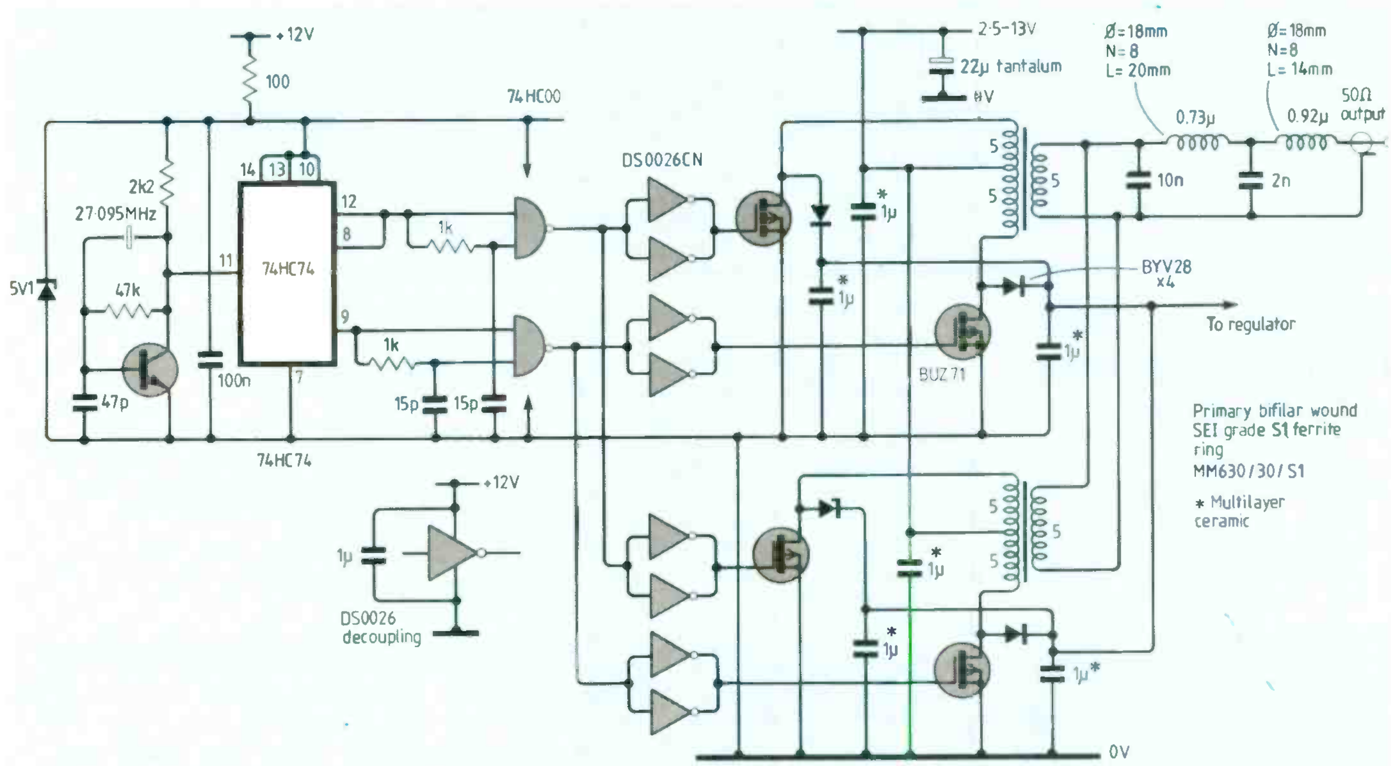
Producing limit output voltages in excess of the supply voltage rails requires gain in the circuit and high-voltage op-amps in the output stages. Other devices in the circuit can operate from normal supplies.

Gain is provided by the lower op-amp, connected as an inverter to increase the input seen by the middle op-amp (which may be a low-cost device). Resistor ratios then provide the desired gain in the normal way.

Typical voltages are indicated. In my application, two low-cost d-to-a converters provided the centre and width signals, making the system programmable.

M.J. Barratt, West Ewell, Surrey





100W 4.5MHz r.f. power generator

With applications in plasma generation and r.f. transmission, this 100W 4.5MHz power generator features output current limiting and mismatch compensation.

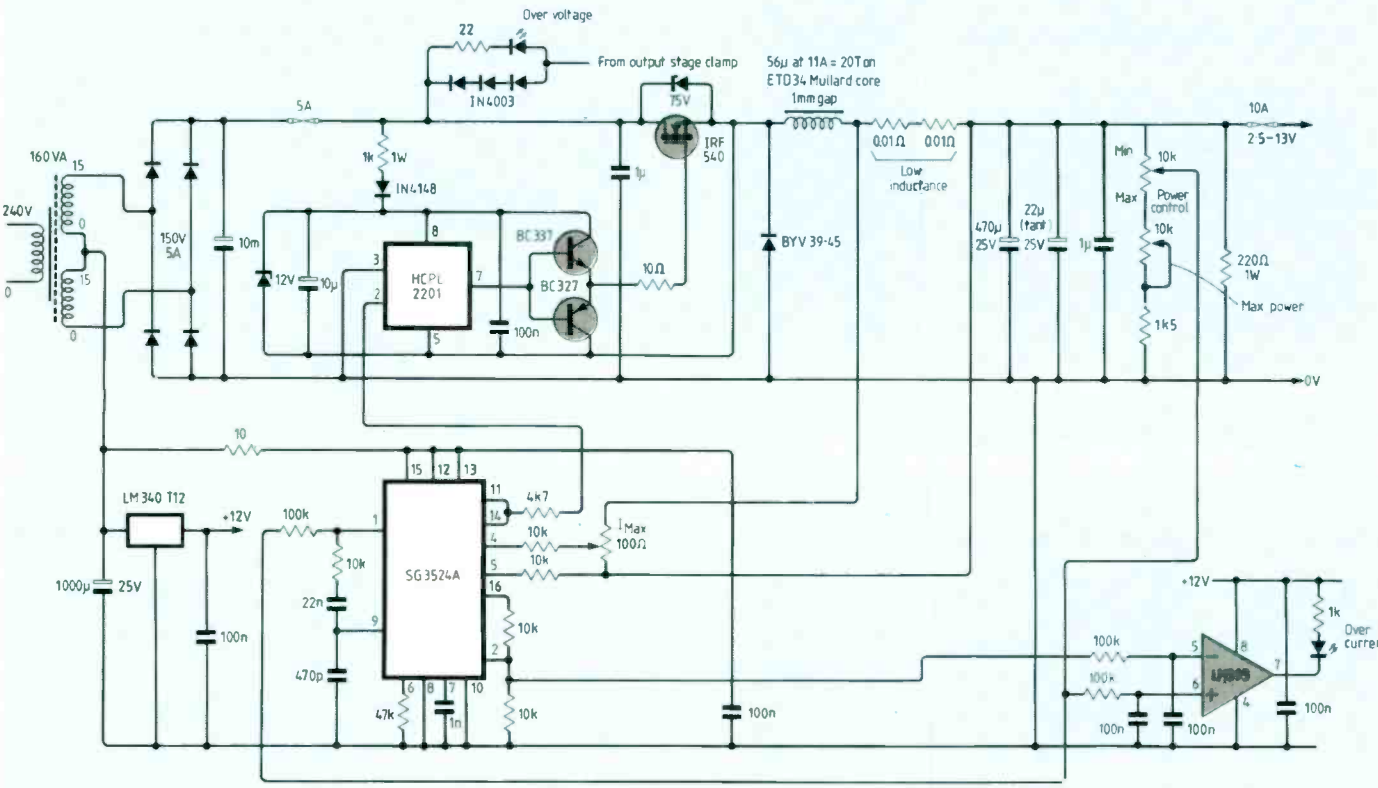
A mains power supply provides a nominal 40V supply to the input of a buck switching regulator. Output, adjustable between 2.5 and 13V, is provided by two pairs of BUZ71 power fets in push-pull driven by square waves from DS0026 mos clock-driver i.cs. The output network picks out the fundamental from the square wave and matches it to 50Ω.

Mismatches cause high currents or voltages to circulate in the output stage. High currents are prevented by the regulator current limit, limiting the maximum short circuit current to about 11A. High voltages are clamped by BYV28 diodes, directing current back to the pre-regulator capacitor and clamping the voltage to around 40V, which is below the $50V_{BDS}$ of the fets.

The 27.095MHz crystal, actually oscillating at 9.0317MHz, clocks a bistable device to provide 4.5MHz antiphase drive signals; Nand gates add delays to ensure no simultaneous conduction of opposite fets. Frequency is limited to about 4.5MHz by switching times in the DS0026 and the layout restriction that the TO220 package causes.

Good layout is vital to achieve the 10ns rise and fall times while switching 5A. The DS0026 and decoupling capacitor need to be as close as possible to the fet gate and ceramic radio-frequency capacitors are needed in the output filter; combinations of silver mica capacitors may just be adequate. Output stage efficiency is about 70% at 4.5MHz, increasing with lower frequencies at the expense of increased filter component bulk.

Paul Bennett
Bristol



Digitally controlled high-Q notch filter with memory

Active filters controlled by digital-to-analogue converters[1] have one major disadvantage – the digital tuning value is lost when the power is turned off. Special back-up memory can solve the problem, but this is not a simple solution; it is more convenient to use a digitally-controlled analogue potentiometer (Xicor) that can store the position of the wiper in non-volatile memory and rescale the filter at a subsequent power-up.

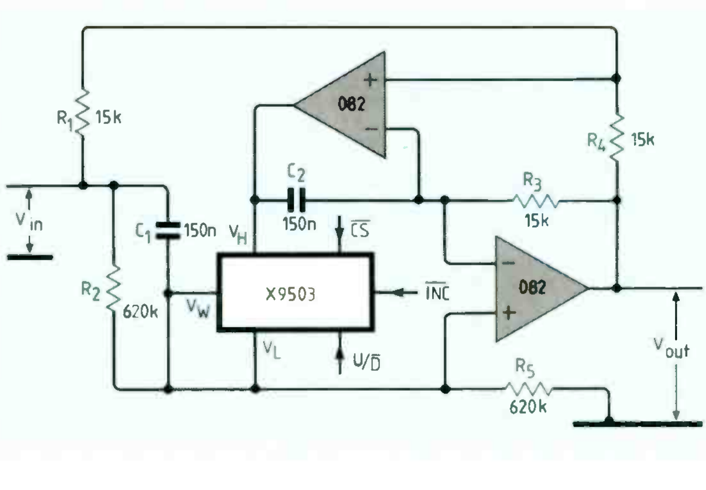
Presented here is a high-Q notch filter built using the X9503, and designed for rejecting low-frequency noise. It is based on Antoniou's generalized immittance converter[2] and has low sensitivity and high quality. Control of the notch frequency can be done by changing the number of actively connected elements of the X9503 potentiometer. Gain of the filter is constant at 0dB. Depth of the notch is about 50dB.

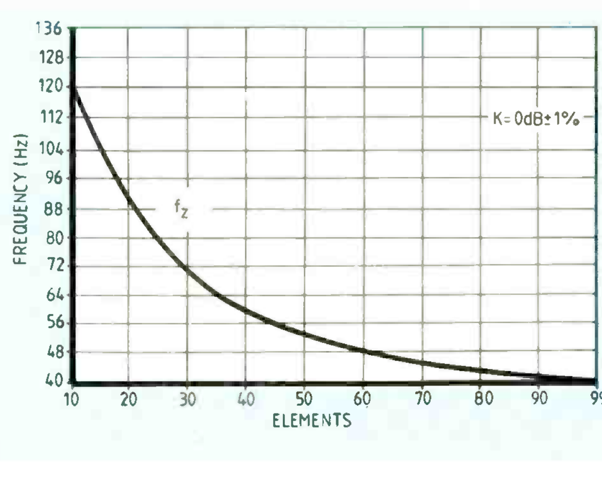
Nikolay T. Tchamov
Sofia, Bulgaria

References:

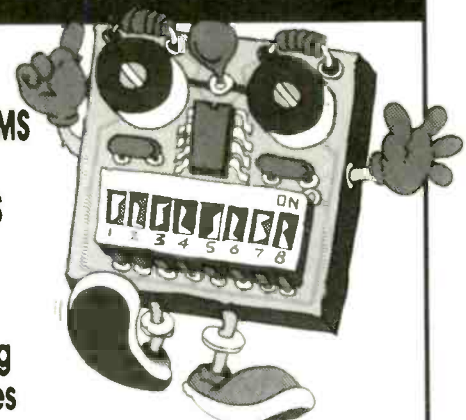
1. Zurada, M. J., Application of multiplying digital-to-analog converter to digital control of active filter characteristics. IEE Proc., Vol.128 Pt.G. No.2, April 1981.

2. Moschytz, G. S., and Horn, P., Active filter design handbook. John Wiley and Sons, New York 1981.





"WE CAN TONE YOU UP FAST."



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ENTER 53 ON REPLY CARD

A CORDLESS FUTURE

Britain's infant CT-2 is the first of a growing family of microcellular radio systems. In less than two decades, we could find ourselves in a world where a 60GHz transceiver is on every lamp-post and where the only wiring in our offices is for mains power.

RICHARD LAMBLEY

With the launch of the first CT-2 digital cordless telephone only a matter of weeks away, the UK manufacturing groups involved have managed to agree upon a common air interface (c.a.i.). This will make inter-working possible between sets from different sources, without the need for multi-standard equipment. Nevertheless, manufacturers intend to launch CT-2 sets using their own interim standards, since it could take them as long as 18 months to bring c.a.i. sets to market.

The implications behind the decision, and the reasons for it, were aired at a one-day conference in London during September. CT-2 is a British initiative with, according to its proponents, good prospects for success in both home and export market; yet it has no more than two or three years in which to establish itself, since by then a CEPT plan for a pan-European cordless telephone standard (dubbed CT-3) is likely to have come into operation.

Features of the CT-2 system (see box) were described by Harold Bibby of Ferranti Creditphone, which intends to launch a nationwide network of telepoints at the end of this year. Ferranti's full specification was being drafted ready for submission to the DTI in October, said Bibby, and the service would begin as soon as possible after approval was granted. To begin with, Ferranti would use dual-standard telepoints, with the change to c.a.i. following later as a natural evolution typical of that in all technical fields. Ferranti would continue to support customers with pre-c.a.i. phones, he said: "I don't think they're going to be disappointed".

Some of Harry Bibby's points were echoed by his business rival Barry Moxley of British Telecom Mobile Communications, who also argued strongly for an early launch. A delay until c.a.i. was available in 1990 would risk putting the whole of CT-2 in jeopardy: the manufacturers' enterprise in creating the system should be rewarded. Objections had been made to the CT-2 concept, with its idea of a universal cordless telephone for home, office and telepoint. "But how many phones will a businessman buy or carry?", he asked; "The answer must be *one*."

WHAT IS CT-2?

CT-2 is a standard for a new generation of digital cordless telephones, developed by British manufacturers in co-operation with the Department of Trade and Industry. CT-2 telephones are intended for use in the home or in the office. They will supersede the present "CT-1" cordless 'phones, which on eight analogue radio channels now support about a quarter of a million users: interference has inevitably become a serious problem. But in addition, CT-2 handsets will be usable in public places as a sort of portable pay-phone; radio relay units (telepoints) situated in shopping centres, railway stations and elsewhere will link calls into the public telephone network. A limitation of CT-2 is that it is not possible to receive incoming calls via a telepoint, since the system does not attempt to track subscribers; though the falling cost of computer power could change that in the future.

In the UK, CT-2 has the use of an exclusive 4MHz of spectrum at 864MHz. Speech is transmitted in a.d.p.c.m. digital form at 32kbit/s, using a single radio channel for full-duplex communication: 2ms packets of speech are time-compressed to 1ms and then cross-fired from alternate ends of the link. With a requirement of 6kbit/s for signalling and control, and a further overhead for the time-division duplexing, the total data rate is 75kbit/s. Radio channels are dynamically selected (f.d.m.a.) by the handset, which may change channel automatically during a call if interference arises. Spectrum efficiency of the scheme is high, some 200 times better than the UK's TACS cellular radio: at least 5000 users can be accommodated per square kilometre (with CT-1 the maximum density is about 80/km^2). Maximum permitted transmitter power is 10mW, and the typical free-space range is 200m.

CORDLESS PABX

An opposing view was put by Colin Buckingham of Ericsson, who saw the main application for cordless telephones as an offshoot of business PABX systems, since business users provided 80% of all call revenue. Sweden is developing a cordless PABX scheme based on t.d.m.a., offering all the normal features of a PABX including "both ways" call set-up. By building radio link equipment into a PABX, explained Buckingham, it was possible to dispense with much of the wiring, which accounted for a large part of the installation cost. Microcellular radio coverage was provided instead. Initially, however, PABXs would typically include a mixture of wired and cordless extensions.

Buckingham reviewed statistics which revealed that key personnel in offices spent only 30 percent of their time at their desks and were thus likely to benefit from cordless telephones. Telephone network operators too would welcome cordless PABXs: with conventional PABXs, up to 20% of network capacity could be tied up in handling unsuccessful calls to people who were away from their desks. In addition, the convenience of cordless telephones generated extra calls.

A comparative table of the costs of CT-2

A CT-2 handset can be used as both a cordless telephone and a portable pay-phone (picture by Ferranti).

shown by Buckingham made gloomy reading for CT-2 supporters, and indeed some later took issue with him over it. The handset, he predicted, would cost £200-£300, and a five-minute telepoint call between London and Manchester would cost £1.40 – as against 51p for a conventional call, or £1.92 by cellular radio. Since cellular telephones had lately been advertised at only £249, this made CT-2 look poor value in view of its inability to receive incoming calls via telepoints. (However, a speaker from the CT-2 side later promised that telepoint calls would be no more expensive than calls through a coin-box telephone). CT-2, said Buckingham, would be too expensive for private individuals, while businessmen would see it as competing with cellular: "Because these CT-2 telephones do not address some of the basic needs of the businessman, the telepoint service proposed in the UK may not succeed".

AND NEXT, CT-3

Buckingham also looked ahead towards what has been called CT-3, the digital European cordless telephone (DECT). This scheme has developed from proposals tabled at CEPT meeting during 1985 – a British one based on f.d.m.a., and another from the Swedish PTT based on t.d.m.a. CEPT adopted the latter and has drawn up a timetable for its introduction as a pan-European service in the 1.6GHz region, with a final specification due in autumn 1991. It is this which represents the cut-off date for a successful launch of CT-2.

DECT was also touched on by Mike Coolican of the DTI, who mentioned that some fixed link services in the 1.6GHz band would have to be displaced to accommodate it there. But other work within CEPT, he said, was focused on the use of much higher frequencies: "The long-term aim must be a world-wide facility for personal communications, operating perhaps at 60GHz, with telepoint facilities on every lamp post, feeding directly into homes or for use by passers-by". However, CT-2, he said, was set fair to become a world-beating product.

Some of the views expressed by Colin Buckingham were robustly opposed by Professor William Gosling of the Plessey Company, who pointed out a drawback of the t.d.m.a. system. Speech delay, he said, would become a serious problem when a call passed through more than one t.d.m.a. network – as, for example, when a call was initiated through a telepoint installed in a public transport vehicle, and relayed from there via one of the GSM second-generation cellular networks. And delay could accumulate still further because the call might be answered on a second t.d.m.a. cordless telephone. Otherwise, he said, there was little to choose between t.d.m.a. and f.d.m.a. – spectra of the two systems were almost Fourier transforms of one another.

A UNIVERSAL 'PHONE?

Looking beyond the CT-2 versus DECT controversy and immediate questions of practicality, Rodney Gibson of Philips Research Laboratories outlined some of the possibilities for a universal mobile communications system – for implementation somewhere around the year 2000. His study formed part of an EEC "RACE" advanced communications project, in which 25 European companies and organizations were involved.

British Telecom is one of several groups involved with CT-2. A further article on CT-2 appears in Industry Insight, p.1212.

What was wrong at present, he said, was that the public was being offered four different types of communications equipment (pages, cordless telephone, cellular and p.m.r. portables), all of which were doing nearly the same job. But what the user really wanted was a single compact, lightweight pocket phone costing $20-$100. Such a telephone could form an element of an elaborate three-tiered cellular system, extending from macro-cells on the motorway down to microcells within the office building. The real problem in creating this network would be the cost of the infrastructure; however, it could grow by stages and would not need to be constructed in a single operation. A common technical standard would permit data, graphics and video to be handled as well as speech, with a maximum data rate on the radio bearer of about 2Mbit/s – a high bit rate would be necessary for pictures, if only for brief bursts. A basic error rate of 10^{-2} would be adequate; coding and protocols could improve this for services which needed it. The system would remember where it last heard from each user and store this information, to help it connect incoming calls quickly; however, it might sometimes need to page the whole of Europe to locate a missing subscriber!

About 60MHz of radio spectrum would be required for an initial service: this figure is based on the commuting population of London and the expectation that about a quarter of these travellers would pass their daily journey making calls (to the other three-quarters, no doubt). A full service covering private as well as public places would require some 200MHz, at a frequency below 3GHz, none of which has yet been found. But with five years of research to complete, and five years of development work, initial implementation could begin in 1998 for a full service by 2005. "By then", said Gibson, "CT-2 will be either a dismal failure or else full up."

• Digital Cordless Telephones, a one-day conference, was staged in London on 19 September, 1988 by IBC Technical Services (01-236 4080).

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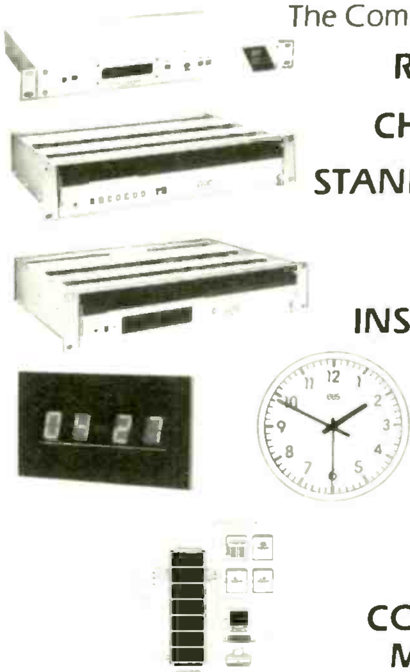

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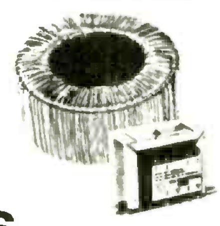

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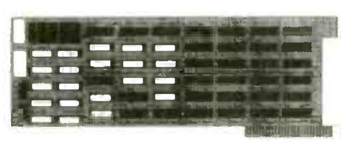

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ENTER 38 ON REPLY CARD

Pioneers

24. Georg Simon Ohm: "an incurable delusion."

W.A. ATHERTON

A web of naked fancies was the phrase used by one contemporary critic of Ohm's Law. It had "no support in even the most superficial observation of facts". As for the book that Ohm published a little later, the same writer described it as "an incurable delusion". Ohm replied that Professor G.F. Pohl, whose words these were, "is well known to be arrogant and his blindness in despising my work is due only to his own attempt to restrain me. He is misguided by his own animosity and not led by the truth." Pohl was perhaps Ohm's main opponent but he was far from being the only one. Neither the law, nor Ohm himself, found easy scientific acceptance.

Georg Simon Ohm was the eldest of three children to survive childhood of the seven born to Johann Wolfgang Ohm and his wife Maria. Though Ohm's father was a master locksmith by trade he had a keen interest in mathematics and gave his sons a sound education in mathematics, physics, chemistry and philosophy. Ohm's brother, Martin, became a professor of mathematics in Berlin. At the age of eleven G.S. Ohm entered secondary school from which he matriculated to the local university at Erlangen, Bavaria, in 1805.

It was at university that things started to go wrong for Ohm. A steady progression towards an academic career, at which he would probably have excelled, was thwarted. After about 18 months he dropped out, having incurred his father's wrath through a supposed extravagance of dancing, billiards and ice skating. Though hardly a life of debauchery it was enough to send him into exile in Switzerland. There, at the age of 17, he started to earn his living as a maths teacher. Being a school teacher was to become a recurring occupation for Ohm, whilst all the while what he really wanted, and what he really deserved, was a university appointment.

