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CRISIS CONTROL

There have been occasions in large control complexes when the amount of information presented to controllers has been so vast and, possibly, suspect, that operators have found it impossible to take in. The author presents his views on methods of training for such moments, and on methods of measurement and presentation to reduce the number of maulifications and the level of stress on operators.

The Senior Shift Engineer was more bewildered than horrified when he answered the "panic" call to the control room and saw his staff rushing backwards and forwards along the almost infinite assembly of panels, obviously not knowing in the least what was going on, and deafened by the ceaseless and ever-growing noise of the alarms. Full horror was to come almost immediately when he realized that hoards of men were surging into the room from all over the huge plant, summoned in a last desperate attempt to find out which, if any, of the meters and indicators were "telling the truth.

Factological vs. Irrelevant? Perhaps. Irrelevant? No, for here is an extract from an account of such a catastrophe: "Incident": Captain Wilson was missed... because of a false indicator... and by signs of an apparent excess of water... All the events were accompanied by an unblushing cacophony of about 100 alarms sounding off, distracting the operators as they faced panel upon panel of red, green and amber lights and dials indicating entirely unexpected combinations of conditions, and as they tried to grasp the significance of the mystifying changes that were happening.

This description of a 'developed' crisis situation is taken from the masterly summary by Sir Alan L. Evans of what might be thought of as the sole example of the large-scale industrial disaster -- the Three Mile Island accident. In actually fact, the near-catastrophic type of accident, with its far-reaching consequences, has been experienced in many industrialized countries.

by R. E. Young,
B.Sc. (Eng), M.R.Ae.S., F.I.E.E.

in the world, but it was not until 'Three Mile Island' had occurred that public awareness of the dangers involved became much more apparent. At the same time steps to introduce improved safety precautions were being taken at both national and international levels: for example, the EEC produced a Directive in 1980 aimed at avoiding major industrial disasters, and the Atomic Energy Agency called an international conference in the same year to harmonize nuclear reactor safety standards worldwide.

Both technical and political interests now realize the need to provide additional, entirely new, safeguards in the operational design of large industrial complexes. The implicit requirement for major changes in the "total" approach to high-risk installations in particular becomes clearer, and has been brought out in what amounts to public debate, largely critical in nature.

This critical element has been especially marked in relation to 'Three Mile Island', where various forms of human error were blamed for the accidents; and with strong attacks being made, in effect, not only on the operators themselves but on their selection and training. It is only when one builds up the background to this incident in the light of 'crisis control' and allied considerations that an entirely different picture emerges, which can be largely summarized by the statement that unless the circumstances in which they were operating, the control engineers at Three Mile Island could not have achieved more than they did.

Before going into the way in which measurement and other information was presented to them -- quite inadequately -- and into the whole question of the 'goodness' (integrity) of this information, it is necessary to look at the state in which these engineers found themselves. It was, in a sense utterly fluid and had features which completely defied explanation. In the words of the Cotterill account: "... (they were) faced suddenly with a totally strange combination of events... preceded by... being misled... because of a false indicator... and by signs of apparent excess of water...

This is the classic example of the final full emergency -- stage of an incident carrying high potential risk, where the control staff come to the chilling realization that they are being given wrong information somehow and that they have no possible means of finding out where. Furthermore, as far as their control of the plant is concerned, they are completely out of contact with it; and, added to this, all their source of control information have to be treated as totally suspect.

Thus it has been recognized that in such circumstances the stress to which the engineers are subjected can only be described as extreme in the full sense of the word. When it is remembered that the conditions producing the emergency are entirely unforeseen, it becomes clear that it is virtually impossible to predict how any individual will behave in circumstances where "there is nothing to get hold of".

Fig. 1. 'Data-marshalling' type of control room, proposed for aircraft testing. Overall situation on wall diagram is broken down on operator's screens.

Nevertheless, there are two related areas where experience can be quoted which bears very positively on this general question of behaviour under stress.

The first of these areas is in the field of 'control room' type operations carried out under wartime aerial bombing attacks. Secondly, it is not unusual reality that in World War II, 'ultimate crisis control' was carried out under these hostile conditions. This was with extensive integrated broad-casting networks under central master control and with large radar command systems, which became, in effect, the equivalent of modern high-risk installations.