He spent some four or five years in Switzerland, eventually as a private tutor, before making his way back to the University of Erlangen where he obtained his Ph.D. For nearly two years he taught mathematics as a *privatdozent*, an unsalaried teacher. It was to be his only university post until late in life.

Lack of both prospects and money at the university led him to seek employment from the Bavarian government and to accept a post as a teacher at a school with low prestige. Two disappointing years ended when the school closed, after which he spent eighteen months at another school as an auxiliary instructor. Ohm was now 28 years old. He felt socially and intellectually deprived and was in a dead-end job.

He now wrote himself out of trouble by publishing a textbook on geometry (1817) in which he gave his thoughts on how mathematics ought to be taught. Maybe his ideas owed as much to the way in which as a boy he had learned from his father as it did to his experiences as a teacher. His brother Martin advocated the book's use in Berlin as part of his own suggestions for reforming education, and so helped brand himself as a dangerous revolutionary. For Georg, however, the book served its purpose for he received an offer of a position as a mathematics and physics teacher at a high school (*gymnasium*) in Cologne. The school not only had a good reputation but a laboratory as well.

At the new school Ohm began to take a serious interest in physics and after Oersted's announcement of his discovery of electromagnetism in 1820, Ohm experienced with electricity and magnetism. It was a path which was to lead him to attempt a theory of electricity and produce what we now call Ohm's Law on the way. However his position at Cologne turned out to be yet another disappointment and he, again, sought a way out by publishing his work. That work was the experimental derivation of his law.

OHM'S LAW

By 1825 it was known that if a good conductor in a circuit was replaced by a poor conductor then the magnetic force (a measure of the current) was reduced. Ohm therefore measured the resultant loss of force when a standard good conductor was replaced by a poor one (a higher resistance test sample). He had six test resistors as we might call them simply thin wire cut into lengths ranging from about one foot to 75 feet. The standard, or "invariable conductor" as he called it, was a four-inch long "very thick" piece of wire. By using these pieces of wire Ohm measured the change in the current when the resistance was changed. The voltage was constant, or as constant as possible with the imperfect chemical batteries of the day. The batteries deteriorated rapidly and Ohm took precautions to normalize his results. The outcome was published in May 1825 and yielded an equation

$$v = m\log(1+x/a)$$

where v was the fractional loss of force, x the length of the test sample, and m and a were constants. It is a good early example of the deduction of a mathematical law from experimental data, something for which Ohm should be remembered. It was also a good description of his discoveries with a circuit where the battery had a high internal resistance.

However it is not what we think of as Ohm's Law. But Ohm was not yet finished. He took advice to replace his chemical battery with a "thermoelectric battery", making use of the effect discovered by Thomas Seebeck of Berlin in 1822. Boiling water and melting ice were used to give a constant temperature difference across the ends of a copper-bismuth thermocouple and so produce a constant, if small, voltage. Eight pieces of copper wire of different lengths provided the resistors and, instead of measuring "loss of force", Ohm went straight for the force of the magnetic field, a measure of the current. The results were published in February 1826 and gave Ohm's Law,

$$X = \frac{a}{b+x}$$

where X was the strength of the magnetic action (current), a was a constant related to the electromotive force, b represented the resistance of the rest of the circuit, and x the length of the test sample. As with his previous attempt at the law, this was a mathematical relationship based entirely on experimental data.

ELECTROSCOPIC LAW

In April Ohm was again in print. This time to assert his "electroscopic law" which enabled any length of any wire of known cross-sectional area and "conductibility" to be replaced by an equivalent length of standard wire, i.e. an equivalent resistance. He also showed that the potential as we would call it, at any point in the circuit can be derived using this equivalent length. Using the equivalent length, l, the law was simplified to $X = a/l$.

He then used his newly-won knowledge to explain some of the scientific puzzles of the day, such as why doubling the number of turns on a coil did not quite double the magnetic force.

Just over a year later, in May 1827, he published a book in Berlin called "Die galvanische Kette, mathematisch bearbeitet" (The galvanic circuit investigated mathematically). It presented his mathematical theory of experimental discoveries. The mathematical approach was that used earlier by J.B.J. Fourier in his analysis of the flow of heat along a wire, which Ohm took to be analogous to the flow of electricity. He assumed that "the communication of the electricity from one particle takes place directly only to the one next to it", and that the magnitude of this flow is "proportional to the difference of the electric forces existing in the two particles; just as, in the theory of heat, the flow of caloric between two particles is regarded as proportional to the difference of their temperatures". This reference to caloric, once supposed to be fluid of heat, helps to place Ohm's work into its historical perspective.

In his mathematical approach Ohm once again expressed his Law, this time as $S = A/L$ where S is the current, A the sum of all electrical tensions and L the total reduced length of the circuit (total resistance).

RECOGNITION

Ohm had turned to publication partly as a bid to leave Cologne and better his position. He was not entirely successful. In 1826, after the two papers had been published, he was given a year's leave of absence on half pay, to go to Berlin to continue his work. Later, with the book published and still no university appointment he decided against returning to the school in Cologne. He resigned in March 1828 and took temporary work teaching mathematics in Berlin. Though his talent was recognized he could still not secure a job he really wanted. Finally, towards the end of 1833 – after more than five years – he was appointed professor of physics at the Polytechnische Schule in Nuremburg, back in Bavaria. It was not really what he deserved, but at least he had the title of professor.

Like its originator, Ohm's Law did not at first get the recognition it deserved. It was received unenthusiastically by most and with hostility by some.

Several suggestions have been put forward to account for its poor reception: philosophic objections, the use of advanced mathematics, and the poor quality of the batteries of the time. However most physicists simply did not recognize the possibility of a relationship between what were seen as two separate phenomena: voltage and current. With backgrounds in electrostatics, their important questions were directed at theories of the electric current and how batteries worked.

The basic truth of the law was slowly recognized, probably first by C.H. Pfaff of Erlangen in a private letter, then by another German physicist G.T. Fechner in 1829 and again in 1831 when Fechner gave experimental verification. Others who used it in the early 1830s included H.F.E. Lenz, W.E. Weber and K.F. Gauss. But even in 1833 – after seven years – it appears that the law was virtually unknown in England and France.

From about 1839 Ohm belatedly received the honour he had earned 13 years before. He became a member of the Berlin Academy and was awarded the Copley Medal by the Royal Society in London in 1841, the same year that Joule established the I^2R law. The award that really mattered though was the one Ohm had sought in vain for so many years, a university appointment. That came on 23 November, 1849, when he was appointed to lecture at the University of Munich. On 1 October, 1852, he was given the chair of physics. Less than two years later he was dead. In 1881, 27 years on, the ohm was formally adopted internationally as the unit of electrical resistance.

A web of naked fancies... with no support in even the most superficial observation of facts.

THE UNIT OF RESISTANCE

By about 1850 telegraph engineers urgently needed practical electrical units. Arbitrary ones came into use, even though Gauss and Weber had suggested a way in which absolute scientific units could be defined in terms of mass, length and time. Wheatstone used an arbitrary unit of resistance based on one foot of copper wire weighing 100 grains, and in many countries local units of resistance were defined as lengths of specified wires. Then in 1860 the German Siemens company fixed its own unit, the siemens, as the resistance of a metric column of pure mercury of one square millimetre cross section at 0°C. It gained widespread use. However in 1863, a British Association committee recommended an absolute scientific unit of electrical resistance of 10^7 m.g.s. electromagnetic units. It was equivalent to 1.048 siemens and was known as the BA unit of resistance. The name ohmad was also suggested. Shortened to ohm it found favour, in a practical form, with telegraph engineers. Other committees followed and the definition of the practical unit was refined. An international congress in Paris in 1881 accepted the ohm as a practical unit, along with the volt, ampere, coulomb and farad. A subsequent international meeting, held in Chicago in 1893, led to widespread legislation adopting legal definitions for the ohm, ampere, volt, coulomb, farad, joule, watt and henry.[2]

Picture of Dr G.S. Ohm opposite is from the bust by von Rümann (Institution of Electrical Engineers).

References
1. Dictionary of Scientific Biography.
2. A.E. Kennelly, "Historical outline of the electrical units", *Proc. Soc. for the Promotion of Engineering Education, J. Eng. Ed.*, vol. 18, 229-275, 1927/28.

Next in this series of pioneers of electrical communication: Hidetsugu Yagi.

Tony Atherton is on the staff of the Harman Engineering Training College of the Independent Broadcasting Authority at Seaton, Devon.

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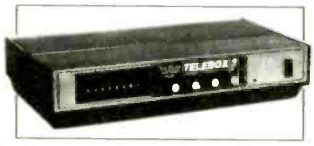

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SATELLITE SYSTEMS

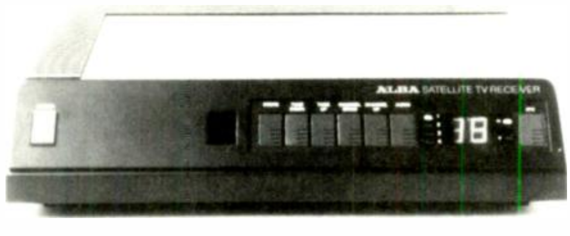
Astra's PAL signals

If the Astra medium-power d.b.s. satellite is successfully launched in November it will shortly be transmitting four television channels and one radio channel from its orbital position at 19.2°E (Eurosport on No 4, Sky Channel on 8, Sky News on 12, Sky Films on 16 and Sky Radio on one of the sound channels of No 8). As already reported, these first television broadcasts will be on the PAL colour tv standard.

These PAL signals will conform to CCIR specifications. Their carriers (at frequencies between 11.21425 and 11.4355 GHz) will be vertically polarized and frequency modulated by the PAL baseband signals with a deviation of 16MHz per volt.

The main sound signal will be on a 6.5MHz subcarrier with a peak deviation of ±75kHz and will have a nominal audio bandwidth of 20Hz to 15kHz. Pre-emphasis with a time constant of 50μs will be applied. But there will also be four other subcarriers which in other services could be used for stereo sound but in the Sky transmissions will carry four different language sound channels to accompany the tv pictures. These additional sound subcarriers are at 7.02, 7.2, 7.38 and 7.56 MHz, have a peak deviation of ±50kHz and the same audio bandwidth as the main sound channel. They will be capable of being used in three different modes, each of which provides a different combination of languages.

Societe Europeenne des Satellites, the owner and operator of the Astra satellite, is recommending that set manufacturers should design their d.b.s. receiving equipment to be also capable of receiving MAC encoded tv signals, which may be transmitted later on. For both PAL and MAC the antenna and r.f. section should have a tuning range of 10.95-11.7 GHz, cross-polar isolation of more than 25dB and a demodulation bandwidth of 24-26MHz. Under clear-sky reception conditions the downlink carrier-to-noise ratio should be greater than 12.5dB. A baseband output to feed a decoder should provide a 1V pk-pk signal over a bandwidth of 25Hz to 10.5MHz.



This receiving terminal for the Astra satellite was designed by STS of Bristol, to be marketed by Alba Radio. The receiver is initially being produced in the far east, but the dish is British-made. Quantities should appear in the shops during January, in time for the start of Astra's service in February.

Space-Earth optical link

An optical communication link between a geostationary satellite and Earth is one further experimental system planned by NASA for its future Advanced Communications Technology Satellite (ACTS – see January 1987 issue, p.32). The system will be based on GaAlAs semiconductor laser diodes, photodetectors and direct detection electronic techniques working on multi-frequency incoherent radiation with a dominant wavelength of 0.87μm.

Previous reports in this column on laser link developments have been confined to inter-satellite and inter-orbit communications. Advantages over conventional radiocommunications – mainly wider bandwidths, smaller payloads and greater privacy – were discussed in the March 1988 issue, p.280. In space the optical beams do not of course have atmospheric absorption and scattering to contend with, so the NASA experiment between space and ground will obviously put greater demands on the communication because of system the air path and the water vapour in it. However, on the ground there is no great problem about the size and weight of the transmitting/receiving equipment needed; and in fact one Earth terminal, at NASA's Goddard Space Flight Centre, Greenbelt, Maryland, will be using a 1.2 metre diameter optical telescope.

An optical transceiver to be carried in ACTS has been built by TRW of Redondo Beach, California, following joint development by NASA and the US Air Force. This uses a 20cm diffraction-limited optical assembly as well as the opto-electronic devices mentioned above, and weighs 12kg in all. Test data will be transmitted at rates ranging from 1.72 to 220Mbit/s, and the information carried by this may well include digitized television-type images.

The first communication experiment will be between space and ground, but at a later stage an inter-orbit optical link between the geostationary ACTS and a low Earth-orbiting spacecraft will be tried out as well.

Traffic hand-over

The penultimate Intelsat V-A comsat, F-13, launched earlier this year (September issue, p.904), has now replaced the old F-3 satellite stationed over Brazil at 53°W. After in-orbit testing at 3°E, it was slowly drifted to this position. The two satellites were co-located with their orbits synchronized at 53°W for a period of seven days to allow all the Earth stations that had been operating with F-3 to work simultaneously with both comsats. This a lowed a smooth transfer of traffic from one satellite to the other.

Once the hand-over was completed the F-3's receivers were shut down and its on-board thrusters were fired to drift the satellite towards the Pacific Ocean. The F-3 has now been re-positioned at 174 E and will continue to provide international services from there.

Four years of dbs

A combination of new, dedicated programme material and recent technical improvements in receiving equipment has given a fresh boost to Japan's direct broadcasting satellite service. M. Matsushita and T. Hasegawa of NHK (Nippon Hoso Kyokai), the national broadcasting corporation running the 12 GHz d.b.s. television system, emphasized this point in a report on four years' operational experience presented at the recent International Broadcasting Convention, Brighton, UK.

After an experimental period using the BSE satellite, the National Space Development Agency (NASDA) launched the BS-2a spacecraft in January 1984 and the BS-2b in February 1986. Broadcasting started in May 1984 with one television channel from BS-2a and expanded to two channels when BS-2b began transmitting in December 1986.

Transmissions are on the 525-line NTSC standard with a subcarrier system for digital sound and data. The digital sound allows two modes of operation. One uses a 32kHz sampling rate and 10- to 14-bit Nicam, while the other, intended for higher quality sound, has 48-bit sampling and 16-bit quantization.

Programmes are uplinked on 14GHz from a main Earth station at Tokyo and a subsidiary station at Osaka. In each satellite, the 100W transponder output signals are transmitted with an e.i.r.p. of 56.2dBW over the Tokyo area and 54.2 dBW on the fringes. This allows receiver antenna diameters from 50cm to 120cm, depending on the receiving site. Noise bandwidth is 27MHz or 74.3dBHz and the resulting c:n ratio (taking into account the free-space loss and 2dB rain attenuation) is 14.7dB.

The new programme service, on one channel, started up in July 1987, creating extra interest from potential d.b.s. viewers. Also, over the past year or so the performance of receiving equipment has been improved by the Japanese set manufacturers. In particular the efficiency of receiving dishes has been increased to values between 69% and 74% and the noise figure of the antenna r.f. input amplifier has been improved to about

SATELLITE

1.6dB by the use of new transistor technology. As a result the downlink c:n ratio has been increased from 14.7 to 16.6dB and it is now possible to use receiving dishes of only 45cm diameter on Japan's main islands.

According to the NHK speakers, the first three years of d.b.s. operation created an audience of about 140 000 households throughout the country. These households viewed the programmes through individual, community or cable tv receiving systems. But after the introduction of the dedicated programmes in July 1987 there was a rapid rise in the number of viewing households of 340 000 in only seven months, and by the end of January 1988 the total was more than 480 000 households. Of these, some 150 000 now have their own individual d.b.s. receivers. The present goal of the Japanese broadcasters is to get an audience of one million d.b.s. viewers by 1990.

The present two d.b. satellites will be joined by two more, the BS-3a and 3b, in 1990 and 1991. This increase in d.b.s. capacity will allow the present programme services to continue and new ones to be added. NHK will continue to use two channels, while a new company, Japan Satellite Broadcasting Inc., will have one channel. At least one transponder of the forthcoming BS-3 system will be used for h.d.tv broadcasting.

Some broadcasters see high-definition television as a means of making d.b.s. into an economic/commercial success. Certainly the Japanese broadcasters believe so and are well along the road to implementing this principle of action. At the Brighton IBC (see item elsewhere) Y. Tanaka, K. Kubota and Y. Iwadate of NHK's Science and Technical Research Laboratories described tests they have been doing, transmitting the 1125/60/2:1 hdtv baseband signal on the 12 GHz operational BS-2 satellite broadcasting system since December 1986.

Test equipment was set up at NHK's broadcasting centre in Tokyo. A wideband source signal on the Japanese 1125/60/2:1 h.d.tv standard was compressed in bandwidth by the Muse (multiple sub-Nyquist sampling encoding) system to a baseband width of 8.1MHz. This was then uplinked to one of the BS-2 satellites and received at various places around the country.

Since the h.d.tv signal is conveying information at a faster rate than the conventional (NTSC) television signal it follows from communication theory that the s:n ratio has to be increased to achieve the required h.d.tv picture quality (in terms of resolution, noise etc.). In practical terms this means that a higher c:n ratio is needed.

The NHK speakers said that with conventional television on d.b.s it was possible to receive the BS-2 signal in nearly all of the main Japanese islands with a c:n of more than 14dB if a 75cm receiving dish was used. This assumed an antenna efficiency of 65%, an antenna frequency converter with a noise figure of 3dB and rain attenuation of 2dB.

For hdtv reception with acceptable noise impairment of the picture, they found that the c:n ratio had to be increased by 3dB to 17dB. With the 75cm dish this could be achieved through a higher antenna efficiency, above 70%, and a frequency converter noise figure of less than 2dB, both of which were now possible in commercial equipment. The ratio obtained in the tests was in fact 17.8dB (the s:n ratio of the demodulated signal being 39.5dB). At the outer edge of the coverage area the receiving system G/T would have to be 16dB/K to give a 17 dB c:n ratio.

Other h.d.tv transmission tests, with tv signal distribution requirements in mind, have been done on Intelsat and Telesat (Canadian) communications satellites. Some of these tests were part of the proceedings of the 1987 Ottawa HDTV Colloquium and were reported by Geoff Lewis in the March 1988 issue, p.277. Here the Muse-T encoder was used to give less bandwidth compression to a baseband of 16.2MHz.

Thus, according to these IBC contributors, "h.d.tv broadcasting in the 12GHz band has reached a practical stage" in so far as it is possible with a satellite transmitter power of 100W and a receiver dish antenna of 75cm diameter.

Scrambling for UK's dbs

British Satellite Broadcasting will be using the Eurocypher system of scrambling and encryption (enciphering) for its subscription and pay-per-view d.b.s. television services. This has been developed for MAC by the IBA and from experience gained in the USA by the American company General Instrument Corporation with its VideoCypher system. It will involve computers, software and encryption hardware at the transmitting end and a control module, containing a single vlsi custom-designed chip, attached to the viewer's tv set. BSB and GI have formed a subsidiary company, European Television Encryption Ltd, to market such television access control systems generally.

BSB is scrambling the D-MAC signal to ensure that the company receives full revenues for those programmes that it broadcasts for sale (as distinct from free-of-charge programmes financed by advertising). Only those viewers who pay for the programmes – those with d.b.s. receiving equipment fitted with the appropriate de-scrambling and deciphering system – will be able to see them as normal pictures and sound.

The encryption associated with the scrambling is the process of enciphering a control signal that will be transmitted along with the scrambled vision and sound signals to enable the d.b.s. receivers to de-scramble and reproduce them. In the receiver this encrypted control signal is deciphered using a secure key – a multi-digit number – and the resulting sequence of control data then instructs the de-scrambling circuits to recover the original pictures and sound.

The scrambling system is based on the so-called double-cut-and-rotate technique, which continually and randomly alters the relative positions of both the luminance and the chrominance information on a line-by-line basis. More precisely, the t.d.m. luminance and chrominance components in the MAC vision signal are independently cut at random positions (i.e. instants of time) along the tv line as determined by a pseudo-random binary sequence generator. De-scrambling, of course, requires a similar, synchronized, p.r.b.s. generator in the receiver equipment.

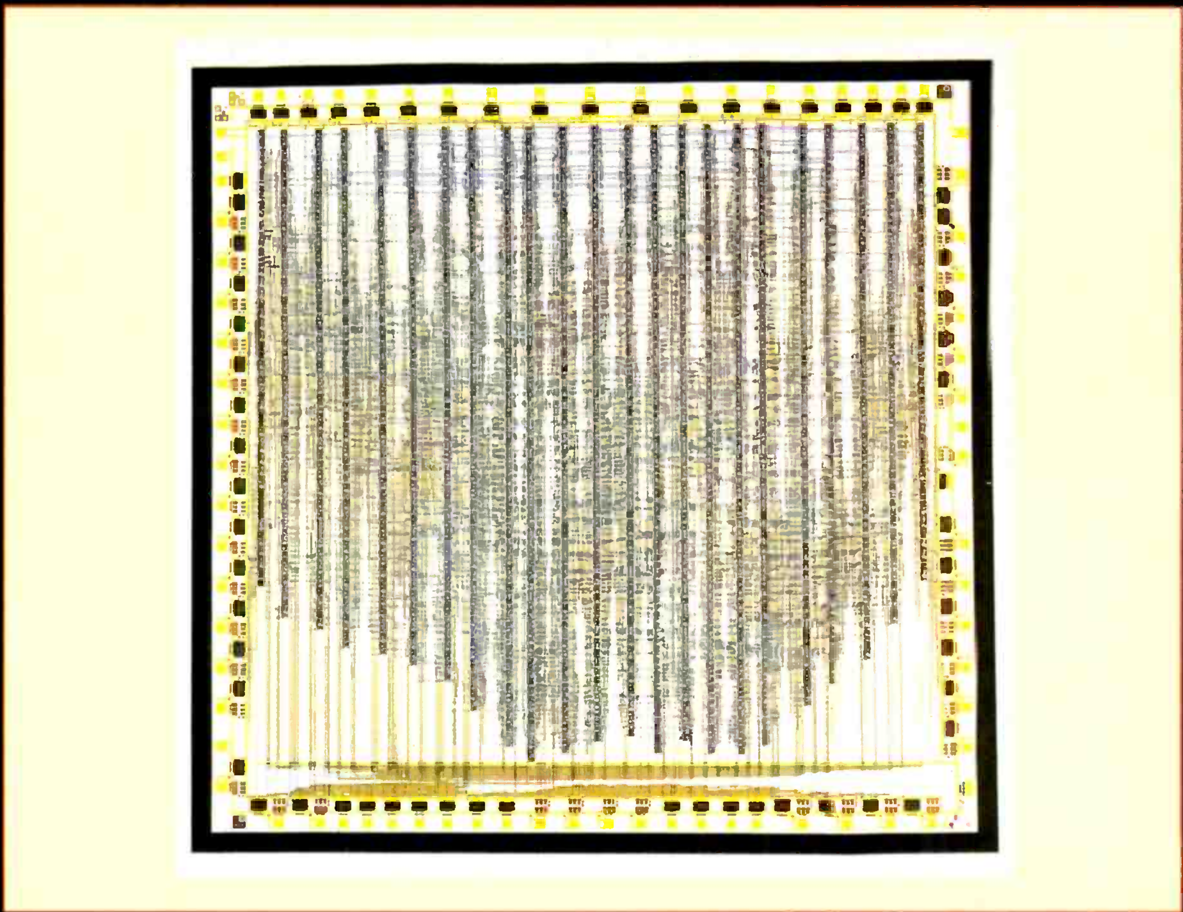
At the recent Brighton IBC D. Eglise and P.A. Hyde of BSB said that the double-cut-and-rotate technique of scrambling was a much more secure method than the simple video signal inversion, synchronization suppression of colour-burst modification processes used in earlier systems. The ability of the D-MAC transmission signal to carry the extra data needed for such authorization control made it particularly suitable for subscription and pay-per-view television services.

● To help receiver manufacturers the IBA is now putting out D-MAC test transmissions and will be continuing them until the start of the actual d.b.s. service. These transmissions are coming from two different sources. One is an Intelsat communications satellite stationed at 34.5°W over the Atlantic, not far from the future 31°W position of the BSB d.b. satellite. Transponder frequency is 11.07GHz and the e.i.r.p. is 47dBW. The second source is terrestrial. Two microwave horns have been mounted at a height of about 100 metres on the IBA's tower at Croydon, south London. These are beaming 12GHz signals at frequencies in the top half of the WARC 77 d.b.s. band in a north-westerly direction over part of Greater London (roughly towards London Airport). At the time of writing no formal timetable has been set for these test transmissions.

Satellite Systems is written by Tom Ivall.

DECEMBER 1988

INDUSTRY INSIGHT



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A FUTURE FOR UK ELECTRONICS?

The electronics industry is the fastest growing sector in the world economy today and its growth potential for the future is huge. Indeed, the *rate* of technologic al change through the application of electronics shows no signs of slowing down, and continues to accelerate. One major multinational company in this sector reckons to launch a new product every two days. Products are increasingly being sold to a world market, and there are fewer 'safe niches' for producers seeking shelter from the onslaught of world competition.

This adds up to enormous opportunities, and risks, for the UK electronics industry. Are these opportunities being exploited to the full? Are other countries ahead of the UK? What are the obstacles to the growth of UK companies? What action can they take to overcome them? What role should the Government play?

Three reports* published earlier this year by the National Economic Development Council's Electronics Industry Sector Group took a long hard look at the industry. In "Strengthening Competitiveness in UK Electronics", management consultants McKinsey & Co. compared eight of the largest UK electronics companies with 22 major competitors in Europe, the USA and South-East Asia, in terms of market share, geographical focus, specialization, financial performance and corporate strategy. McKinsey concluded that to secure their future UK electronics companies need to

- ★ Focus on their core businesses and invest to develop the 'critical mass' needed to be viable competitors.
- ★ Develop structures and leadership styles that can support long-term growth strategies, encourage cross-term growth strategies, encourage cross-business synergies, as well as a more commercial culture and strategic vision.
- ★ Communicate long-term strategy and commercial outlook to the financial market to overcome the market's perceived 'short-termism'.
- ★ Work actively with suppliers to create and encourage a better supply infrastructure.
- ★ Create world class skills, re-emphasize human resource development, and enhance the image of the electronics industry to compensate for deficiencies in the UK educational system.

The report places the responsibility for the future of the UK electronics industry firmly in the hands of the companies themselves, while recognising a role for industry bodies and Government in providing an environment for success. A case of "physician, heal thyself"?

*"Strengthening the Competitiveness of UK Electronics", "Government IT Policies in Competing Countries", "Comparative Education and Training Strategies", NEDO. A binder containing all three reports is available for £65 from NEDO Books, Millbank Tower, Millbank, London SW1P 4QX, tel 01-211 5989.

INSIDE

Cover. This shot of RSRE's Viper 32 bit microprocessor made by MEDL is the first public viewing of the 1A version, with formally proven computing logic and exhaustive fault detection.

TELEPOINT TAKEOFF

Second generation cordless telephony could be the start of the biggest revolution in the way we use telephones since the introduction of the fixed network.

Second-generation cordless telephony – CT2 for short – is not simply an inferior implementation of cellular. It is aimed at a different type of user, will be introduced in a different way, and has advantages as well as disadvantages over the cellular system. It is not a replacement for cellular. Many businesses that currently use cellular systems have said they will also use CT2 – partly to do what cellular does already, but also to introduce new types of user.

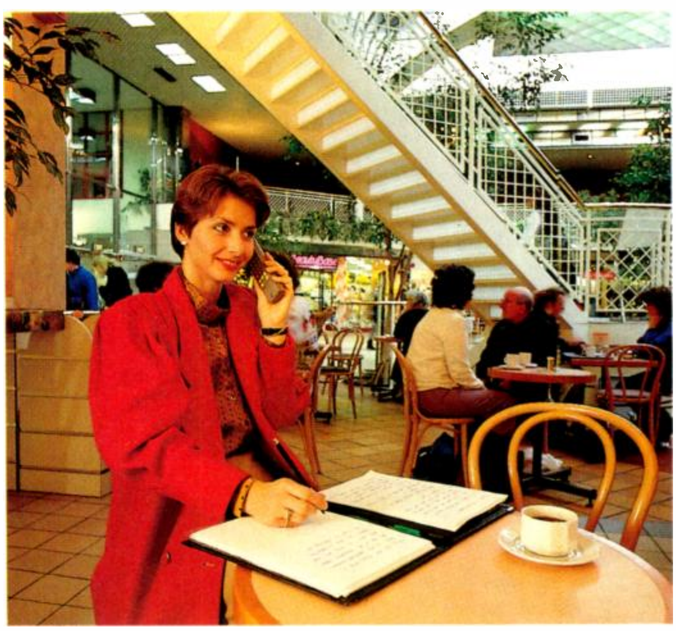
CT2 is in fact three systems in one. At its heart is a universal handset. With a compatible base station, this can be used as a conventional domestic cordless telephone – with the advantage that the system will automatically select a free channel from the 40 that are available, and will have consistent digital speech quality out to the edge of its range. Since the system selects channels dynamically, there will be no interference from neighbouring phones, and no risk of overhearing. Each handset has a unique identity code which is "enrolled" at the base station, and the base station will only converse with the handsets it recognises.

In an office, the same handset can be used with a network of base stations, in a microcellular pattern, to form a cordless p.a.b.x. Users can move from place to place with their own handset and receive or make calls from anywhere on the site.

Finally, CT2 allows for a network of public base stations or telepoints, operated by a telepoint service provider. Possessors of a CT2 handset will be able to make (but not receive) calls from within range of any public telepoint. Telepoints will be placed in railway stations, airports, garages, motorway service stations, department stores and ultimately in high street shops, restaurants and pubs. Calls will be billed to users' telepoint accounts.

The first CT2 system introduced is Ferranti's ZonePhone system, developed by PA Technology. Shaye Communications have also said that they will be producing handsets, and other companies such as Plessey and STC are also developing systems. The Ferranti system will initially cover the domestic and public applications: p.a.b.x will follow later. Some observers have suggested that the logical first step for CT2 should be cordless p.a.b.x exchanges; this is likely to be a significant application in the long term, but there are good reasons for leading with the telepoint service.

Market research has shown that the demand for telepoint will be far greater initially, than the demand for cordless exchanges. A high volume of sales is needed to drive down the initial cost of the handsets and ensure rapid growth. And installing a large number of self-contained public base stations is, paradoxically, likely to be easier than persuading large numbers of current p.a.b.x users to wire their offices for radio.



One of the most significant differences between CT2 and cellular is the way the infrastructure is likely to develop. A cellular infrastructure requires careful planning, the building of air-conditioned sites for cellular base stations, careful positioning of antennas and installation of a high-speed, special-purpose, communications network. By contrast, installation of a single-line ZonePhone base station requires a conventional BT phone socket, an ordinary mains outlet and screws to fix the unit to the wall. A cellular base station provides, of course, many more channels; but it is far easier to provide an initial PhoneZone network, which will grow organically as the need arises. Ferranti Creditphone plan to launch the service with a network of 500 to 1000 telepoints installed, and expect the system to grow rapidly.

The reason this approach can be taken is that the CT2 protocols provide a framework which allows almost complete anarchy in the siting of base stations. CT2 is the first protocol framework which does not rely on central planning. The system will automatically adjust, and make use of whatever free channels are available at a location.

Regarded as a cellular system, CT2 has definite limitations. It will only work within 100 metres of a base station; in the public system only outgoing calls can be made, and there is no provision for roaming. But looked at as a system in its own right, it has some distinct advantages. It is smaller, lighter and cheaper than cellular: it really will fit into a pocket or handbag. It will last much longer between recharges – days or even weeks in the public system, since the handset can be completely switched off when not making a call. Those who need to be reached when out and about may prefer to add a pager, which gives them the option of when or whether to reply. CT2 can handle some 5000 users per square kilometre, many times the capacity of cellular, so congestion is less likely. Most important, call charges will be a fraction of cellular costs – about the same as a call from an ordinary telephone box, according to Ferranti Creditphone, who will operate the ZonePhone service. The extreme interest shown in CT2 suggests it will find its own classes of user.

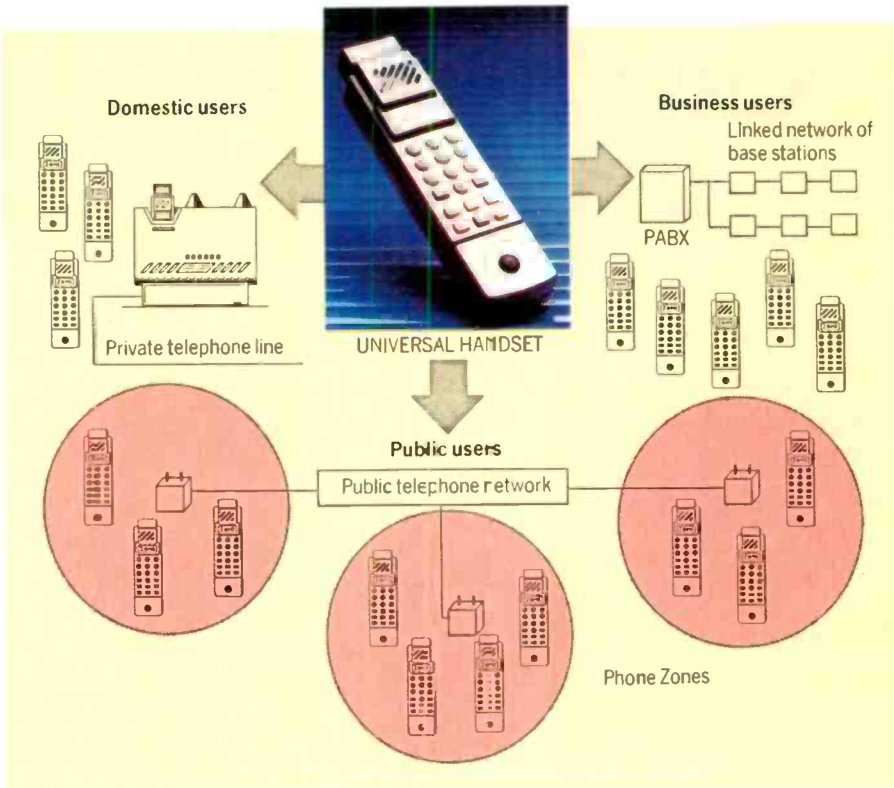
The origins of telepoint go back to an idea conceived by PA Technology in 1978 a prototype system was developed and shown to British Telecom. A report produced by PA in 1981 for a consortium of European PTTs also described the telepoint system and concluded, on the basis of market research, that the potential market for such a system was about half the population of Europe, or 150 million users – roughly in line with current predictions. But at that time none of the regulatory authorities were interested in pursuing the idea.

In the wake of an unsuccessful application for a cellular licence, Ferranti reached the same conclusion as PA: that there was a need for a low-cost, short-range mobile communication system to address the mass market that, because of limited spectrum availability, cellular could never reach. Ferranti commissioned PA Technology to develop the system. The CT2 cordless telephone standard being proposed by British Telecom became the natural vehicle for the telepoint system.

A Ferranti ZonePhone system was demonstrated at a public press launch in November 1987. So far no other system has been demonstrated in public, although Shaye Communications are believed to be well advanced in development.

A number of companies participated with British Telecom in developing the CT2 standard, although not all with the intention of developing a telepoint system. Because BT's original intention was simply to replace domestic cordless telephones, the CT2 standard only provides for non-interference between different manufacturers, and not for interoperation. However, UK manufacturers have now agreed, in outline, a common air interface standard. Until this is fully defined and implemented, in perhaps two years' time, operators are likely to launch systems with their own proprietary protocols. The DTI is expected to license two, three or four telepoint service operators by the end of this year.

From the user's point of view, there would seen little point in waiting for the common air interface to arrive. Ferranti Creditphone Ltd have promised to ease the transition by providing dual-standard telepoints and to continue to support their own system "indefinitely", other operators are expected to follow suit. In fact, it is likely to be common air interface users who will be least well served until existing telepoints are retrofitted to the dual standard (a situation similar, perhaps, to the new pan-European cellular network).



In Europe, the regulatory situation is more confused. The UK CT2 standard is opposed by a rival proposal from Ericsson. This is based on a time division multiple access scheme, as opposed to CT2's frequency division multiple access, time-division duplex. Ericsson's proposal rests on the belief that the initial drive for digital cordless telephones will come from the cordless p.a.b.x UK companies, on the basis of market research, would question this. The EEC is starting work on a new digital European cordless telephone standard: UK companies are hoping that the success of the telepoint service will cause European PTTs to press for its adoption across Europe. However, at present the European lobby for Ericsson system is strong. Whatever the outcome, it is likely that some European countries – such as France and Spain – and others around the world will adopt the UK standard on a national basis.

It is to be hoped that an agreement will be reached shortly that is acceptable to all, since at present the UK – and Europe – have a world lead in this technology. Estimates of the UK market variously put the number of CT2 users between three million and six million by 1995; the eventual European-market for handsets could be worth as much as 1.5 billion pounds a year. Ultimately, the cordless personal handset carried in the pocket, the handbag or on the belt could be as much a part of everyday life as the ordinary fixed phone is today.

Geoff Vincent is a Senior Consultant at PA Technology and led the development phase of the ZonePhone project for Ferranti Creditphone Ltd.

PHONE ZONE PROGRESS TO DATE

Since its first demonstration only just over a year ago, the PhoneZone telepoint concept and its partner, the ZonePhone CT2 handset, have made great strides and would appear to be on the verge of public launch. There is only one final hurdle to leap – obtaining a licence as a telepoint operator, the result of which may be known by the time this appears in print.

At present, Ferranti Creditphone, the putative operator of the PhoneZone service, is in the throes of the beta trials. In parallel with the development of the radio hardware, the company has been devising and setting up the equally important computer systems which will manage the network of PhoneZones and provide the administration and billing facilities. Potential providers of sites for the PhoneZones, major national and international companies with chains of outlets across the country, are participating in a full operational test of the whole system, from the installation of the hardware in the field, through the enrolment of customers (actually selected staff from the site providers' organisations) and making of calls, right through to provision of bills and site revenue statements. The Department of Trade and Industry licenced Ferranti to carry out these trials over a six-month period to the end of January 1989.

Lord Young, the Secretary of State for Trade and Industry, recently gave notice of intention to provide two, three or four licences to operate telepoint services, and eleven companies have responded with applications.

Important safeguards built into the licencing will ensure fair competition between the various operators, with consequent benefits to the users, and timescale is stipulated within which all licencees must conform to a common air interface and eventually support roaming.

All the major companies with an interest in telepoints have agreed a common air interface and have made recommendations to the DTI. The early adoption of the UK specification, and the practical experience which will be gained by UK operators, will make a strong case for the adoption of that same standard for Europe. It is not unlikely that before the millenium the owner of a telepoint handset will be able to use the same instrument at home and in public anywhere in the UK, Europe and perhaps even the world, with all the calls billed to a single account.

CAN HARDWARE PRICES CONTINUE TO FALL?

Is the computer industry hiding behind reasonable price reductions rather than delivering the cheapest possible product, asks professor Martin Healey.

The PC industry, and the Taiwanese clones in particular, has highlighted the fact that the price/performance ratio of computers has fallen dramatically and is continuing to fall. It is of course not confined to PCs; all computers up to the biggest mainframe and super computer are benefiting from the technical advances. But can the price continue to fall? We might also ask whether the technology is being fully utilised or is the industry hiding behind a reasonable price reduction rather than delivering the cheapest possible product.

The case against the computer manufacturer can be demonstrated by looking at a product like the Atari ST1020. This machine contains a 68000 microprocessor, a megabyte of ram, high resolution display, 3.5M floppy disc, a mouse and a GEM windows interface plus an asynchronous comms port. At $500 or thereabouts, this machine is about five times as powerful as an IBM PC. In effect it is a high-resolution graphics workstation priced considerably less than dumb terminals from IBM, DEC and the like.

The case for the computer manufacurer is that stand-alone boxes are not important in the corporate world and that vdus are merely part of a bigger system. In effect, the user is paying for the basic product and all the development and support surrounding that product. But the PCs are stand-alone and they are still expensive in comparison with the Atari.

I am not recommending users to rush out and buy an Atari rather than a 3178 or VT100; I am merely pointing out that there is room yet to bring the price of standard products down considerably. In the future, workstations will replace vdus, without the price overhead carried by current PCs and PS/2 s.

While those in the d.p. industry are really only interested in the final product, I think we should all be aware of how this price reduction is being achieved. Perhaps we wouldn't have got into the current mess with PCs if we had been more aware! The key is the large-scale integrated circuit components, in which a chip manufacturer can create a major sub-system on one piece of silicon, containing tens and hundreds of thousands of elementary cells such as gates, registers, memory, etc. As the single chip is much cheaper than the set of components it replaces, and since it is smaller, consumes less power and is easier to design into a system, the use of l.s.i. parts has brought the price of computing down considerably. The key components are obviously microprocessors and memory chips, but there are many others such as d.m.a. controllers, interrupt controllers, communications interfaces, disc controllers, etc.

Price reduction is not the only impact of l.s.i. however. It now takes far less effort to design a system, in turn implying that the life span of a product is now much shorter. Systems are easier to assemble and particularly easier to test, all contributing to further price reduction *and* an increase in reliability.

Now most l.s.i. components are designed for mass consumption. The cost of the initial design is very high, while the cost of the actual component is low, a concept suited only to high volume production. Thus by designing standard components such as ram or c.p.u. the chip manufacturer can attract many users with medium and even small volumes, accumulating to the large volumes needed for production. As a result, and look at the motherboard or adapter cards of an IBM PC/XT as an example, only half the components in a product are l.s.i. there is also a lot of smaller, medium-scale chips needed to complete the product.

However, if the volume of a given product is high enough, then as well as the l.s.i. microprocessor, the rest of the logic incorporated in dozens of m.s.i. parts can be combined into one or two special i.cs, dramatically cutting the total component count and therefore size and costs (I didn't say price, I said cost!). It is the extensive use of these special chips, referred to as application-specific integrated circuits, that allows Atari to produce the ST machine at such a low price, a technique pioneered in microcomputing by the Sinclair ZX80.

Despite the low price, one could still feel overcharged if you look inside the ST; there is very little there! It is disappointing then to look inside a PS/2 and to find a large motherboard with masses of tiny components all over it. True, there are a number of asics as well as the 286/386 c.p.u. and a welcome use of surface/mounted technology which reduces board size by using smaller physical chip packages and mounting components on both sides of the board, but it is nothing near the class of the Atari or its current rival, the Macintosh II. Opening up the MacII, you will find a heavy use of asics, more akin to the Atari than the PS/2, but with a PS/2 price tag. Clearly then, Apple have room to manoeuvre with prices as the IBM v. Mac battle hots up and IBM must be readying a new round of PC/2s with much cheaper motherboards.

There is however another intriguing side to asics in that certain products based on older technology are there in sufficient volume. For example, one company could develop an asic to make a replacement board, a display adapter for a PC say. What has happened is that companies like Chips-and-Technology and Western Digital, are making l.s.i. parts for EGA and VGA adapters, which can be purchased by any board manufacturer. In effect these asics are becoming standard components, at least in the narrow field of PC cloning. (When is an asic not an asic?) Thus asics are available to provide all the logic needed to map an Intel c.p.u. into a PC-clone. The latest chip is a component to do all the control logic of a PS/2 card to interface to the MCA bus. We know of components specified to implement a motherboard providing an MCA bus; a PS/2 clone. We await then the legal wranglings and finer details of the unique (and proprietary) IBM asics used on the PC/2 motherboards to see how PS/2 cloning will develop. I expect much earlier release of PS/2 Model 30 clones, which are only XT replacements, not in the PS/2 family, but at least have an improved display, 3.5-inch floppies and a smaller footprint. It couldn't survive without the IBM badge, but it has got one and so it will be cloned.

Martin Healey is chairman of Technology Concepts Ltd, Cwmbran, technical director of Miracom Ltd, Ipswich, and professor emeritus at University College, Cardiff.

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OS-9: WINNING THE REAL-TIME RACE?

The success of real-time software products has undoubtedly been helped by the level of support from microprocessor board vendors. But why has the board-level market become so significant? Peter Watson reports.

The way in which real-time microsystems are designed has changed since the early eighties. Designers have become less concerned with circuit design, more with system design. Using a standard bus format such as VME or STE, the designer can move more rapidly from concept to final system using existing, proven board-level products supported by hundreds of manufacturers and distributors.

The choice of operating system becomes secondary to the choice of board-level vendor who will provide support for the complete hardware/software environment. Since the board-level vendor is competing in the open market, he needs to be seen to be offering this high level of system support. It is therefore in his interest to heavily promote his support for, and the benefits of, his chosen operating system.

Bus Wars

Motorola has now explicitly recognised the integral relationship betwen real-time software and board-level hardware in the market for real-time designs in the choice of name for their new product, VA Exec. Versados/RMS68k, which currently has the largest share of real-time 68000 designs is being abandoned by Motorola in favour of their Unix/VMExec project, with support from independent software houses Software Components Group and Industrial Programming Inc. Their established pSOS and MTOS real-time executive products will be adapted to conform to Motorola's Real-Time Executive Interface Definition.

Motorola's attempts to enlist the aid of its fellow board-level vendors in support of VMExec appears to have backfired, however. Most of the VME industry have given the product a public thumbs down, leaving Motorola with a new product visibly failing to win general market acceptance, and leaving their current market leader Versados with a lame duck image.

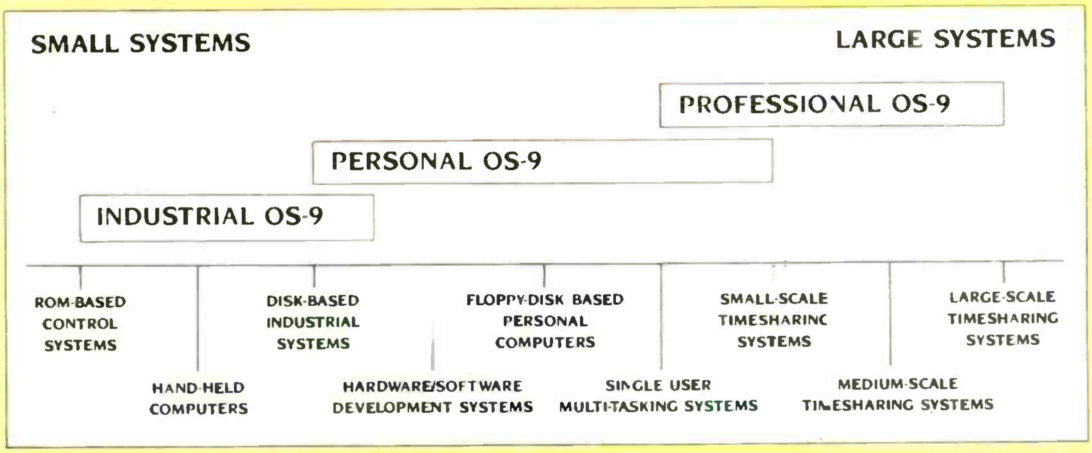
One factor contributing to the demise of Versados is Motorola's position as a board-level vendor itself. It was therefore seen as being unable (or unwilling) to provide independent support to other board-level vendors.

Microware's early support of the board-level vendors is now paying off, a fact recognised even by Microsoft who attempted to gain a fast entry to this marketplace with an unsuccessful bid for the company. Microware's OS-9 product with less than 10% of the 68000 systems market two years ago, is gaining market share rapidly and currently appears to be gaining the largest share of new real-time VME design-ins.

Ken Kaplan, president of Microware, has proclaimed OS-9 as potentially the most popular operating system of all time on the back of several design wins, most notably that of the Sony-Philips compact disc interactive (CD-I) standard, with projected sales of 30 million units/year, to be launched next year.

Modelled on Unix with an almost identical command structure, OS-9 is largely compatible at the C source code level. Like Unix it supports a wide range of development tools, such as compilers, editors and debuggers. It has considerable third-party support with languages such as Modula-2 and even ADA being announced recently. Unlike Unix, it is a small, fast, real-time, 'rommable' operating system. It is built in a modular fashion allowing the full disc-based development environment to be stripped down progressively to a small real-time kernel for target installation.

Like VME, it has been designed to maximize the performance of a single processor



family in real-time applications, originally the 6809, now the 68000. This has been a significant factor in its comprehensive adoption by VME board-level vendors. The fact that VME is now the leading bus standard in this marketplace has further enhanced the position of OS-9.

The Empire Strikes Back

Intel is fighting back against the success of VME and the 68000 processors in real-time applications with Multibus II and the 286/386 processors supported by its iRMX and iRMK software products. However, it is later into the marketplace with products which are less well developed and less well supported than their VME equivalents. Third-party software support for Multibus II is also less well developed. In particular, there is no obvious Microware/OS-9 equivalent. The market on the processor-independent buses, such as STE and IEEE896, is even more open.

One possible contender is the Digital Research product FlexOS. Optimized for the Intel range of 80186/286/386 processors, it is very fast and efficient in real-time applications. It has a development environment supported by PC/AT and 386 machines, with a MS-DOS compatible applications environment, and high-level integrated graphics and networking support.

In spite of these advantages, FlexOS has not attained a great level of visibility amongst the vast majority of designers of real-time systems. One reason appears to be the policy by Digital Research of concentrating its resources on winning a small number of very large OEM design-ins.

REAL-TIME OPERATING SYSTEMS: AN OVERVIEW

Real-time refers to the ability of software to respond to events generated in the real world as they occur. A simple and common example is keyboard input to a wordprocessor. From this point of view, most operating systems can be considered to have some real-time capability. A more useful definition would require the software to react within a predictable response time appropriate to the number and speed of external events generated in time-critical applications.

Many applications in communications and industrial automation require software to react quickly to many external events occurring at random times, sometimes simultaneously. Disc-based operating systems such as CP/M, MS-DOS or Unix have not been designed for such real-time capability. They are more concerned with optimizing the use of limited computer memory and disc storage by large program and data files. This limits their usefulness in real-time applications since the response to an event may require loading the executable code from disc. An automated fork-lift truck travelling at full speed may not have time to wait for tasks to be swapped to disc before reacting to the presence of an obstruction. A further drawback is that disc-based operating systems cannot be placed in rom, since they are designed to swap between ram and disc.

Real-time applications are frequently developed under such operating systems, however, in spite of the apparent drawbacks. This usually involves replacing the disc operating system, once the application code has been developed, with a real-time kernel or executive. This real-time executive might be written by the application programmer, or a standard product such as VRTX may be employed. Such executives provide an efficient real-time environment for the application code, but generally have limited ability to manage memory and disc storage, and poor support for development and debugging tools. Support for peripheral functions such as networking may be nonexistent.

The major penalty of such an approach is the increased time required to test and install the application code in the target system. The radical change of operating environment between development host and application target system adds complexity and makes demands on the knowledge, skill and time of the programmer to solve problems which would not arise under a real-time, rommable operating system.

Back to the Future

Where will the market go from here? One trend of increasing importance is the introduction of products designed to support the development of real-time applications under Unix. For major projects, often in the defence and aerospace industry, where the work of a large programming team must be coordinated and monitored efficiently, the advantages of Unix as a development environment may outweigh the increased overhead and complexity in the interface with the target system. VMExec from Motorola, mentioned earlier, is aimed at this market.

Another major board-level manufacturer with considerable experience in real-time defence applications, Radstone Technology (formerly Plessey Microsystems), has launched VXcel. This real-time development environment for Unix System V.3 has been developed with the help of Ready Systems, a US company with several years experience as a specialist in real-time executives for a wide range of microprocessors.

Perhaps confirming this trend, even Microware has recognised the coming importance of Unix in real-time applications by its recent announcement of UniBridge, another product designed for real-time Unix support.

Peter Watson is with Bob Squirrell Marketing, specialising in the microsystem and computer industry.

PC DSO EASES SMPS MANUFACTURE

Quality control of the electronics manufacturing process often relies on detailed statistical data. With its ability to record and trace every measurement, the Compuscope gives the evaluation engineer facilities for constant quality monitoring and fault diagnostics whilst the information available can be fed into compatible statistics programmes to generate data for production management and engineering report purposes. A sample output is shown in the Table.

Typical Manufacturing Report Model PS124XL-01

Serial number	OVST V	LREG %	LREG %	RIPL mV	HTIM ms	EFF %	ICUR A	POUT W	VRAN V
1045	0	0.2	5	100	18	63	18	120	85-126
1046	0	0.15	4.5	85	15	64	10	121	84-124
1047	0.5	0.2	5	100	19	66	20	122	85-126

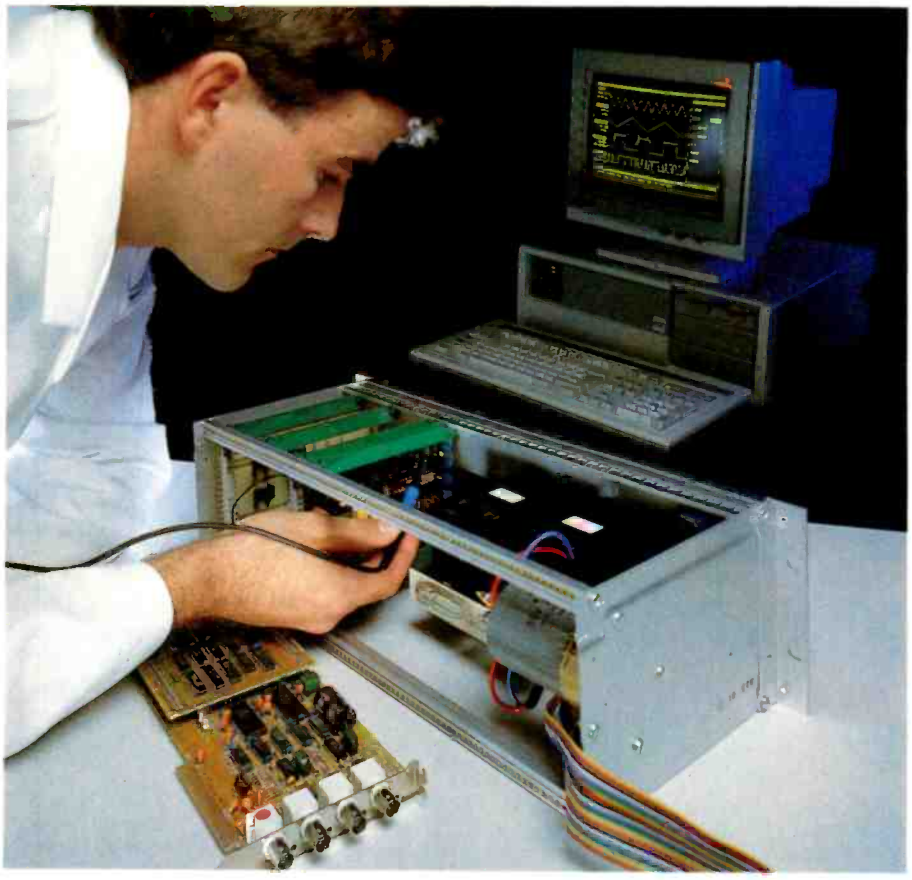
SMPS manufacturers need to measure parameters which are of a transient nature which, when obtained using conventional equipment, can involve a great deal of time and a significant level of computing. Statistical data is also necessary in order to judge the quality and reliability of the manufacturing process. The Compuscope addresses these requirements in one cost-effective solution.

To illustrate the Compuscope's capabilities in s.m.p.s. manufacture, look at two set-up examples. When configured as in the upper diagram, transient parameters of turn-on overshoot, total power output, efficiency, input-rush current and hold-up time can be measured and recorded on disc.

Using appropriate resistors, the Compuscope is set-up to sample at 1MHz with the trigger source and trigger level (0.1 volt) set on channel A in the mid-trigger mode. Channel A is connected to the output voltage of the differential amplifier, whilst channel B is connected to the output of the supply under test.

When power is applied to the s.m.p.s. Compuscope will trigger and display the measurement results, channel A will show the input current profile and amplitude and channel B the output response of the power supply under load. Cursors can be used to measure the overshoot on channel B and the input rush current amplitude on channel A. Ripple on the output voltage can also be measured on channel B.

Total output power is computed from channel B's quiescent value. Similarly, the input power can be computed from the waveform on channel A; the resulting ratio giving the efficiency of the unit under test.

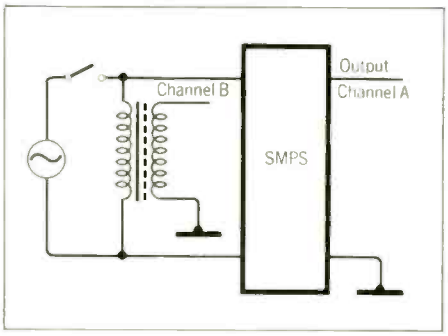


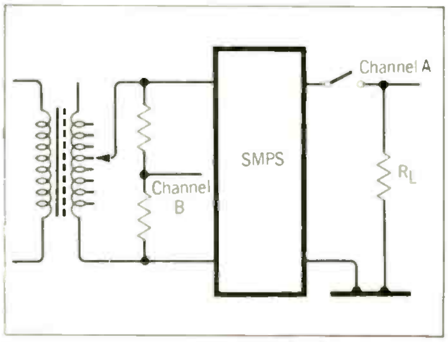
FROM PC TO DSO

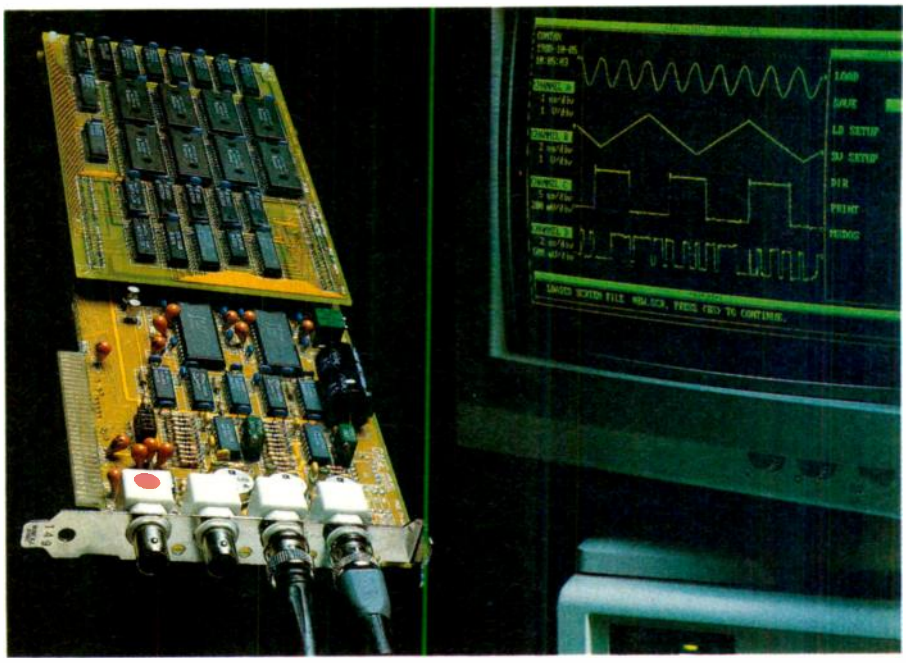
Recently launched by Contax is a PC expansion board which turns any IBM or compatible into a two-channel digital storage oscilloscope, combining the computation and statistical analysis capabilities of a microcomputer with those of a conventional d.s.o.

Compuscope provides a depth of storage of 256kbytes and a maximum sampling rate of 40MHz on one channel. Functions windowed into the main display include a d.v.m. facility, and many mathematical facilities, including Fast Fourier Transforms, curve fitting and waveform integration and differentiation.

Timebase ranges from 10ns up to 10 seconds per division are provided and waveforms up to 10 volts amplitude can be displayed. Other features include delta T and delta Y cursors and zoom facility. Compuscope can store random transients and, with a minimum sampling rate of 1Hz (and thus a maximum sampling duration of three days), as a simple logger. Pre and post-event histories around a trigger can be recorded and stored for later evaluation and analysis.







Changing the trigger slope to negative enables the hold up time to be measured. When power to the supply is switched off, channel A will display the decay of the output power. The hold up time can thus be measured using the cursors.

In the second configuration example, line regulation, load regulation and input voltage range can be measured. Test equipment is set-up as shown in the lower diagram, with the voltage divider made up from appropriate resistors. Channel A is connected to the divider output and channel B connected to the supply output. The dummy load on the supply should be equal to the full load as per specifications. The trigger is again set to channel A but in the PST-trigger mode. With power applied to the s.m.p.s. with the load switched on, varying of the input alternating voltage through the entire specified range will cause the input voltage to be displayed on channel A and output voltage on channel B. Line regulation and input voltage range can, therefore, be computed.

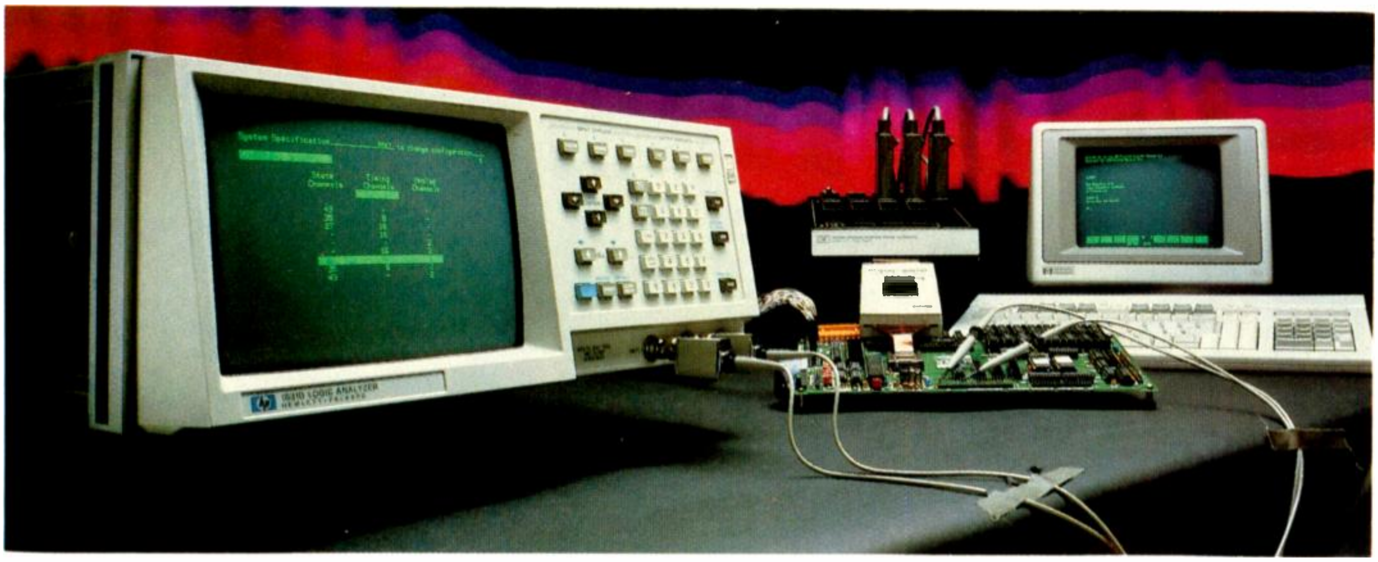
To measure the load regulation, the load is disconnected, channel A is connected to the load side of the switch and channel B to the s.m.p.s. side of the switch. With the trigger on channel A set to a positive slope, the load regulation will be displayed on channel B. The cursors can be used to measure the response time as well as amplitude of deregulation.

The set-up configurations and screens can be saved and recalled for future use and screens printed off with individual s.m.p.s. serial number and values.

Of the 12 parameters most often used to evaluate power supplies, these two example configurations cover all but three.

Temperature coefficient and input frequency range can be measured in a similar manner, however in-circuit over-voltage protection is difficult to measure in power supplies with non-adjustable voltages.

Contax are in Showling, Hants, tel 0703 434141.



A DIGITAL SCOPE FOR £400?

With recent advances in the technology applied to t & m equipment, great strides have been made on both sides of the market. But what will happen next?

New and more exciting items of specialist test and measurement equipment appear on suppliers' shelves every month – each one claiming to represent massive advances, in both technological and performance terms, over its competitors and predecessors. Given the rate at which new manufacturers of t & m equipment are arriving on the scene, this is at first sight an entirely happy state of affairs for prospective purchasers. And the manufacturers, too, benefit indirectly from the market forces these purchasers bring with them. This has become particularly apparent in recent years, when price and performance have become far more important to the customer with the advent of imported "me too" equipment. The net effect of such changes in attitudes of customers has in turn affected the way in which manufacturers of test equipment have gone about fighting their respective never-ending wars on price, performance and features available on their products – and this has, quite naturally, affected the technology within their equipment.

Some four years ago, Hewlett-Packard took the decision to cease manufacture of analogue 'scopes entirely, and instead concentrate on the then relatively new field of digital 'scopes and logic analysers. This was to some extent something of a gamble, as other manufacturers had already dabbled in the magic arts of analogue to digital conversion – and their customers had found them lacking in terms of bandwidth available and also errors generated in the analogue to digital conversions. To resolve these problems Hewlett-Packard realised that considerable technical effort would have to be applied to restore the confidence of a market already disillusioned by the attempts of others. Such effort is now history – and by the time other analogue oscilloscope manufacturers had started to delve more seriously into digitizing 'scopes, Hewlett-Packard had resolved many of the problems yet to be encountered by the others.

Later, the market began to get more even as competitors began to catch up – and it was time to look at new ways of improving price, ergonomics, and also the performance of the then 'third-generation' digital oscilloscopes. Last year, that improvement was suddenly available thanks to the introduction of the NMOS III process, whereby 140,000 logic gates became available on one chip, opening up a multitude of possibilities for greatly improved human interfacing and vastly superior 'number crunching'. Overnight, the digitizing oscilloscope was promoted to first-line support equipment from its previous position as a rather esoteric piece of kit that only a specialist could use. Logic analysers, too, benefitted from computer style pop-up windows and icons for prompting, nudging and interrogating the operator and the equipment under test.

Perhaps most important of all, though, was the dramatic cost reduction achieved through the application of this technology – equipment that sold yesterday at £12,000 was now available for £6,000.

Whilst pop-up windows and cost reductions were all good things for the market in logic analysers, NMOS III allowed additional functions, such as transitional timing, to be introduced – using much less memory.

At the top end of the market the 16500 Logic Analysis System is a genuinely powerful tool for c.a.e. applications (amongst others) – particularly with regard to stimulus and response time testing. Using this logic analyser, the theoretical results produced at the c.a.e. level could be translated into practical results from prototype production equipment. Starting at around £9,500 and going up to £20,000 for the high-performance version, it compares very favourably with the Tektronix DAS which runs from £20,000 to £40,000.

In parallel with this technology, higher sampling rates became available for digitizing oscilloscopes, and the 54111D has, at 2gigasamples/s, the highest sampling rate of any 'scope available. Looking at laser modulation and the examination of 'single-shot' events is now perfectly attainable, and indeed is exactly what the 54111D enjoys doing best.

The opposite end of the spectrum holds the 54501 'scope with 100MHz bandwidth and four channels for £2,500. This model offers automatic parametric measurements, and operates in what can be described as a 'babysitting' mode, whereby irritating logic glitches that occur at irregular and disastrous intervals can be recorded, providing pre and post-trigger analysis – more useful than earlier types which could only offer post-trigger analysis, with no clue as to what preceded the event.

Application-specific i.c. technology has also helped by removing warm-up time, and also discarding the need for re-calibration as the equipment gets hotter.

But where will the test and measurement market go from here? As stated earlier, the big fight is now on for better and better performance criteria at lower and lower prices, but things are changing . . .

Over the last 10 years, the microprocessing industry has boomed, but now it's beginning to level off – and the need for ever greater logic analysis has, therefore, also slowed down. Instead, the emphasis has shifted towards logic analysers which are easier to use and offer greater measurement accuracy. In parallel with this, for digital 'scopes, more attention and now needs to be paid to the front-end amplifiers of the various systems, and the various methods employed by which the systems sample and interpret results.

In parallel with these exploits, further attention will be paid to manufacturing techniques to bring costs down further still, and yes, it is possible for a digital 'scope to be sold at around £400 – it won't happen for a few years yet, but happen it certainly will.

So what does all the technology do for the customer – is it just an excuse for development engineers to put stranger technologies into action, or does it really help? The answer, of course, is that it really does help the customer. By providing better interpretation and accuracy of results, the equipment under test can be produced to better tolerances faster and more cheaply. This benefit in turn passed on to yet another customer – and so on it goes. As time goes on, there will be less incentive to use analogue 'scopes, and no need for the expensive, hand-blown c.r.ts used in them. The digitizing 'scope needs only an ordinary monitor screen.

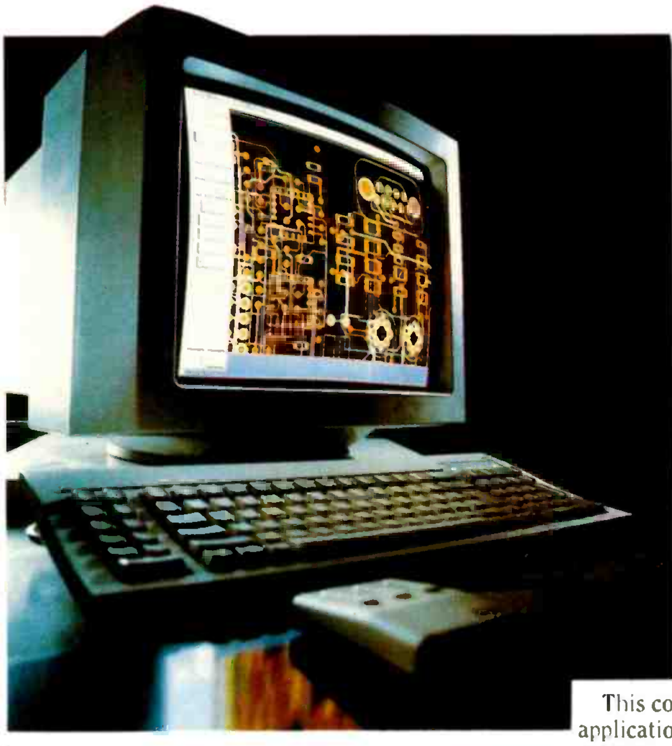
The last couple of years have seen some major changes and advances, but it hasn't stopped yet. Next year, $1 billion will be spent at Hewlett-Packard purely on research and development into t & m equipment.

David Gee is instrument product manager with Hewlett-Packard

HP1631D logic analyser (left) has a built-in digitizing oscilloscope, enabling hardware designers to make the cross-domain measurements needed to troubleshoot and characterize systems. Nine months of extensive evaluation has led to an MoD order for 156 HP54501A low-cost digital oscilloscopes.

ENGINEERING WORKSTATIONS

With recent expansions in the power of graphic workstations Peter Harverson asks: Have the standards arrived?



BroadMaster is one of Daisy's sophisticated cad packages providing a totally integrated solution to pcb design.

Providing comprehensive cad and cae tools for a design team is a major investment – and one which even large companies have justifiably deliberated upon before committing to a product line. Even the aspect of increased productivity may not be sufficient to allay the fear of ending up with many thousands of pounds of obsolete equipment.

Such fears are also fuelled by some vendors making offerings which create an impression of conforming to a 'standard', while really only providing partial solutions – such as operating system coexistence or network gateways. Their customers may fall prey to such marketing techniques out of an overwhelming desire to justify the investment in these tools. The confusion, however, may be coming to an end, as evidenced by the fact that, Unix, TCP/IP, NFS and X-Windows are emerging as *de facto* standards. It is becoming clear that although full conformance to these standards may involve short-term costs, the long-term result of non-conformance may be disastrous.

No marketing effort can disguise the fact that technological advances now permit the kind of system environment the industry has been trying to achieve for years. A 4 mips workstation running Unix, TCP/IP, NFS, and X-Windows can accommodate not only most engineering applications and peripherals but also the integ ation of related applications such as computer-aided project management, manufacturing, documentation and publishing. No longer do we have a situation in which conformance to standards implies the compromise in performance or capability suggested by a general-purpose 6116solution. Instead, the standards have been slowly evolving as if in anticipation of hardware technology that could take advantage of them for greater performance and functionality.

Over the long term, both tools vendors and design engineers alike will migrate to these standards because they provide a winning opportunity for all concerned. One reason is that more software applications will be available for integration into the design environment because third-party software developers are confident that investment in applications running on Unix, TCP/IP, NPS and W-Windows will run on a variety of platforms and therefore will be used by a wider market.

This confidence in the portability of their applications allows third-party software developers to focus on optimizing the applications themselves rather than on adapting the applications to a variety of system environments. For the users, this increased focus translates into a potential for higher performance and higher quality in the applications that they purchase.

In addition to wider availability and greater range of applications software, standards

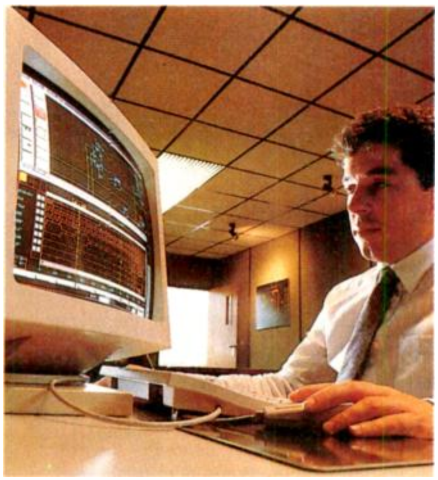
Advansys is Daisy's state-of-the-art cae product line incorporating latest Unix-based Sun 386i workstations.

benefit users by protecting their investment. As hardware technology or software applications improve, the design team can reconfigure the engineering computing environment without major modifications to the environment. For example, they can add the latest development in hardware workstations to the existing environment without making previous hardware investments obsolete, and without any impact on the applications they are running. Or, they can replace existing applications without requiring additional systems software development.

The vendors of workstations and turnkey cae/cad systems will also benefit by the migration to system-level standards. With standards in place and third-party software available, workstation vendors can sell into wider markets. Vendors of cae/cad systems can focus their development and support on their core area of applications with full confidence that they can integrate niche applications for their customers' individual needs into the cae/cad environment.

The absence of system-level standards in cae/cad slowed the growth of the industry because the turnkey-system vendors had to make huge investments in system-level development and engineering teams could not afford to purchase expensive, dissimilar workstations for discrete engineering tasks.

The current *de facto* system-level standards evolved independently of any one vendor because no one vendor had the complete solution for an operating system, a distributed file system, network communications, graphics, and database standardization. Unix became a standard, not because it was running on one vendor's popular platform, but because it was a superior operating system for engineering development that was widely available for use in both the universities and private industry. TCP-IP became a standard partly because of its close association with Unix and partly because the US Department of Defence made it a requirement in its contracts. NFS became a standard because it was the first technically superior distributed file system available for Unix and because Sun Microsystems, Inc. championed its wide distribution. X-Windows is becoming a standard for much the same reason that Unix did – it meets technical requirements for graphics and is widely accessible at a time when no other graphics standard has emerged. In the field of automated design tools for the electronics engineer, Daisy Systems has been a front runner in porting its proven software tools into this standard environment – a move which is being welcomed by the industry as it allows other applications to be run on the same equipment ensuring maximum return for the investment and optimizing productivity.



Multiple window displays and mouse control provide the engineer with a highly interactive design environment.

Once vendors and users fully conform to the standards today, all can work together to guide the evolution of existing standards as well as those potential standards such as edif that have not yet been fully embraced. This team effort will help tools vendors and design engineers alike avoid the surprise of having invested in the wrong standard system environment.

Peter Harverson is Vice President for Northern Europe at Daisy Systems International

SECURE PACKAGING AT HOME

Even in the present day and age, it is hard to believe that a European industry could be so dominated by competition from the Far East that over 99% of its product is supplied from countries such as Hong Kong, Taiwan, Korea and the Phillipines. But it's true, and the industry concerned is semiconductor assembly.

Dataquest estimates have put the annual European consumption of semiconductors in excess of 12 billion *per annum*, and the vast majority of these are assembled 'offshore' for reasons of cost. Semiconductor assembly is a relatively labour-intensive process, and labour is still cheap in the Far East.

Current estimates put the number of people employed assembling European semiconductors in the Far East in excess of 100,000. With European companies currently trying to increase the European con-

Two packaging operations at Iteq: bonding wires to a 40-lead side-braze package (above), and sealing pin-grid arrays (top right).

tent of their products, this could be seen as an opportunity of bringing some of these jobs back here.

There are currently several factors working in favour of the few European semiconductor assemblers, companies like Iteq Europe, the largest independent, employing some 280 staff at its Irvine factory.

State-of-the-art automation and increasing asic business may mean that semiconductor assembly has a place in Europe after all

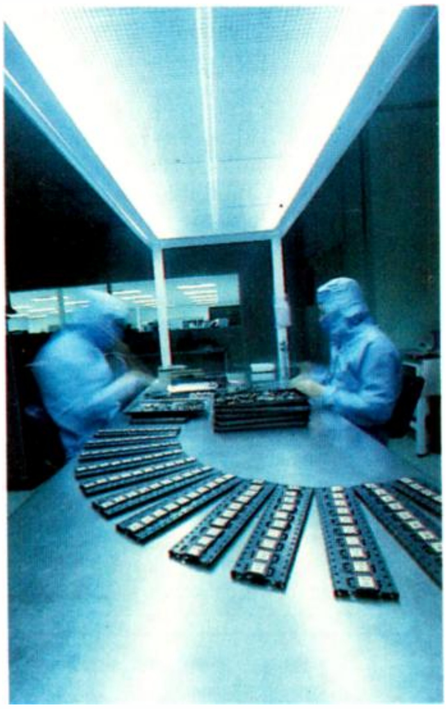
The first is automation. The newest equipment is making the semiconductor assembly process much less labour intensive and by tooling up with state-of-the-art equipment, Europe can bring its costs close to those of its competitors.

Another factor is design security. Today's semiconductor manufacturers are playing for very high stakes – and the risk of plagiarism is very real. Semiconductor manufacturers see European assemblers as being less vulnerable than their Far Eastern counterparts, and are looking for ways to bring the assembly of sensitive chip designs back to mainland Europe.

One of the most important factors of all is the fast-increasing popularity of the application-specific integrated circuit. They often present complex assembly problems which require close liaison between the chip designers and the assemblers. Under these conditions, European assembly is a very attractive proposition.

As Mick Denham, managing director of Iteq puts it: "The rapid emergence of computer-aided design has led to higher pin-count, more complex v.l.s.i. products – there may be so many as 300 wires in a package – which in turn has led to a change in the assembly market, a change which we believe will favour European companies, which can assemble high pin-count packages on a very cost-effective basis."

Iteq is a good example of an independent European semiconductor assembler trying



to carve out its own niche in a highly competitive market. Because of its location, the company can offer very fast delivery. Standard turnaround time – door-to-door – is ten days, compared with five weeks in the Far East for assembly. It also has a premium service of only three days, a time which Far Eastern companies could never hope even to approach. With the 'just-in-time' philosophy becoming accepted throughout industry, prompt and reliable delivery is becoming essential.

Iteq grew out of Indy Electronics, a company launched in 1980 in Manteca, California, with the idea of providing an 'onshore' semiconductor assembly service to the US electronic industry. In the mid-80s Indy's owners decided to establish a base in Europe, and the European operation opened its doors for business in 1986. Just before Christmas of last year a management buyout was completed, and the company passed into local hands.

The next step for Iteq in becoming a world-class contender is to be able to reduce costs and increase productivity through automation, says Denham. "This will enable the assembly fees for our service to be closer to those charged in the Far East. At the same time, we will continue to provide a substantially shorter cycle time, a higher level of engineering support and greater service flexibility than are currently provided by the Far East."

FIRST HIGH PERFORMANCE VXI INSTRUMENTS

Tektronix claim to have the first high-performance development system based on the emergent VXIbus standard for card modular automated test equipment. The Tektronix system includes all the components needed to allow users to develop instruments on a card, providing a platform for VXI instrument development, performance evaluation, or other VXIbus applications requiring tight timing co-ordination, high-speed data transfer between modules and precision trigger routing, as well as a specialized test system.

The development system is the first to exploit the VXI standard D-size modules and P3 backplane – the most sophisticated supported by the standard – comprising a 13-slot mainframe, a VME conversion module, a slot-0 resource manager, and two D-size development modules. Options include a C-size card adaptor module, D-size wire-wrap module D-size vector card, and additional D-size development cards.

Tektronix launches first VXI products to use P3 backplane at October show

Tektronix believe VXIbus is the most important development since the introduction of the IEEE488 bus standard, and that users should start developing products that work with it. "That's why we wanted to get a development system to market as quickly as possible," says Robert Stubbings, product manager of Tek UK's laboratory oscilloscopes and systems division. "We expect some of our competitors to be releasing working products based on the less sophisticated VXI definitions, but that's not what the market needs at the moment. People need products that will allow them to get to grips with the standard and exactly what it can do."

The Tek mainframe accommodates all four card sizes defined by the VXI standard, and will also house equivalent VMEbus single and double-height boards, C-size cards, and equivalent Eurocard boards. As a result, standard VMEbus cards such as interfaces, memory, input/output and single board computers can be integrated into the VXI test system.

The VXIbus open system architecture and specification for card instruments allows a wide range of interfaces, computers and instruments from different manufacturers to coexist as fully compatible modules within the same card chassis. VXIbus is an extension of the existing VME open architecture, as first described in detail in

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THE YEAR OF THE VIPER

Safety-critical computing is aided by the verified Viper 1A microprocessor, now being introduced commercially

Patients in hospitals are monitored using instruments which contain microprocessors; railway junctions are controlled from signal boxes in which mechanical relays ha' e been replaced by microprocessors and computer programs; aircraft fly over the Earth's surface guided in three dimensions by on-board computers; microprocessors control and monitor hazardous processes in the chemical and nuclear industries. Military designers are working on advanced fighter aircraft which are inherently so unstable that human pilots cannot fly them without computing systems calculating the required deflections of the control surfaces every few milliseconds.

These applications have one thing in common: design errors in the electronic hardware of the computers or mistakes in computer programs may result in disastrous accidents. The name "high integrity computing" has been applied to such critical computing applications. The accidents caused by design flaws may be of such severity that lives are lost or massive damage is done to the environment.

Many items of computer-based equipment may be seen as important by the general public yet do not fall within the definition of "high integrity", for example bank cash-points. High integrity computing tends to be concentrated in a few key areas, such as the control of nuclear reactors, automation of flight control in aircraft, control of chemical plants, and the safety of weapon systems. These regimes are subject to scrutiny and regulation by certification authorities. In the UK, these would be the Nuclear Installations Inspectorate, the Airworthiness Division of the Civil Aviation Authority, the Health and Safety Executive, and the Defence Ordnance Board.

The role of the computer in these applications is typically to accept inputs from various sensor systems, perform some calculations or logic and then provide outputs to actuators. All designers of critical systems should know the consequence of component failure in service. Random failures of microchips, sensors, and actuators are coped with by using redundancy, for example triplicated autoland systems in aircraft and quadruplicated emergency shut-down systems in nuclear reactors.

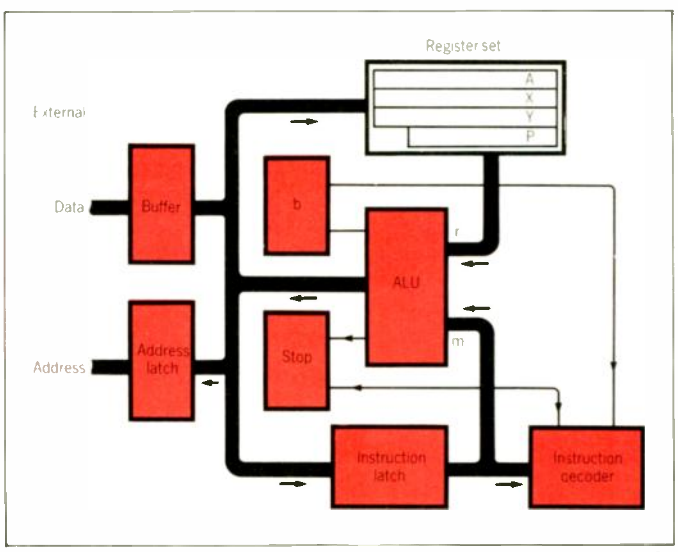
But replication of hardware in this manner will not help if there are underlying design flaws in either the hardware or the software. Mistakes in computer programs have been known to stop the parallel computer channels in an equipment simultaneously, leaving no means of control.

Equally serious is the risk that unsuspected design faults in the computer hardware or software may allow the system being monitored to carry on running, even though possibly crucial temperature and pressure limits have been exceeded. It is these technological problems which caused the Royal Signals and Radar Establishment at Malvern to embark on a programme to provide designers in both military and civil regimes with safer means of designing automated control systems.

Research at RSRE is conducted in a variety of disciplines, which range from fundamental work on electronic materials to the construction of complex models of the UK Air Traffic Control Environment. The primary task of the establishment is to conduct research and development in support of UK Defence, but within this overall framework RSRE is able to make substantial contributions to civil technology.

In the disciplines which relate to safety-critical computing, the work at RSRE is concentrated in three areas. Firstly, research is being carried out on methods of writing technical specifications for high integrity hardware and software using formal mathematical methods. Secondly, RSRE has had considerable success in collaboration with the University of Southampton, UK in devising methods of mathematical analysis for detecting deeply hidden flaws in computer programs. Finally, the RSRE team, with a second team from the University of Cambridge, have devised new methods of designing provably correct microprocessor hardware.

Work on this last-mentioned topic started at RSRE because of increasing doubts amongst scientists and engineers about the integrity of the processors which are available. The microprocessor chips used in nuclear reactor control systems and aircraft autopilots are mass-produced devices. Both the UK MoD and other organisations have found that many of the types of microprocessor on the market have internal design mistakes. From the scientific evidence, it is reasonable to conclude that low-cost, mass-produced microprocessors do not provide a satisfactory basis for computation in systems which must be certified as safe by independent regulatory authorities. So serious is this problem in some safety-critical defence applications, that a team at RSRE created a high integrity microprocessor called Viper specifically for the most hazardous regimes.

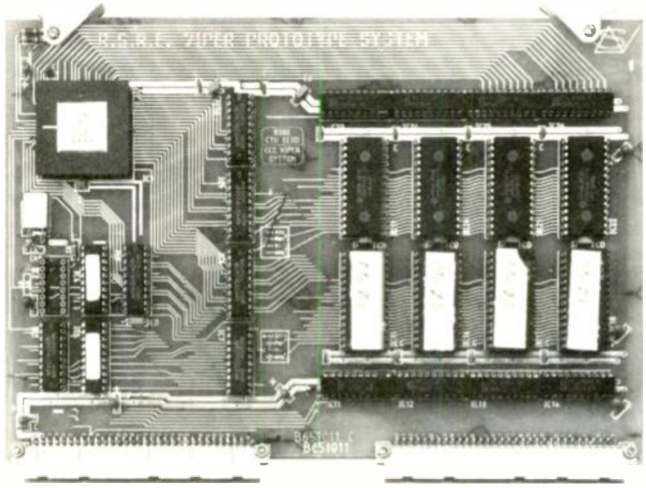


RSRE's latest Viper (1A) – a 'verifiable integrated processor for enhanced reliability' – allows one processor to check another.

To assess the contribution which future products based on Viper can make, it is important to understand the underlying causes of design errors. The first point at which confusion can arise is in the writing of the technical specification for a particular microprocessor-based black box. Suppose the equipment in question has to deal with 12 incoming Boolean alarm signals, each of which can take the values true or false. Then the specification must cover the actions to be taken in: $12^{12} = 4096$ sets of circumstances. If the specification only tells the design team what to do in, say, 2000 of these cases, it is seriously deficient.

Most technical specifications for control boxes in reactors and aircraft are written in plain English, with a little mathematics in the form of equations, and possibly some numerical values. Experience has shown that this is not good enough and leaves the designers with too much latitude. The design team have to guess the response required from their equipment when certain combinations of inputs are present. Of course, they are free at every stage to go back to the prime contractor or other author of the technical specification. Sometimes this kind of clarification is not sought and an equipment is supplied for use in the main system which works according to the clauses of the original specification but also possesses undesirable and unexpected behaviour in other (non-specified) regimes.

When it comes to writing the computer programs which implement the required logic, it is usual in high integrity projects to have two teams. One team writes the software and the second verification team follows the design in detail. The verification team checks, by eye and a variety of testing methods, that each module of the computer program obeys its specification. This may seem to be a reasonable arrangement in human and engineering terms but it suffers from a serious flaw. Work by RSRE and other laboratories has shown that conventional testing of software may explore only a small fraction of the logical paths through a computer program. Far more powerful techniques are needed to scan a program thoroughly to detect errors. The techniques now known as static code analysis, developed by RSRE and the University of Southampton, have an important role in the detection of flaws in software. All programs written for the Viper microprocessor should be analysed using three rigorous techniques before real-life operation of systems is attempted.



The Viper 1 processor card, shown here on a standard double Eurocard, contains all the necessary components (64K words of memory, bus buffers, decoding and clock logic) needed to interface the Viper microprocessor to the Hi-Bus backplane of the Viper Prototyping System manufactured by Charter Technologies Ltd of Worcester.

It is important to consider where the scientific research on the design of safety-critical computer hardware and software is heading. In an ideal world the designer of a high integrity computer system would begin with:

A A formal specification of the requirement, provably complete, consistent and unambiguous.

B A formal description of the programming language to be used.

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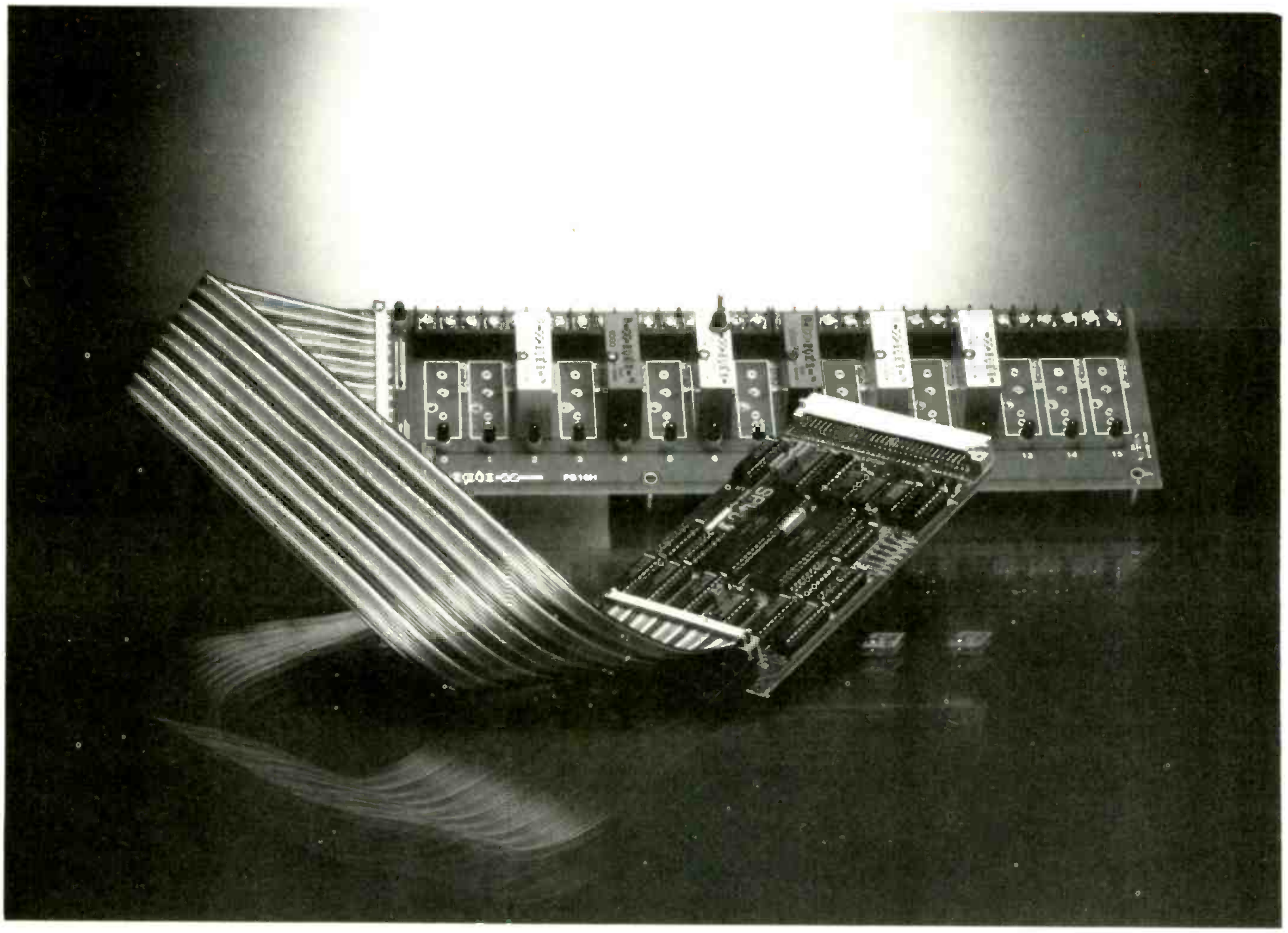
STEBUS LOOKS TO THE GLOBAL MARKET



If STEbus can build on the progress made over the last year, it could yet become a standard to rank alongside VMEbus and Multibus – no mean achievement for a bus system conceived and developed in the UK, says Alan Timmins of STEMUG

Proponents of STEbus have seen encouraging progress for the Eurocard-based 8-bit backplane bus standard over the last twelve months. Last December, along with VMEbus and 896bus, it finally gained full approval from the IEEE, the main standardization body for backplane standards.

Sales of STEbus boards continue to grow almost exponentially with market estimates at about £4 million for 1988, almost double the figure for the previous year. Predictions are that this growth is likely to continue, with sales currently running at about £7 million a year according to Arcom, one of the main producers of STEbus boards.

The number of board types built to the standard has also increased, though at a slower rate. Following the first introductions back in 1984, the number grew rapidly to reach over 750 in 1987; since then there has been a stabilization and rationalization of product introductions.

The major manufacturers now have established ranges and are launching boards at the rate of one or two a month. The latest annual STEbus guide, which details all the current offerings for the bus is shortly to be published and will contain about 100 new offerings.

This far, the portents for STEbus appear very good. It has undoubtedly gained a major following particularly in the industrial and control markets and still appears to be gaining momentum. At the recent STE-88 Conference organised by the STE manufacturers and Users Group at Essex University some 65 delegates from all corners of industry gathered for two days of papers. The subject matter was wide and varied but was pertinent to system designers, engineers and application engineers and managers responsible for the implementation of systems for applications such as process control, data acquisition and robotics. STE is an excellent i/o bus and the seminar featured a comparison of i/o sub-systems and a guide to analogue i/o, even showing how to design one's own i/o using custom boards.

One development in STE of particular interest is the introduction of low power, all-cmos systems by companies such as DSP Design. These systems have many advantages for the industrial systems designer. Low power consumption increases the options available: the power supply may now be a low-noise linear supply, rather than a noisy and more expensive switched-mode supply: it also opens up the possibility of producing systems run entirely on batteries, or even from solar power.

Portable systems can be built that don't suffer the inconvenience of frequent battery changes. Cmos devices generate less heat than their ls-ttl/nmos counterparts consequently cmos systems don't need forced air cooling and can be sealed against dust, water, oil and corrosive gases. Packaging requirements are also simplified.

Other subjects covered during the two days included networking, multiprocessing, rom-based target systems, data communications, system development using intelligent slaves and an example of the use of Aztec C with its recent upgraded ability to cross-compile to the 68000.

Pictured opposite is Dean Microsystems cmos version of DSP Design's STE parallel i/o card.

Those that were new to STE – about half of the delegates – had attended the conference to assist their decision making of which path to follow, and many went away convinced that STE was the route for them. But STEbus remains very much a British standard: 90% of the market is still in the UK.

Created and developed in Britain, it is not surprising that STEbus has found most of its support on this side of the channel. But if it is to gain the status of a major standard such as VMEbus and continue to grow, it must soon find international recognition and achieve a similar penetration in Europe and the USA.

In mainland Europe, the market for 8-bit buses is rather parochial with a variety of buses favoured in different countries. And so far there has been no European company with sufficient clout to wave the flag for STEbus.

There are signs, however, of a ground-swell of activity which holds the promise of better things to come for STEbus in Europe. The IEC is considering adopting STEbus. It is currently being processed by a committee under Joint Technical Committee 1, the IEC/ISO body with responsibility for standards in information technology.

Last month saw a distribution deal with important implications for the break-through STEbus needs in Europe. Industrial electronics supplier EAO has become Arcom's European STEbus partner and will provide a major source of STEbus boards in Switzerland, Federal Germany, Netherlands and Sweden. And other deals between British and European companies are in the pipeline.

So far, the massive American market has remained largely untouched by STEbus, though the first steps in taking the standard across the Atlantic have already been made – last October an American branch of the STEbus Manufacturers and Users Group was formed following the Buscon East.

The endorsement of the standard by the IEEE has finally given STEbus credibility in the US market and several board manufacturers either have introduced or plan to launch STEbus cards. American designers seem very much oriented to VMEbus, and much of the current interest is reported to be in using STEbus as an i/o bus within VMEbus systems.*

*All as set out in October's 1987 issue of EWW

SYSTEM INTEGRATION ACHIEVEMENTS AND OPPORTUNITIES

Peter Nicholson reports on why 1988 was the year that system integration came of age

This year has seen some startling achievements in the field of system level integration. It has also seen the unveiling of many significant opportunities – to save costs, improve reliability or simply make possible things that have been impossible. The next twelve months will see developments just as remarkable.

The increasing technological capability of semiconductor vendors has led to the realisation of increasingly complex devices at a seemingly ever-increasing rate. 1988 may well be remembered as the year that system level integration came of age and produced the level of functionality necessary to build true 'systems on a chip'.

Through close relationships, and equipment manufacturers have been able to harness the raw technology advances of their silicon suppliers to produce devices that so closely match the needs of the application that the resulting reduction in component count is nothing short of staggering. Truly, the era of system level integration is upon us.

To the user, the cost of this silicon technology in component terms is more than offset by the reduced cost in peripheral devices and offers a lower overall system cost. Yet lower component counts have benefits that extend from the goods inwards department, through reduced assembly and test costs, to improved reliability and, of course, greater compactness of the final system. Four areas have gained the most significant advantages of this trend: the computer industry, automotive electronics, communications and consumer electronics.

The most visible benefits of system integration in the computer industry have been in the field of graphics – now approaching almost photographic clarity, with video realism. Specialized processors such as TI's TMS340 have given graphics system designers the opportunity to exploit the flexibility of software, whilst maintaining the computation speed necessary to perform complex manipulations.

1988 has seen continued development and support for the first generation graphics processor. Software libraries have been extended to include support for industry standards in desktop publishing and communication of graphics data, as well as for personal computer standards such as IBM's 8514A graphics card. More significantly, the latter part of this year has seen the announcement of the first second-generation graphics processor: the TMS34020.

This enables the design of a high-performance graphics accelerator, capable of 3D graphics and costing less than $500. Graphics accelerators would be based on the powerful 32-bit processor coupled to a dedicated floating-point coprocessor. A typical system design with these components at its heart is illustrated opposite and has applications well outside the traditional workstation sphere. Laser printers, facsimile machines, copiers, avionics systems will be amongst the other beneficiaries.

Another area of the computer industry that semiconductor vendors have had to address is the problem caused by unparalleled improvement in central processing units. The execution speed of the current generation of cpus is no longer the governing factor in system performance, which is now often limited by d-ram timing capability. Data is being processed faster than it can be handled by mass storage devices.

This has led to the increasing popularity of cache schemes for data storage. In these, the data most frequently accessed is stored in memory set aside from the main memory. The processor gains faster access to data via the cache by first checking to see if it contains the data it needs. The vlsi logic devices known as cache tag comparators mop up the logic needed to perform this task. Such devices are now becoming available for most of the popular microprocessors.

Turning to automotive systems, the 1980s has seen an increasing reliance on electronics for various tasks within the vehicle. Ignition, engine monitoring and fuel injection systems are today being supplemented by electronic systems aimed at making cars more comfortable, safer and – through increasingly sophisticated entertainment systems – more fun. All have benefited from the reduced cost and improved reliability of microcontrollers.

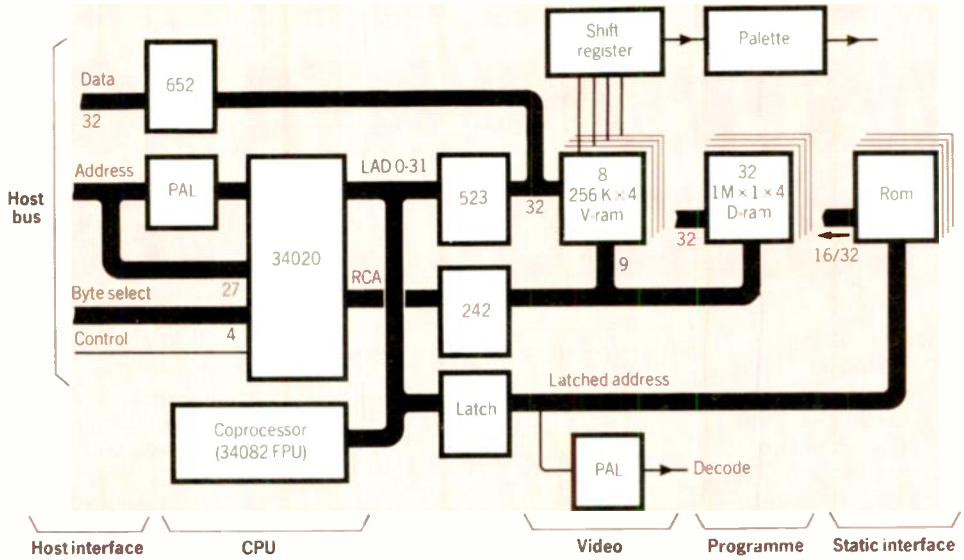
1988 may well prove to be one of the most significant years in terms of microcontroller evolution for the automotive domain. Whilst the early 1980s were dominated by eight-bit board-level controllers based on popular microprocessors, this year one of the major international car manufacturers has built its vehicle electronics around a single-chip microcontroller. TI's TMS370 was its choice – an eight-bit device that includes on-chip all of the peripheral functions that would normally be placed adjacently on a board.

Analogue-to-digital and digital-to-analogue conversion are on-chip. So are sophisticated timers, a watchdog, serial peripheral and serial communications interfaces. The controller can read values from temperature and pressure sensors, process the data and can display it through a digital display or via a pulse-width modulation output to the conventional type of dashboard.

Such facilities have been added in a modular way to an eight-bit processor core, so that designers need only ask for the peripheral functions they need. Rather than have to pick a particular device from the manufacturer's range that most closely meets his system requirements, a designer is now able to define exactly the microcontroller of his choice.

Also significant is the use of e-eprom on chip – a key technical achievement as well as one with immense practical uses. For example, engine management data (we used to call it tuning in the days when cars were built like musical instruments) can be stored in the e-eprom and adjusted for optimum performance as the car's mechanical components bed-in, age, wear and otherwise fall out of adjustment.

Further up-market, powerful digital signal processors have continued their contribution in the field of active suspension systems. The Lotus Formula 1 racing car



In this advanced graphics display based on Texas Instruments' second-generation graphics system processor (GSP), the TMS34020 is coupled to a new floating-point co-processor, TMS34082. Graphics co-processor operates at up to 40 Mflops and has been designed to interface directly with the 34020 address and data buses. In addition, the graphics processor is optimized for use with TI's 1Mbit video ram, taking advantage of advanced capabilities such as block-write, write-per-bit, enhanced page mode and split register reload.

pioneered the technique, in which transducer inputs from each wheel are fed to a 32-bit processor, which then controls servovalve actuators which dynamically adjust the ride of the car. These hydraulic systems replace conventional springs and dampers, producing safer handling and a fully adjustable ride over a wider dynamic range than is possible with conventional systems.

Volvo cars have experimented this year with a similar system – essentially as a research tool to investigate and tune the characteristics of traditional style suspension systems.

The technique has been developed for Lotus road cars and early in 1989 the first mass-production cars with such a system will roll onto American roads.

It is all made possible through the very high speed mathematical capabilities of the digital signal processor. Without it the system could not possibly perform the complex data manipulation required in real time.

Moving on to communications, the trend is toward ever faster data rates with increasingly complex capabilities for error correction as well as a growing amount of on-board intelligence. Again, digital signal processing chips provide a powerful core with the necessary capabilities for implementing filters and other mathematical processing.

The development of analogue functions in an application specific cell library (Linasic) is leading to reduced component counts in such systems. Indeed a V32 modem is being developed with just six components (right). Yet further space and cost reductions will come as dsps become a part of the standard asic cell library.

One of the most exciting opportunities in the consumer field will come as digital technology increasingly penetrates the video market. This year, a classic piece of system integration has borne fruit with the joint TI/Ferguson development of an application-specific i.c. to perform stereo sound decoding in tvs. A single chip now carries out decoding to nicam standards, where previously a board-full of components was required.

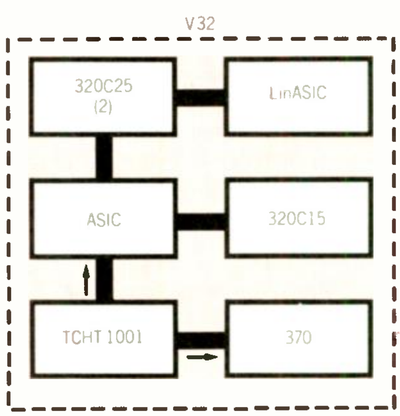
Another exciting development is expected to be in the field of video recorders. The need is to improve picture quality – involving better resolution coupled with image processing techniques. The technical demands are strenuous – such a system must be able to perform 500 million operations/s on a continuous data stream exceeding 15 million byte/s.

Multi-chip approaches using lsi will undoubtedly prove not to be cost-effective; which is why current development is focused on a massively parallel vector processor, capable of implementing digital algorithms on the video data.

TI envisages a single chip, integrating 768 1024-bit processors, depending on the broadcast standard. It would have 256Kbits of working memory on-chip and have embedded control algorithms, configurable by the designer. The chip will, of course, interface directly with the serial video data stream and support multiple frame store functions to carry out its task.

All the systems described are much more than conceptual ideas. They are active research and development projects – prompted by demands of the marketplace. Technology is not the barrier. It is the end market – the users of computers, cars, communications and consumer goods – that will decide whether they succeed or fail.

V32 modem using just six components. Linear application-specific integrated circuits could revolutionise the design of modems like this. In this diagram, digital signal-processing chips TMS320C25 provide the modem core. Also included is TI's recently-introduced modular eight-bit microcontroller, TMS370. Greater reductions of board space and cost will be possible when digital signal processor cores are built into an asic standard cell library.



By Peter Nicholson, Manager of Texas Instruments' Regional Technology Centre.

COST-EFFECTIVE INSTRUMENTATION CONTROL IN 1988

Recent developments in PC-based instrumentation have made available highly sophisticated systems which can offer users exceptional price/performance advantages as well as greater versatility in terms of expansion and reconfiguration than can be offered by dedicated test and measurement equipment.

The idea of using the power of the PC in conjunction with t & m instrumentation is not, of course, new. Just over six years ago, an American manufacturer hit on the idea of producing a PC expansion card which had all the attributes of a 50MHz storage oscilloscope. It was not, therefore, an instrument in the accepted sense of the word but it heralded the start of an entirely new approach to test and measurement.

Today, the plug-in card approach still remains popular but three further options are now available – instrumentation rack modules which can contain a combination of different PC-based instrument card stand-alone modules each with its own housing and power supply, and the linking up of standard instruments which can operate with the PC via standard interfaces.

In the last-mentioned area, where many users will have acquired a wide variety of instruments with the necessary interface requirements, the possibility of linking them into a suitable PC could be an attractive route into the PC t & m area, particularly with the decrease in PC prices which has come in parallel with increases in operating power at virtually no extra cost.

There are also other cost savings which arise from the elimination of such redundant pieces of equipment as displays, operator controls, printers, vdus etc.

Another point worth noting is that even if a new PC has to be purchased, it then becomes available for a wide variety of other applications – something that a piece of dedicated t & m equipment cannot offer.

However, in looking at the real cost benefits, there is one important cost area which must not be ignored – the software for running the required programmes. This should ideally be capable of expansion to cater for the regular addition of the further application programmes, likely to be required to meet changing needs. Even in this area there are aids to reducing costs, such as

The inroad of PCs as low-cost tools into virtually all engineering sectors has not excluded the area of test and measurement.

the Siemens programme generator which has been designed to help generate test programmes much more quickly than previously.

In addition to the more obvious advantages, there are virtually unlimited possibilities for processing measured values such as the generation of a wide range of statistics, analysis tables and diagrams, together with the filtering out of important parameters (e.g. limiting or peak values) from a data stream. And, by linking to a host computer via a local area network, it is possible to allow the transmission of data for long-term storage as well as the loading of test programmes.

The most significant benefit, however, must surely be that the power and speed of PCs will continue to progress into – as yet – undreamt of areas which will enable t & m to comfortably encompass the increasingly stringent demands as technology continues to race forward.

What, then, are the significant trends today?

For the user seeking high performance in a comparatively small unit, discrete instrument modules are the ideal answer. Siemens, a leader in this field, has promoted the fact that by putting each module in a separate housing with its own power supply they are all electrically isolated from each other; mutual interference and interference along a common device bus are avoided and, depending on the measurement conditions, optimal shielding and central earthing arrangements can be achieved.

Another useful aspect of such a system is that it does not restrict the provision of instruments which have the complexity and power demand by the market – unlike PC-cards where problems arise as to module size, the number of available slots, and/or overloading of the single power supply.

Already, it is possible to employ modules offering a choice of such 'instruments' as multimeters, universal counters, transient recorders, digital i/o units, function-pulse, generators, voltage/current calibrators and scanners.

When required, the IEC625 or IEEE488 bus with a standard instrumentation interface enables the user to drive a combination of PC-based and stand-alone instruments – all via the same interface.

It has become clear that the ultimate user acceptance of such PC-based instrumentation is conditional on the availability of software to simplify the task of accessing and exploit all the options offered by the PC.

Despite the computer revolution, however, it would be dangerous to assume a particular level of computer knowledge on the part of the user. That level could lie anywhere between no knowledge, to the extraordinary capabilities of the true computer "buff".

Operator input to computer systems has certainly undergone rapid change over the last few years – from using commands which were difficult to grasp, through plain English commands, to icon-based systems, which go some way toward meeting the needs of the user that is more interested in performing a task than learning how to service the computer system.

Dual benefit

Measurement technology can benefit in two distinct ways from the developments and experience in the field of PCs. Firstly, the user's measurement task is simplified by the ability to operate the instruments using PC software that relies on the operating philosophy of icon-based systems (Apple Macintosh, Smalltalk language, or the GEM graphics system, for example).

Secondly, the PC software has a familiar appearance to the vast number of people who are already acquainted with such systems on personal computers. This considerably alleviates the anxiety that may be generated by working with instruments that do not have any physical operator controls such as knobs or switches. They can also be reassured by the similarity between any Macintosh and GEM programms to those required for advanced PC-based instrumentation.

As an example, the software provided for the Siemens modules not only offers a uniform and friendly user interface – with all control via a mouse or the keyboard of the PC – but also provides software toleration of user errors to prevent incorrect setting up.

Communication between the PC and PC-based instruments can take place on any of three levels:

- interactive mode
- free programming and
- automatic programme generation.

The first enables the user to prescribe the setting of the PC-based instruments, initiate measurements, or request a display of the result of the measurements. The second allows the setting up of instruments in the same way as a stand-alone unit using IEC bus commands. The third enables users with no experience of IEC programming to simply specify the instrument settings required in their correct sequence according to the programme to be executed. The programme generator will then produce a suitable programme. There is also a facility enabling existing programmes for IEC bus units to be easily merged into these or other programmes.

A modern system of instrumentation is an information system providing details of the characteristics and status of a technical environment. As well as providing the detailed information, the instrumentation system processes it to produce results of varying complexity. Because it may be necessary to pass on these results in an appropriate form, instruments must be capable of being integrated into a system.

The term "integrated instrumentation" encompasses the means by which physical values are measured, items of information processed, and communication with higher level data networks effected. It is an area which has two aspects – integration of various methods and integration of the instruments. This involves the integration of knowledge from the fields of instrumentation technology, systems theory and information processing. It must also include specific product knowledge together with a link-up to the information flows required in manufacturing.

Advances in microelectronics, sensor technology, systems theory and, not least, in information technology, have made it possible to implement completely new forms of measuring and testing concepts. Economically-priced microprocessors and signal processors with enormous computational power have mastered complex signal processing tasks.

Through the development of new sensors, semiconductor and optical, it is now possible to determine physical quantities that previously would have been difficult or impossible to measure. It is possible to make integral sensors containing both the sensing component and the electronics required for processing resulting data, thus making extremely compact transducers available.

From research into the field of artificial intelligence, two practically applicable developments have emerged – knowledge-based systems and expert systems. Among other applications, these tools can be used for fault diagnostics and now form an area of considerable interest within instrumentation technology. We see, therefore, developments which can employ the increasing power of the PC to remarkable advantage. Within five years, we could be measuring the values of occurences which today may be virtually, or indeed completely, unknown to us. The years ahead will undoubtedly take us into realms of t & m that, in terms of existing capabilities, would be extremely difficult to comprehend but will nevertheless continue to provide the challenges and excitement that today's new and radical developments already offer.

Tony Leach acknowledges the help and encouragement provided by Siemens engineers in the preparation of this article. He is marketing manager at STC Instrument Services, Dewar House, Central Road, Harlow, Essex.

Front panels of PC instruments are uncluttered by controls because parameters are software selectable over the 488 interface bus.

ENHANCED PULSE MEASUREMENT USING VXI-BASED INSTRUMENTS

How to get your instrument's time delays down to nanoseconds.

Automatic test equipment of one form or another has been around for over twenty years. Early systems utilised b.c.d. programmable instruments and had to make do with a great deal of human intervention. The establishment of the IEEE 488 brought about a revolution in a.t.e. design; sysem integrators no longer needed to be instrumentation specialists, which could now be left to the dedicated instrumentation specialists. Off-the-shelf instruments were now available with a standard communications control interface. The systems integrator could at last get down to the real problems of writing software and configuring the system.

Device-under-test interfacing and signal interfacing became one of the biggest headaches for the systems integrator. D.u.t. interfacing is between the device under test and the a.t.e. system, and the signal interfacing is the routing of signals between instruments, both measurement and stimulus. The interfacing to the computer controller was of course resolved with the advent of IEEE 488.

The first problem, that of interfacing between instruments and d.u.t., has very nearly been resolved for military applications by the interface connector assembly.

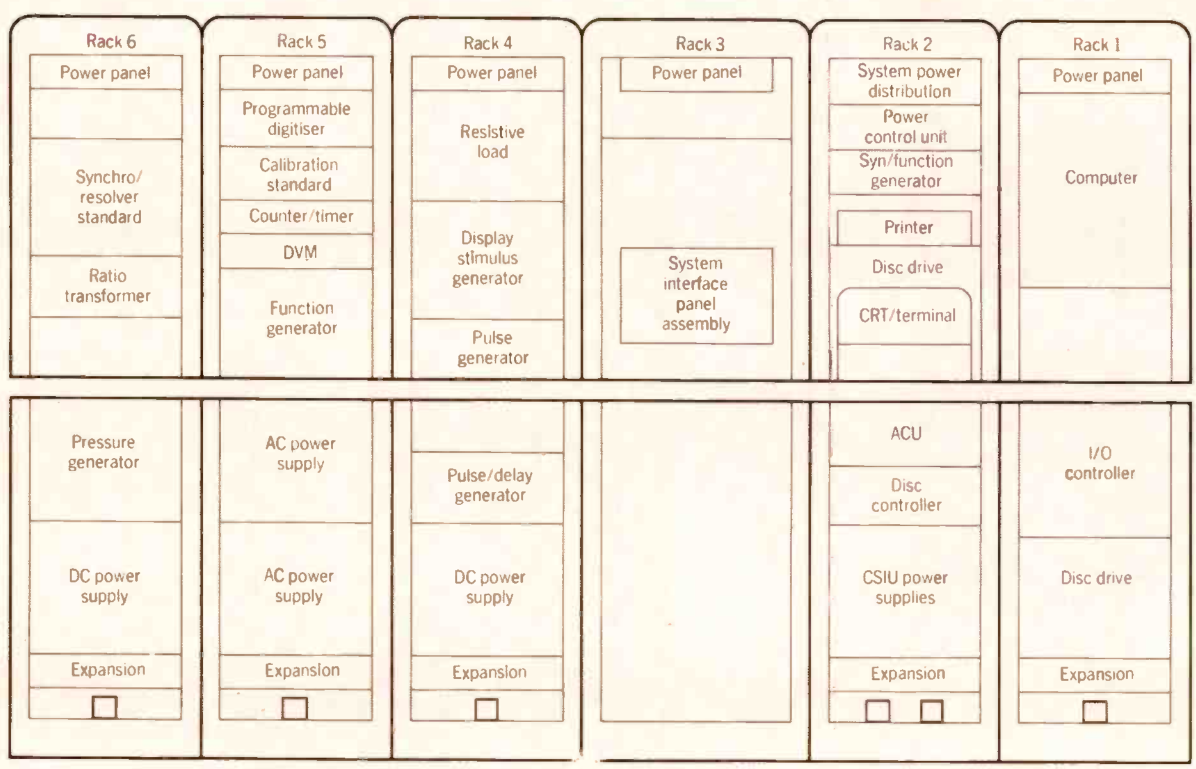
Instrument-to-instrument interfacing

What are the problems of instrument-to-instrument interfacing? The most serious is that of timing between instruments, often referred to as "the orchestration of the instrument suite". Consider a large a.t.e. for testing avionics (including radar), as shown in the diagram below.

Notice that the pulse and delay generators are as close to each other as possible, and close to the d.u.t. interface so that in theory synchronization pulses have minimum lengths to travel and minimum differential lengths. On closer examination, the critical pulse generation and measurement instruments cable lengths present significant problems. The diagram opposite shows how the cable is routed between instruments in a test rack: it is not just a simple matter of a short interconnection between the two units. Cable retractors and rack-to-rack wiring add many feet of cable.

Unwanted timing delays

Why are the lengths of these cables so important? To synchronize pulse generators and arm counter/timers coax cables are used



to connect them to each other, and unfortunately, it takes a finite time for a pulse to travel down a cable. In free space an electromagnetic wave travels at 3×10^{10}cm/s, so to travel 30cm it will take 1ns. Coaxial cable, however, slows down the e.m. wave, nominally by a factor of 0.66 (velocity factor for solid dielectric coax cable). It will thus take approximately 1.5ns to travel 30cm.

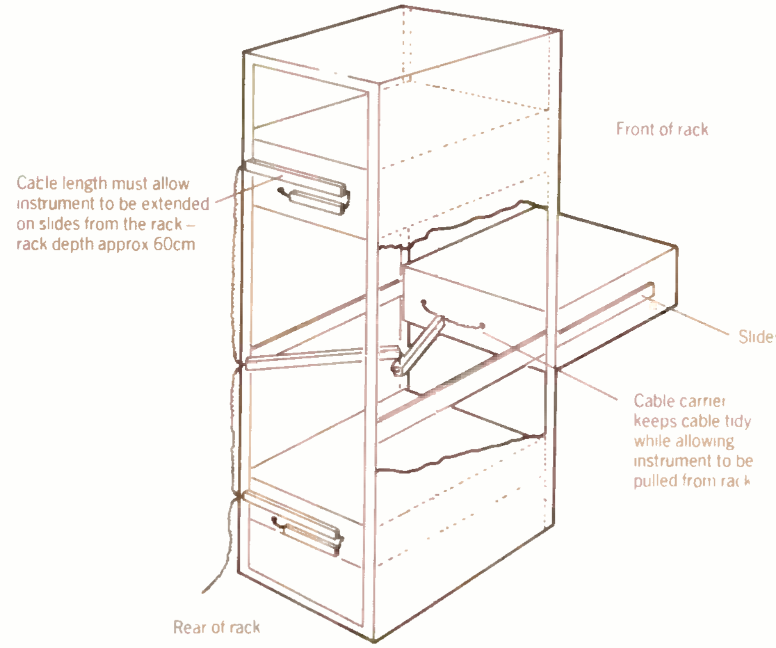
The time delay, when connecting two instruments mounted close together, say with 2 metres of cable, can add up to 10ns. In modern radar environments, this is unacceptable. In medium to long-range radars, where the radar pulse is between 1 and 10μs long and ranges are in excess of 100m these instrument-to-instrument delays have never been considered a problem.

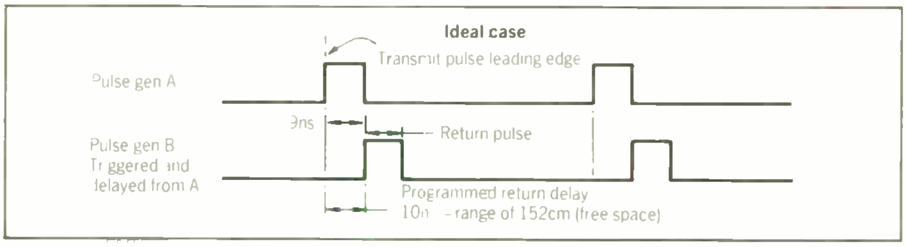
But today busy airfield ground-movement radars need to resolve to tens of centimetres and automatic aircraft carrier landing systems need control to within metres.

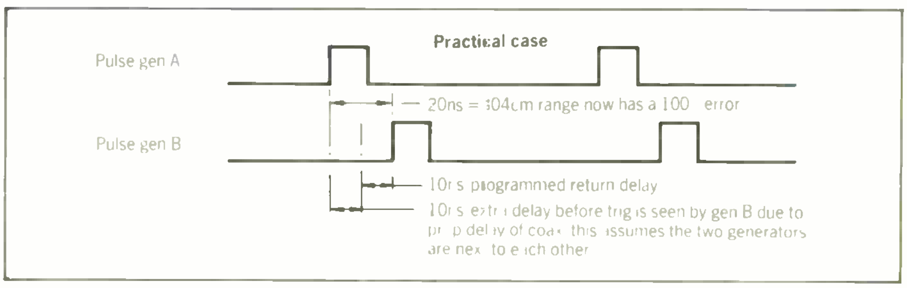
The radar pulse simulation diagrams show the ideal case for a radar simulator. Pulse generator A is triggered and a sync pulse is fed to generator B for delay of simulated return pulse. In the radar system, the delay between the transmit pulse and receive echo is primarily a function of range. In the ideal case, this range can be programmed into pulse generator B. There is now a delay to be considered, between the trigger out from generator A and the input into generator B, due to the propagation delay along the interconnecting cable. In the case described this will introduce an additional delay of 10ns. On a medium to long-range radar, this extra delay would only introduce, at the most a 0.1% error. However, for radars requiring resolution down to 30cm and operating in the tens of nanosecond area, the cable delay introduce a 100% error.

Accurate timing measurements of these pulses is also a problem as cable lengths to inputs A and B on a timer/counter must be matched.

All these errors can be removed through calibration and software correction, however, this creates more software overhead and increases the test time.







The solution

An environment that allows the critical pulse generation and measurement instruments to sit far closer together is bound to reduce the time delay problems. Instruments-on-a-card and the VXI concept take care of this problem in more than one way.

The VXI chassis allows for 12 instruments, plus a slot-0 controller to have inter-module spacing of only 3.05 cm. Pulse generators and counter/timers arranged in adjacent slots can now offer transmission time delays of <0.25ns. Even when mounting two pulse generators at extremes of the cage and placing the counter equidistance from both, the worse delay would be 2ns.

The VXI system specification, Revision 1.2* defines clocks, syncs triggers, start-stop signals and their timing relationship. The P2 connector on a VXI chassis delivers resources to modules particularly oriented to instrumentation. P2 as well as all of P1, retain their basic VME functions. P2 in addition adds:

- ★ −5.2V, −2V, ±24V and additional +5V power
- ★ 10MHz differential clock
- ★ six parallel e.c.l. trigger lines.
- ★ eight parallel t.t.l. trigger lines.
- ★ module indentification pin.
- ★ 12 lines of manufacturer defined local bus lines that connect to adjacent modules.
- ★ 50-ohm terminated analogue summing bus.

For even higher performance, P3 provides more capability:

- ★ additional +5V, −5.2V, ±24V, −2V, and ±12V power.
- ★ 100MHz differential clock which is synchronous with the P2 10MHz clock.
- ★ synchronizing signal for 100MHz clock edge selection.
- ★ four additional e.c.l. trigger lines.
- ★ 24 additional local bus lines, for a total of 6.
- ★ 'star trigger' lines for precision module-to-module timing.

For instance, CLK100 on P3 is defined in the VXI specification as follows: "The CLK 100 and SYNC100 backplane distribution network MUST NOT insert more than 2.0ns timing skew between CLK100 and SYNC100 at any slot." The specification also states that "the trace lengths should be matched to within 1ns." Manufacturers of VXI chassis may wish to provide better performance depending on the application, but the worst case is defined, and is a lot tighter than that in the rack-and-stack system.

Thanks to Jill Fuller, VXI product specialist, with Racal Dana for help with the preparation of this article.

*VXIbus Consortium VMEbus Extensions for Instrumentation, VXIbus System Specification, Revision 1.2, June 21st 1988, is available from Racal Dana Instruments Ltd.

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last February's Industry Insight, and is fully compatible with both the VMEbus and Eurocard standards.

The extended performance features of the VXI-defined P3 connector include a 100 MHz clock and synchronization signal, 36-high speed local bus lines for card-to-card communication, and the Starbus for precisely matched trigger timing between modules, regardless of their relative positions within the chassis. Test systems built using the system will allow data to be transferred between adjacent modules or instruments at speeds of up to 1GHz over the local bus. This is four times faster than the data transfer speeds available with VXI products using C-size cards and the local bus available on the P2 connector. High-speed data transfer can occur between several modules simultaneously, thereby allowing private communication between modules. As this data transfer occurs on a dedicated local bus, system buses (VMEbus, trigger bus and analogue bus) are not occupied and can be used for other tasks.

Signals exceeding 250MHz can be routed over the development system's starbus, which provides two private, bidirectional, differential e.c.l. lines between instrument modules and slot 0 of the D-size mainframe. Each module within the mainframe appears equidistant from slot 0, allowing precisely matched trigger timing regardless of the module position in the chassis so that high frequency clocks can be distributed to multiple instrument modules without the need for multiple clock drivers.

The development system is suited to commercial applications in research, development, manufacturing, and for a.t.e. system integration where automatic testing needs surpass the capabilities of the 488 technology. Military prime contractors who typically build and use high-speed functional testers of electronic circuit boards, hybrids, subassembles and final products, will use the development system or its components for early custom VXI card development, and as a base for future test systems.

● More recently, the company announced its first three VXI 'instruments on a card' – a waveform digitizer, arbitrary waveform generator for D-size mainframes, and a scanner controller card that links VXI systems to its line of a.t.e. switching products. Announced at Autotestcon, New York, in early October, the new Tek VXI products are:

Dual-channel waveform digitizer with 8bit vertical resolution, 250 MHz analogue bandwidth, up to 200 MS/s, programmable record lengths of 16 kbyte per channel, internal waveform storage with memory partitioning, P3 functions including Starbus triggering and extended start/stop, and internal waveform functions that include parametric analysis, timing measurements, waveform math and waveform processing in a VXI D-size module.

Arbitrary waveform generator for custom waveforms up to 100 MS/s at frequencies from 0.01 to 26 MHz. It has 10-bit amplitude resolution, 128 kword of reconfigurable waveform memory, and extensive trigger sources and modes using the advanced VXI P3 features available to a D-size module.

Scanner controller interfacing four to eight scanner modules with signal switching requirements from high power d.c. to microwave signals, 32-bit bi-directional t.t.l. lines per port for digital i/o, power for up to 12 probes, test sequence storage for 500 steps per port, and alias naming for complex switch paths. The scanner controller is packaged in a C-size module.

All three products operate in Tektronix' VXI1500 D-size mainframe and VX7501 Development System for building 'instruments on a card' and functional test systems. In addition, the VXI products comply with all aspects of the VXIbus specification Rev 1.2, making them easy to integrate into multi-vendor VXIbus systems.

ALVEY'S FINAL PHASE

In January's issue Rob Morland, director of the Alvey v.l.s.i. programme, looks back on what has been achieved so far and also looks forward to the future with a new programme and a new organisational framework. Here we extract essential features of the updated summary chart which highlights the v.l.s.i. bipolar and cmos projects.

ALVEY VLSI PROCESS SUMMARY UPDATED FROM NOVEMBER 1987 ISSUE

Technology	Bipolar CDI		UHS	Complementary m o s Digital		Digital		Analogue	SOS*	
Participants	Plessey semi-conductors		Plessey Research So'ton, Oxford Univs	British Aerospace Racal STC		Plessey Research GEC Research		MEDL Plessey Research	GEC Research RSRE MEDL	
Minimum feature size (micron)	1.2	0.8	1.0	1.25	1.0	1.5	1.0	1.5	1.5	1.0
Maximum toggle frequency (MHz)	650	1200	11000	165	210	450	300	375	410	600
Effective circuit (logic gates/cm^2)	5×10^4	2.2×10^5	3.6×10^4	8×10^4	1×10^5	1.6×10^5	5.2×10^5	1.8×10^5	2.25×10^5	6.25×10^5
Figure of merit (gate Hz/cm^2)	3.2×10^{13}	2.6×10^{14}	4×10^{14}	1.3×10^{14}	2.1×10^{13}	7.2×10^{13}	5.6×10^{14}	6.7×10^{13}	9.2×10^{13}	3.8×10^{14}
prototype silicon	July 1987	July 1988	June 1987	Mar 1987	Dec 1989	Feb 1987	June 1988	Dec 1987	June 1988	Oct 1989
production	April 1988	Dec 1989	Oct 1987	July 1987	June 1990	Oct 1987	April 1989	Sept 1988	Mar 1989	Mar 1991

*Radiation sensitivity: transient upset = 10^2rad/s

Having chosen a computer, one would then have:

C A formal description of the hardware and its response to every possible combination of inputs and instructions.

D A compiler to turn the language of B into machine code for C, with a proof of correspondence between source and object programme, for every construct of the language.

Once the programs are complete there will be:

E An operational program with proofs that both source and object programs conform to the original requirement, A above.

The real world is not like this. Scientifically, not enough is known yet to make the steps A to E above totally feasible, although the position will improve steadily as more results are achieved in the various research programmes which are under way. To guide the designers of safety-critical military equipment in the 1990s, MoD is in the process of preparing a new Defence Standard, number 00-55, which will describe in detail how far the above points can be satisfied, within the limits of current scientific knowledge and industrial capabilities.

The Viper microprocessor, its related means for the development of safe software and the associated prototyping hardware is an integral part of this quest for ever safer systems. Though produced by a MoD research establishment in association with contractors and licensees, it is a central feature of the overall policy that all of the work and its products are available for use immediately in civil projects where computers may threaten human life in the event of design errors.

Thanks to Charter Technologies of Worcester for help in the preparation of this article. Charter leads the group promoting the use of viper technology, which include MEDL at Lincoln, Rex, Thompson & Partners of Farnham, Program Validation of Southampton, and Praxis of Bath, as well as Charter and associate Viper Technologies, and RSRE. Rolls Royce Associates and Plessey Semiconductors are also expected to join the group.

DUAL-WAVELENGTH TIME-DOMAIN REFLECTOMETER

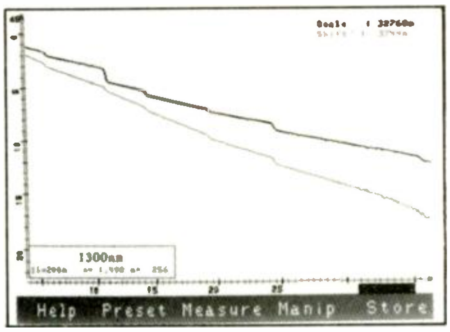
A recent survey of the European fibre optic scene high-lighted some forthcoming changes in the market. Until recently long-haul installations have consumed a high percentage of fibre, but this market is due to decline within the next five years as many countries complete their long-haul networks. Telephony will, however, remain the largest application throughout the nineties as fibre moves into feeder routes and the subscriber 100p. Fastest growing markets will be datacomms, video communications and military applications.

It is predicted that sales of test equipment will reflect these trends, with increasing demand arising from developments in fibre optic lans and from contractors to military markets more than compensating for decline in demand from long-haul contractors. The optical time domain reflectometer will continue to be the system installer's basic measurement tool and the market's major product segment.

The 7727 being marketed by Schlumberger Instruments is the latest in a range which has achieved success through a combination of automatic measurement capability with large dynamic range and compact 'all-in' packaging. This is the first in the range to feature dual-wavelength capability, and the first on the market to offer performance in a dual-wavelength instrument comparable to single-wavelength instruments. Schlumberger say they have this by careful selection of the laser and photodiode and novel setup of the coupler.

The 7727 evaluates fibres at 1300 and 1500nm, an extremely useful feature in testing of single-mode links. The instrument completely characterizes the fibre at 1300 and 1500nm under the same injection conditions, confirming the quality of transmission at both wavelengths – important in multiplexing applications. Some defects are wavelength-dependent, so this tester can show up weak points that may remain undetected in a single-wavelength test. The wavelength is directly switchable from the front panel or over the IEEE488 interface.

The essential design objective was to produce a compact instrument offering high measurement performance combined with



ease of use. High performance implies large dynamic range, good spatial resolution and linearity, obtained by generating low-width, high-amplitude pulses within a perfectly linear system.

Schlumberger achieved these design criteria with following:

- Using a p-i-n photodiode with high linearity. The gain of this type of photodiode is very much lower than that of an avalanche diode. A high-performance amplifer is therefore required with a very high gain/bandwidth product, and with perfect linearity to preserve the advantages of using the p-i-n photodiode.
- Using electronic masking to combat the effects of highly-reflective defects. Optical masking carries the drawback that a preliminary measurement must be made to determine points of high reflectivity, followed by positioning of the mask and further measurements. In addition, the optical mask is controlled by an r.f. power control which can interfere with the measurement system at the time of reconnection. Electronic masking uses a limitation system designed to provide a short path through a diode for the large number of carriers released by highly-reflective defects, and operates completely automatically.
- Introducing a quiescent point check enabling compensation for drift in the amplifier components.
- Complementing the limitation system with a disconnection system to protect the amplifier stages from saturation and enable the system to work perfectly even in the presence of highly reflective defects.
- 14-bit analogue-to-digital conversion, enabling the full dynamic range of the instrument to be utilised (26dB for 1550nm, 28dB for 1300nm fibres). Averaging is performed on 32bits and the averaging process is hardwired, enabling the microprocessor to simultaneously perform other tasks. Accumulation is performed over the entire range of the instrument; it is of fundamental importance to the correct operation of the 'noise rejection by accumulation' principle that this is performed in the linear domain prior to taking the logarithm. Whatever the original signal the logarithm is taken to an accuracy of 0.01dB.

The processing capability which enables totally automatic measurement is unique to Schlumberger's o.t.d.rs and allows complete characterization of the link in just a few seconds by pressing a button. Time to connect the fibre, capture and process the data is about two minutes – up to ten times faster than measurement by conventional test methods. For both-ends measurement the average value is determined automatically, and users are presented with an average curve rather than the averages of results, giving unrivalled measurement accuracy. For comparison of current and historical data two curves can be superimposed on the screen. Disc storage may be used to save acquisition points for subsequent processing of the curves.

The two-instruments-in-one 7727 is priced at £22,990, which includes a built-in printer, internal memory, IEEE 488 and RS232C interfaces, 12Vd.c. input, and a range of optical connection accessories.

For further information contact Philippe Guerineau, Schlumberger Instruments, Victoria Road, Farnborough, Hants GU14 7PW. Tel: (0252) 544433.

RESEARCH NOTES

Plastic chips are here

No, I'm not 20 years behind the times and I'm not referring just to the encapsulation. A team at the Cavendish Laboratory in Cambridge reports success (*Nature* vol.334, no 6186) in fabricating high-performance diodes and transistors from the organic polymer polyacetylene. Richard Friend and his colleagues have used a preparation technique developed at the University of Durham to prepare working devices from this, the simplest of all conducting polymers.

In an accompanying comment, Professor David Bloor of Queen Mary College, London, says that the performance of the Cambridge group's diodes and transistors is several orders of magnitude better than any previously reported organic devices. And whilst they are not yet ready to replace inorganic semiconductors, this improvement in performance does open the way to the construction of devices that could not be made from inorganic materials such as silicon or III–V alloys.

Although organic polymers exist with electrical conductivities rivalling those of metals, attempts to make electronic devices from them have in the past been frustrated by difficulties in the chemical processing and manipulation of the polymer materials. Also, as Friend points out, there remains considerable doubt as to whether it is possible or appropriate to make use of modes of operation employed with conventional inorganic materials.

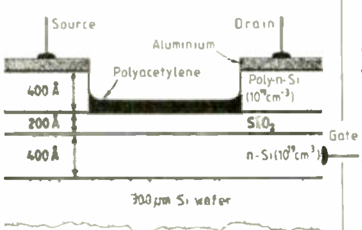
Up till now the work has largely been limited to p-n and Schottky diodes exhibiting forward/reverse conductivity ratios of no more than a few hundred. Misfet (metal-insulator-semiconductor fet) structures using polymers have also been attempted in Japan.

The chemical processing techniques developed at Durham are complex, but essentially allow the production of thin films of p-doped polyacetylene with very low levels of residual oxygen. From this material the Cambridge team have fabricated Schottky diodes, mis diodes and misfets. For the Schottky diodes they are now routinely able to measure forward/reverse conductivity ratios of 5×10^5. As for misfets, almost textbook performance has been achieved from a device (below) in which the polyacetylene channel is accessed via polysilicon source and drain contacts.

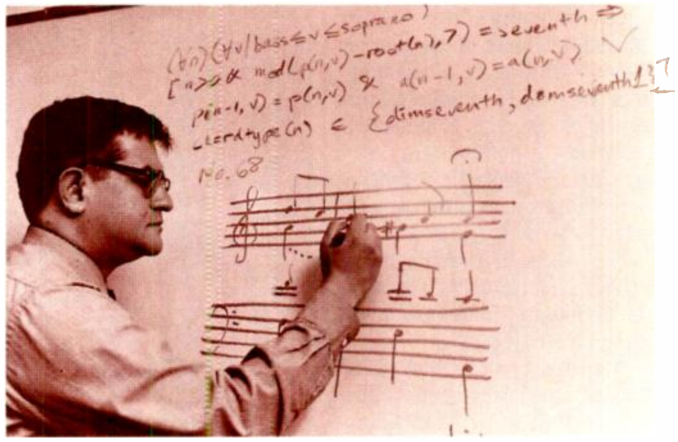
The mode of operation is novel, since charge is not stored in the usual form of electrons and holes. Instead there exist what are referred to as soliton-like excitations of the polymer chemical chain. Evidence for this comes from expectedly large changes in the optical properties of the polyacetylene as an electric field is applied to its surface.

These opto-electric effects are in themselves interesting because of the possibility of being able to exploit them deliberately in the design of optical modulators for computing and other applications.

All in all, this latest work suggests that more-or-less wholly plastic devices are likely to feature in commercial service for at least some specialized applications in the not-too-distant future.



Even more switched-on Bach



Kemal Ebcioglu of IBM explains the harmonization added to Bach's Chorale No 68 through the application of his expert system and the mathematically-expressed rule seen above the notes.

IBM researcher Kemal Ebcioglu has designed an expert system for harmonizing music. Choral, as the experimental program is known, adds bass, tenor and alto parts to chorale melodies and produces four-part scores in conventional music notation that can be read on a computer terminal screen, printed and performed.

Ebcioglu used chorale harmonizations by Bach as the primary source for developing the knowledge base of his expert system. This contains more than 350 rules divided into groups that observe the chorale from multiple viewpoints, such as the harmonic outline of the chorale and the individual melodic lines of the voices.

One of the interesting features of the program is an intelligent generate-and-test algorithm, a set of instructions, that incrementally constructs the harmonization of the melody according to a larger set of rules. The harmonization is built stage by stage. Choral backtracks and changes notes that it considers to be responsible when a dead-end is encountered, just as if it were negotiating a maze and had run into a wall. This is necessary because rules are not by themselves sufficient for producing beautiful music. Composers use additional knowledge – what we call talent – for choosing among the many possible extensions of a partial composition at each stage in the process. Translating "talent" into an algorithm would be an impossible task, though Ebcioglu has learned that a large number of precise, style-specific recommendations can provide a good approximation.

Choral uses an extensive base of style recommendations about which notes or chords to choose among the many musically correct possibilities at each stage of the harmonization. Ebcioglu designed Backtracking Specification Language (BSL) to reduce the number of instructions and consequently the processing time to complete a chorale harmonization. Using BSL, a chorale harmonization requires about 30 minutes on an IBM mainframe processor. During this time, the mainframe executes about 23×10^9 instructions.

The acid test, of course, is the quality of the resulting music. And while it is unlikely that Choral or any other expert system could rival the real Bach, it would probably, according to Ecbioglu, receive an above-average to excellent grade in a university composition class.

New buzz for magneto-striction

Magnetostriction, considered by most engineers to be something of a curse, is the subject of an important feasibility study now being undertaken at the British Non-Ferrous Metals Technology Centre at Wantage. Magnetostriction is the property by which magnetic materials change their dimensions when they become magnetized. Although the relative change is rarely more than three parts in 10^5 it has the annoying effect of making mains transformers hum and television sets whistle.

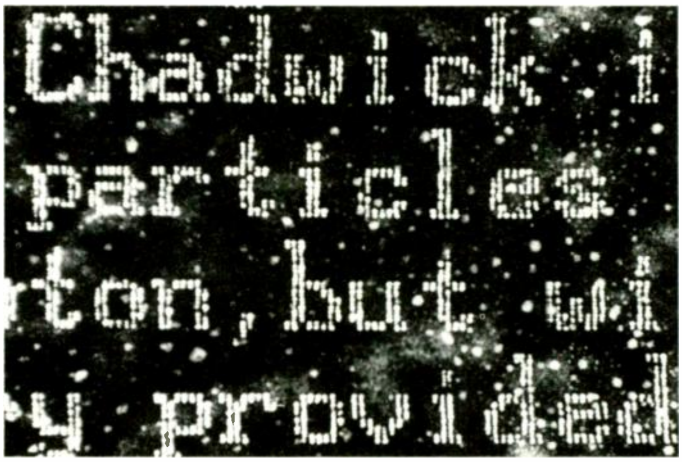
Yet magnetostriction has an enormous range of actual and potential uses. Ultrasonic transducers are but one example. The trouble is that with conventional metals the dimensional change is not enough to allow the construction of powerful and yet compact devices.

In the last decade, however, researchers in Britain and the USA have discovered a range of what are called 'giant' magnetostrictive materials, the best-known being an alloy of iron with the rare earth element, terbium. This material, $TbFe_2$, exhibits a degree of magnetostriction almost two orders of magnitude greater than any pure element. Other new giant magnetostrictive materials are composites, based on dispersions of iron particles in synthetic rubbers. These can grow as much as one part in 200 when magnetized.

The causes of the magnetostrictive effect are not yet fully understood in these new materials, though two different mechanisms are thought to be involved. One is a bulk effect due to the action of demagnetizing fields while the other, less well understood, mechanism is a consequence of interactions between magnetic dipoles at the molecular level.

BNFTC, which is coordinating a research programme involving universities, polytechnics and a number of companies, sees a great future for magnetostrictive materials in a whole range of practical applications. Because large forces can be generated there are obvious uses in vibration testing, machining, cleaning and impulse tools. Rapid response time also means that transducers based on giant magnetostrictive materials are good candidates for microphones and loudspeakers that will work well into the ultrasonic range. A high inherent coupling coefficient also means that acoustic energy can be efficiently transferred directly to where it is needed at larger power levels.

BNFTC and its collaborators are now engaged in the development of cheap magnetostrictive materials that will satisfy all the necessary practical criteria for use in a range of specific applications.



Encyclopedia entry on "neutron" as cut into an alumina substrate. Holes are approximately the diameter of two atoms. Photograph by courtesy of the University of Liverpool.

Atom-sized holes never forget

Drilling a hole of atomic dimensions – that's roughly 10^{-9}m in diameter – is a mind-boggling achievement. But it's now almost a routine operation at Liverpool University thanks to a unique combination of an electron microscope and a computer.

Professor Colin Humphreys and his colleagues are using an advanced electron microscope in which a fine beam of electrons is steered by a computer over the surface of a specimen and used to punch holes in it. The team has found that whereas the metals used to coat specimens for conventional electron microscopy are immune to the effects of an electron beam and simply reflect it, other materials are easily perforated. Common salt, ceramics and some semiconductors are examples of materials that can easily be drilled with an electron beam.

Precisely how the electron beam drills its way through these materials is a mystery. It certainly doesn't do it by melting, as would be the case with a laser beam. In fact, the cooler the specimen, the faster it can be drilled. Another curiosity is that a round electron beam sometimes drills square or triangular holes. But by far the most bizarre discovery is the way the hole is actually cut. In the case of crystalline aluminium oxide, for example, the hole begins to appear on both sides of the specimen at once, whilst in amorphous aluminium oxide the hole begins to appear as a bubble at the centre of the material which then breaks open to both surfaces.

Using computer control to steer the electron beam allows the equipment to cut larger holes to virtually any shape. Large is of course a relative term as such complex holes are still only the size of molecules. This makes it possible, using the electron microscope, to cut holes exactly the shape of a protein molecule or perhaps a virus. A larger piece of material with several such holes could therefore conceivably be used as a sort of sieve to strain out – and hence purify – such commodities.

The possible applications of atom-sized holes to data storage is equally exciting. Holes a billionth of a metre in diameter are roughly a thousand times smaller than the pits or holes on a Compact Disc or the memory cells on advanced l.s.i. chips. Ceramic materials also offer a degree of permanence unrivalled among existing storage media. As for storage density, thirty encyclopedias on a pinhead would certainly be possible. Or on a larger scale, all the world's libraries could be held in a single machine. And, though an electron microscope would be needed to read the material, it would still be cheap compared to the cost of storing the equivalent number of books in more conventional ways.

Memories – do they radiate?

How private are our thoughts? Not very, if you take seriously some recent research at Princeton University. Robert Jahn is Professor of Aerospace Sciences but, since 1979, has also been director of the PEAR programme. PEAR is an acronym for Princeton Engineering Anomalies Research, a body set up to carry out scientific studies into the quantifiable aspects of psychic phenomena. These in practice include extra-sensory perception (e.s.p.) and psychokinesis.

In a recent paper (*Phys. Bull.* 39, 1988) Jahn lists some of the work done at PEAR and elsewhere and offers a few theories to explain such bizarre effects.

Psychokinesis, because it involves the exercise of mind over matter, is the easiest psychic phenomenon to investigate, and also the easiest to quantify. One way this has been done in the PEAR laboratory is to get people to try and influence – by pure thought – the behaviour of a random pulse generator.

Jahn and his colleagues set up an electronic device designed to produce noughts and ones in random sequence. By the normal rules of chance, this generator occasionally produces regularly alternating sequences, i.e. 010101 etc. Experimental subjects were then asked to concentrate their minds on the black box to make it generate more of these alternating sequences.

Needless to say, no-one succeeded in making the behaviour of the generator totally regular. But when huge numbers of tests were analysed, there certainly did seem to be a statistically significant effect. Equally significant – or so it appeared – were the results of tests into e.s.p., often over distances extending from one country to another. The paper describes a quite astonishing example in which a subject was asked to describe a scene in the mind of someone several thousand miles away. This was done with remarkable accuracy.

As a professional engineer, Jahn is no mystic; nor can he explain these phenomena on the basis of classical physics. Instead he wonders if we can think of consciousness by analogy with the wave/particle duality of electromagnetic radiation. In the same way that a photon has no definite boundary, but extends to infinity, Jahn considers that thoughts may not only be trapped inside our heads, but may be capable of impinging on someone else's consciousness or perhaps on a machine.

Although no detailed hypotheses is offered, Jahn is convinced that the evidence warrants further investigation. Just imagine the benefits of being able, by thought alone, to influence the sequence of noughts and ones in your competitor's mainframe!

Research Notes is written by John Wilson of the BBC World Service's science unit.

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S.s.b. on h.f. – but when?

"The possible adoption of s.s.b. broadcasting is like high-definition television (h.d.tv) – a good idea but nobody knows how they are going to do it", suggested S. D. Pace (Marconi) at IBC88. Although it has now been recommended that the transition to s.s.b. should begin immediately, with d.s.b. transmissions ceasing altogether by the year 2015, "there is the risk that in prematurely switching to the proposed system, which has been subject to only limited trials, the overall situation (increasing frequency congestion of the h.f. broadcasting bands) will not be improved... the enormous number of conventional receivers currently in service precludes any sudden changeover".

The present proposal is that initially the carrier should be reduced by only 6dB relative to peak carrier and subsequently by 12dB. Diminished carrier transmissions would be receivable with envelope detection but both receivers and transmitters would introduce a significant amount of third-harmonic distortion. There is the further problem that the heavy audio processing used on current d.s.b. signals, greatly boosting the average modulation index, could prove counter-productive on s.s.b.

Marconi engineers claim that the only current transmitters capable of efficiently amplifying s.s.b. signals at high enough peak power are likely to be those using the various forms of series switching modulators, such as the Advanced Pulsam system now used on Marconi high-power transmitters. In tests, such transmitters have been shown to be capable of delivering hundreds of kilowatts peak envelope power, far in excess of the capability of any existing h.f. linear amplifiers, with an efficiency only recently attainable on conventional d.s.b. transmission: "Nevertheless the peculiarities and limitations of such systems need to be at least appreciated by both broadcasters and the international authorities. It must be remembered that within barely two years, given the existing WARC (ITU) recommendations, all new transmitters may have to be capable of s.s.b. operation." Clearly, the engineers believe that more extensive trials and the development of new transmitter measurement and test techniques are needed before there is a mandatory requirement for s.s.b. operation or capability, despite the good performance in this mode of series switching modulators.

Mast hazards

With 24-hour services now increasingly common for radio and television broadcasting, it is becoming difficult to carry out maintenance of antennas, masts and towers without lengthy interruptions and without subjecting riggers to unduly high r.f. fields. Recently, riggers have been climbing masts at the crack of dawn in summer, but now there are virtually no daylight hours in which maintenance can be carried out without affecting some viewers or listeners.

While broadcasters have always followed the safety guidelines for non-ionizing radiation hazards, the American ANSI guidelines of 1984 introduced lower limits for frequencies between 30 and 1000MHz and it is likely that by the time these notes are published the new guidelines of the International Radiation Protection Association (IRPA) will have been confirmed, extending the lower levels to frequencies between 10 and 30MHz.

As a BBC paper at IBC88 made clear, it is extremely difficult to measure accurately the power density within the near field of an antenna, where the electric (E) field and the magnetic (H) field differ widely. For television and f.m. radio, the main practical problem arises where riggers need to climb through several antenna stacks or where there is a question of working on a split stack with the other half, or a stand-by antenna, powered.

G. E. Hatfield (Telecom Australia) described the steps taken by Telecom to keep exposure of staff, contractors and the public to radiation as low as reasonably achievable, including the identification of "hot spots", and the issuing of training and safety publications. For h.f. broadcasting there is the additional problem of strong E fields near open-wire transmission lines.

The BBC recognizes the controversial nature of the large number of reports of athermal effects and considers that "any link between e.m. radiation and cancer has yet to be established", but sees that there is pressure to recognize the possibility of harmful athermal effects and reflect them in safety standards particularly where the public is concerned.

Radio digits

At IBC88, BBC engineers admitted that "Despite the fairly rapid growth of digital audio broadcasting equipment, the integration of such equipment into the broadcasting environment has been very slow. Until recently, certainly within the BBC, audio equipment which employs digital signal processing (d.s.p.) has almost invariably been connected to the rest of the system via its analogue interfaces."

But progress is being made. During September, Radio 3 broadcast from the Royal Albert Hall a Promenade Concert in which, for the first time, the signal remained in digital form right through to the transmitter sites. Previously BBC digital audio has always been converted to analogue form while passing through the continuity and master control room at Broadcasting House before being reconverted to digital signals for distribution over the BBC's Nicam 3 digital network, to the transmitters.

The BBC has also built two digital, disc-based audio editors using a series of Winchester disc drives to store audio recordings in digital form and permitting non-destructive editing.

The BBC paper notes that a system for achieving all-digital broadcasts from an outside-broadcasts site has now been designed and installed: "Only by actually installing such systems in a working environment can all the potential operational and engineering problems be revealed and understood."

On future developments, R. K. Lawrence *et al.* in their IBC paper point out that an important realization is that a serial multiplex interface comprises a very economical way of packaging audio, communication signals, and control and other data with technical and programme uses. A major consideration remains that of effective and economical digital audio signal routing.

Transmitting digits

Although UK listeners will soon have digital stereo signals on terrestrial and satellite television channels, broadcasters would like to provide a digital sound radio service that could be received not only on fixed radios but also on portable and car-radio receivers. BBC trials in 1978 at Pontop Pike on a Band I television channel showed that mobile reception "was fairly disastrous, whereas fixed reception generally worked well" according to Daniel Pommier (CCETT, France) at IBC88.

CCETT and BBC are currently co-operating within an European Communities Eureka project on "digital audio broadcasting". It is recognized that "although v.h.f. f.m. services can still provide excellent service to properly-installed fixed receivers, the solution for the future development of sound radio is to provide an entirely new digital sound broadcasting service... a complete digital sound programme chain would be established from studio to domestic receiver". Such a service might be transmitted via satellite if the necessary spectrum allocation between about 1 and 2GHz can be obtained.

Digital sound broadcasting still faces complex technical problems since multipath propagation can be both frequency selective and time varying. Typically, at u.h.f. the delay spread is urban areas is about 1-2 μs but exceeds 3μs in about 1% of locations.

CCETT is proposing a new form of digital coding and modulation that it believes would be suitable for high-quality reception on portable and car radios as well as fixed sets. The ability of convolutionally-coded, orthogonal frequency division multiplex (o.f.d.m.) systems to work in a selective multipath environment is considered to create this possibility, even in dense urban and wooded rural areas.

Radio Broadcast is written by Pat Hawker.

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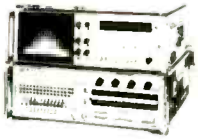

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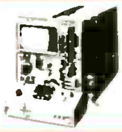

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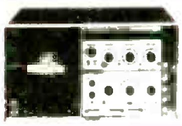

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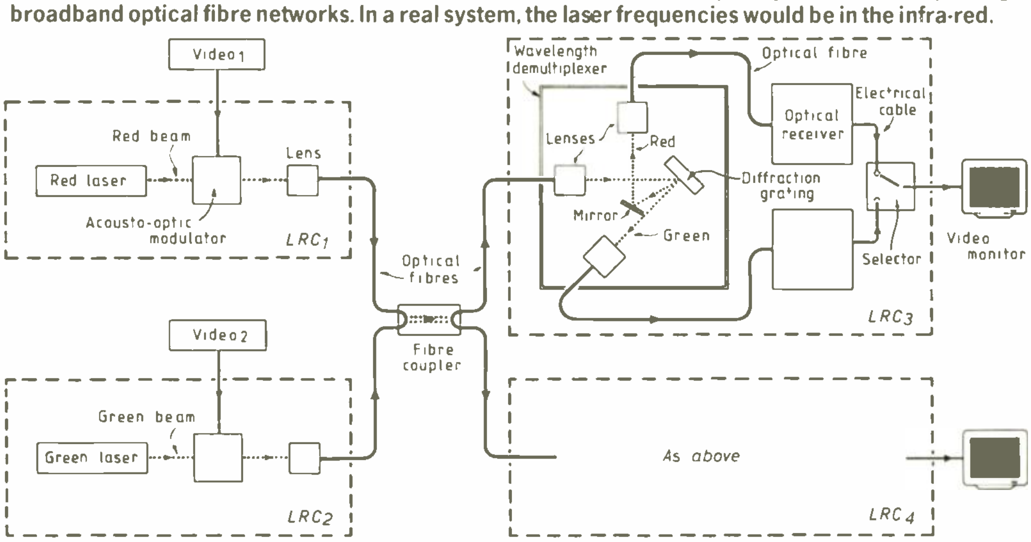
RADIO COMMUNICATIONS

Digital routing networks

In a Television Broadcast item in April 1987 (p.445) – "Bits all round" – an outline was given of an ambitious BBC Research project, then still only a paper design, aimed at making possible the routing of multiplexed digital video streams, basically independent of the digital production standard (although suitable for 4:2:2 or even high-definition television), around large studio centres. Transmission would be in the form of 2.4Gbit/s digital streams in optical fibres by a combination of time-division and wavelength-division multiplexing. IBC88 showed that since then an international consortium has been formed with nine participating organisations to develop this standards-independent system as a broadband customer premises network – an European Communities RACE Project 1036, with the BBC as prime contractor, responsible for project management and construction of a "test bed". STC and GEC Hirst Research Centre are among the participants.

Apart from television studio centres, many other applications are foreseen within the developing integrated broadband communications network. Development of the hardware appears to be making good progress and was shown in outline on the BBC IBC stand. Target date for the completion of this development is the end of 1992. A. Oliphant (BBC) suggests that "The success of the Integrated Broadband Communications Network (IBCN) will depend on the widespread use of video communications, which will depend in turn on the availability of broadband customer-premises networks such as the WTDM system."

This demonstration system by the BBC illustrates the use of frequency-division multiplexing in broadband optical fibre networks. In a real system, the laser frequencies would be in the infra-red.



Reducing s.h.f. interference

An IEE colloquium, "Radio frequency co-channel interference measurements and modelling at 1 to 30GHz", under the chairmanship of M. P. M. Hall (RAL) included 14 presentations reflecting recent work carried out for CCIR Study Group 5 and for the European COST 210 project (see Radio Broadcast, November 1988 p.1140). Prime aim of the work is to determine more accurately the minimum safe distance between co-channel microwave systems, both under "clear air" propagation conditions and in the presence of hydrometeor (rain, fog, snow etc.) scatter, and also to develop improved interference reduction techniques. COST 210, initiated in 1984, is due to be completed by 1990 but may be extended.

In attempting to quantify and model the effects of anomalous propagation on high-capacity communication and broadcast systems, significant new information is emerging. For example, 11GHz transmissions from Cap d'Antifer, Normandy, received over a 150km sea path in the Portsmouth area, using high and low sites at each end of the path, have shown clearly that over-the-horizon signals exist on the low/low paths for more than 50% of the time, less frequently on either high/low or low/high paths, and still less frequently on high/high paths. Measurements have also shown that even relatively limited over-land, coastal strip paths in mixed sea/land paths, tend to determine the overall propagation. An earlier report of work carried out on the French transmissions by Portsmouth Polytechnic, presented at the URSI fifth national conference, showed that rain-scatter can occasionally result in signals as strong as those due to tropospheric ducting but lasting for much shorter periods.

However, theoretical studies followed by field trials by BTRL in conjunction with the University of Essex, now involving receiving stations at about ten sites, and investigating the possibility of rainscatter interference between satellite and terrestrial links for separation distances up to 200km, show that interference is likely only when very precise geometries exist. With the equivalent of over 7.5 years of data already collected, very few cases of potential interference have been observed. This problem appears less serious than was originally predicted.

A bistatic scatter experiment by the Dutch PTT includes observations of signals from a 19.76GHz, 100mW transmitter with 28.5dB antenna gain at Boskoop beamed straight upwards with a beamwidth of 7°, received at the Dr Neher Laboratories in Leidschendam about 16km distant (receive antenna 45dB gain, beamwidth 0.7°) continuously scanned in elevation from 0° to 30° and back every ten seconds. This is enabling an analysis to be made of transmission loss as a function of height for fixed percentages of time; in effect determining the height of the scatter area.

Tim Hewitt (BTRL) has developed a new model for clear-air microwave interference prediction that when tested against COST 210 measured data is generally within 5 to 10dB accurate, with no evidence of the 20-30dB errors and discontinuities that arose with earlier models and has overcome all the identified failure mechanisms of the current CCIR prediction models.

Officialese

The new amateur radio licence, due to be introduced from 1 January, includes a number of welcome relaxations and clarifications on modes, logging, data and operating procedures; but it is not without some puzzling examples of officialese. What, for example, is one to make of parts of the lengthy section on "interpretation" which tells us in all seriousness that "words importing the masculine include the feminine, words in the singular include the plural and words in the plural include the singular" and a few paragraphs later "any reference to a statute in this Licence includes a reference to that statute and to any statutory instruments made under that statute as the statute or statutory instrument may be amended from time to time and to any other statute or statutory instrument that has the effect of adding to, replacing or superseding the statute or statutory instrument, whether before or after the Date of Issue."

One wonders what has happened to the DTI's library copy of "Plain Words" by Sir Ernest Gowers, originally published in 1948 for the guidance of officials when communicating with the public.

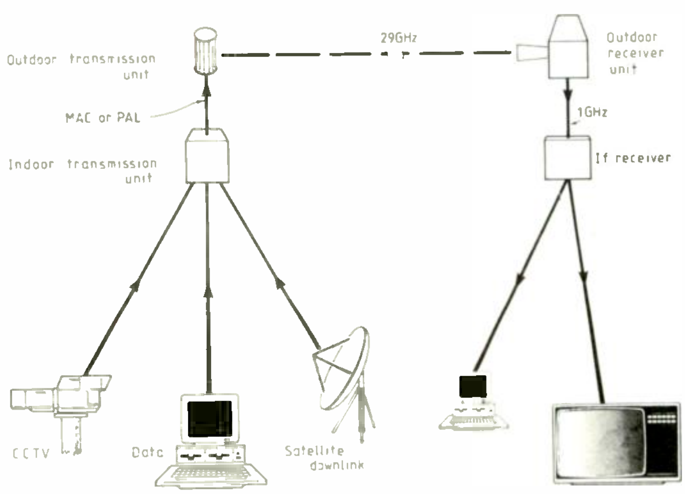
Radio Communications is written by Pat Hawker.

TELEVISION BROADCAST

Millimetre channels

In Television Broadcast (December 1987) an outline was given of the British Telecom proposals for M^{3}VDS (millimetre-wave, multichannel), multipoint video distribution system) on 29 or 38GHz and also the renewal of interest, stemming from the Russian NIIR studies, in terrestrial broadcasting with frequency modulation in the 12GHz (25mm) band. The attractive feature of both, it was noted, is that such systems could use the MAC/packet transmission standards and hence use the same "indoor" unit (or integrated receiver) as for d.b.s. reception.

Since then, there have been further developments, including an experimental demonstrator unit set up by BT at Saxmundham, Suffolk and experimental 12GHz transmissions by the IBA in London.



The IBA transmissions from the Croydon site are intended primarily to provide a source of D-MAC transmissions to assist the development of d.b.s. decoders and receivers, but the opportunity is being taken to assess the feasibility of low-power terrestrial distribution or broadcast systems. Initially the transmissions on about 12.3GHz use a 100mW transmitter with directional antennas mounted 120 metres above ground level on the IBA Croydon tower, but later it is intended to increase power and possibly install an omni-directional antenna. The IBA suggests that for a multichannel system about 12 D-MAC channels could be radiated in a bandwidth of about 200MHz using standard f.m. or possibly some form of vestigial-sideband f.m.

The basic 29GHz M^{3}VDS system, developed by BTRL at Martlesham in conjunction with Philips Microwave Components Group and VG Electronics, was originally intended for some inner-city "betting shop" installations of the "Racenet" project (already claimed as the largest private satellite network in the world) where direct satellite reception is blocked by urban shadowing. Racenet uses the B-MAC transmission standard stemming from Scientific Atlanta which is also used in the Australian outback service. Philips Microwave are marketing 29GHz systems for multipoint reception within a 2km radius of the transmitter.

BT's demonstrator system at Saxmundham is based on a 100mW thermally-stabilized Gunn diode oscillator. The base bandwidth of the video channel is suitable for 5.5MHz PAL up to 12MHz for D-MAC or HD-MAC. The PAL demonstrator is claimed to offer Grade 4 pictures for 99% of the time at 3.3km range. A 15cm diameter dish antenna is used. It is claimed that excellent stability of the outdoor down-converter is achieved with a high dielectric-constant ceramic resonator. It is admitted that at present the GaAs millimetre-wave i.c. devices result in receiver unit costs of the order of £1000 but is is argued that in mass-production costs would be slashed, making the system fully competitive with most other forms of multichannel programme distribution.

Transmitter efficiency

To a noticeable extent IBC88 reflected the changing pattern of the UK television broadcast equipment market. Until recently this was dominated by the purchasing policies of a relatively small number of broadcasters plus the few facility houses specializing in the production of commercials. Today, the BBC and the ITV companies represent less than 50 percent of the UK market for studio equipment, with the industry depending increasingly on the growing number of independent production and facility houses. One result is an increasing number of small and medium-sized national and international firms competing, on price or specialization, for equipment orders rather than for massive systems (turn-key) orders, and with the broadcasters placing much more emphasis on exploiting commercially their own costly research and development.

But on the transmission side, at least until the UK radio and later television companies gain the right to own and operate their own transmitters, BBC and IBA dominate the UK market. Again, Europe is increasingly diverging from North American practice where for television the emphasis is on super-power installations. Whereas the highest power UK u.h.f. transmitters are the parallel 40kW units (80kW output per channel) at Crystal Palace, North American practice has progressively edged upwards from 60kW to 110kW to 220kW and even 280kW with effective radiated powers of over five megawatts. Such powers ensure the continued importance of multi-cavity klystrons and the newer Varian klystrodes, with priority given to improving overall conversion efficiency to reduce the horrific power costs.

Klystrodes suitable for 60kW vision transmitters and able to operate in true Class B mode are now being offered in the Comark range. An alternative development is the multi-stage, depressed-collector (m.s.d.c.) klystron in which electrons with differing velocities in the used beam are collected on five collector segments. This latest form of klystron is expected to be incorporated in production transmitters in the next year or so. Experimental units have shown even higher conversion efficiencies (figure of merit) than klystrodes, according to Ian Walters of Varian-TVT.

For medium- and low-power networks, such as those used in Europe, interest for terrestrial networks is now clearly centred on all-solid state transmitters. Currently, state-of-the-art for single power devices at the upper end of Band V is an r.f. output of the order of 150 watts (SGS-Thomson SD1492, TRW) whereas at frequencies up to about 100MHz mosfet devices can provide an output of up to about 600 watts, with the advantages of higher gain and higher voltage (lower current) characteristics. For planning engineers, the $64 000 question is whether and how soon will fet devices of equivalent or greater r.f. output to bipolars become available for use up to 850MHz? It was clear at IBC88 that some firms have imposed a strict news blackout on the latest state of fet developments – suggesting that they have not ruled out the possibility of responding to the next round of the BBC/IBA modernization projects with modular fet transmitters to at least the 10kW level.

At IBC88, J. M. Barriere (Thomson-LGT) reported that 1kW solid-state transmitters, designed for combined vision/sound operation in 8MHz G-standard channels, can be readily adapted to transmission of D2-MAC/packet (a.m.) signals. He showed that, should it ever prove possible to introduce MAC/packet on the terrestrial networks, there would be appreciable benefits in terms of transmitter efficiency, with output power increased by some 50% without increasing power consumption. Transmitters specially designed for this mode could be simpler, more economical to run and would give a better service to viewers. Unfortunately, the enormous viewer investment in PAL/SECAM receivers makes it most unlikely that there will be MAC transmissions in Bands IV or V for many years to come. Again, only the D2 version of MAC could be contained within an 8MHz channel.

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BC178	0.15
BC182	0.10
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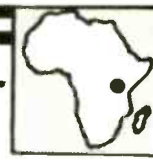

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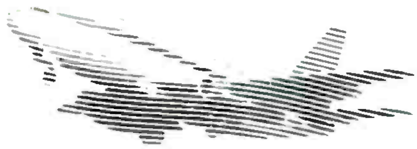

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