As will be treated in more detail in Part 2 of this article, observation has led to a number of conclusions on unexpected operational stress and methods of preparing people for it.

The most significant of these conclusions was that under such stress, one or other of two conditions -- A or B -- was reached: assuming, of course, that a panic state was not developed, where 'panic' is differentiated from conditions A and B by being "unreasoning" and "sudden" in nature.

Briefly, condition A is one in which, despite the severe stress -- the person thinks and takes action exactly (as far as the outside world is concerned) as before the incident occurred. The method of training and presentation for this condition should be largely 'subliminal' in nature, i.e. without the training mechanism being really obvious.

One of the main differences between conditions A and B is the virtual disappearance of B in the ability to take action, i.e. all initiative appears to be lost. In most cases "leadership by example" can restore it, and these in this condition are "near the surface" from this point of view. In practical terms, they appear not to be in a state of shock, as is generally understood.

However, in it is not the only irreplaceable change in facial expression to the blank look of mental handicap, familiar to those working in that field, which is most characteristic in Condition B. The 'mentally handicapped look' and other relevant aspects of that complaint will be discussed later in the context of a research programme which has been in progress for a number of years. This programme, conducted essentially on a voluntary basis, has nevertheless attracted an increasing amount of interest, particularly during the last two years; and has enabled major correlation to be established between observations made in one field and 'practice' in the other. Examples of such correlation include "thinking fatigue" which is relevant to the design of data presentation and other equipment for
Data marshaling

This concept, first introduced by the "wire" in 1960, maintains conformance with the testing of complex aerospace vehicles and aircraft generally, may be described as the separation, streaming and systematic presentation of "masses of data". The figure 1 shows the flow of data and the installation as originally envisaged for aircraft testing. The main display consisted of a wall of cathode-ray tubes, with sections of the aircraft, selected on a functional basis and broken down in order of detail displayed on corresponding panels placed on the operator's console itself.

This family of transducers has a 'parameter-dependent' frequency output derived as a difference (beat) frequency between light from matched oscillators, themselves tuned by high (electrical) resistance moving areas. These probes move differentially within their sensing coils at the input to the dual-chain system, which is terminated with a baffle, allowing the basic symmetry of the mechanical-electrical combination and its inherent balance provide a high degree of compensation for ambient changes.

The general operation of this configuration, however, attains with extreme environments, where the series-resonance operation of the Clegg oscillators which are used, makes it possible to install the sensing coil and probe remotely from the less 'hard' electronic unit. This is in virtue of the low-impedance (coaxial cable) connection, which can be used between the two with the series-resonant oscillator.

From this diagram it will be seen how this installation, as part of the intrinsic safety precautions built-in to the system, is an advantage. Thus, with the 'barrier' protection shown, the coil can be situated in the hazardous area and can be made effectively neutral, with little risk of energy at this point to initiating a spark.

References


To be concluded

Action on private mobile radio

Unless the Government takes action quickly to implement the recommendations of other systems, along with other measures to improve the effectiveness of private mobile radio, commercial, enterprise service and public bodies will become increasingly inefficient as their foreign counterparts and the UK radio industry will suffer.

The advantage of a system, prepared by the Committee on mobile radio, is that it is not subject to the same problems of performance and efficiency, and by broadcasting, PACTEL says: "there is little doubt" that the MoD keeps some of its secrets, even in peacetime, simply because they might be needed some day, in spite of claims by m.r. lobbyists that, if they should be released, they could be taken back in emergency in a matter of hours or even minutes. In the use of broadcasting, the report is critical of the efficiency with which the spectrum is used and says that it could be improved upon without any deterioration in service.

Among the consequences of the failure to secure a more equitable share of airwaves are delays, possibly more serious because of the low level of safety and security. The question of the relative merits of m.r. in the U.K. (around 5% against 2.7% in the US) is, says PACTEL, no help at all to the UK radio industry, in contrast to the state of affairs in Japan and the USA, where a healthy home demand acts as a spur to development and production and results in efficient systems and lower costs.

In a repeater, a common base station, located on high ground, gives a wide power output and coverage. Many mobiles sharing one channel and a "channel busy" indicator helps avoid a user hearing a message not meant for him. The current position is that not enough channels are available for this type of system. Trunked systems provide a number of channels to each user and are therefore frequency-efficient, the operator uses a multi-channel radio which is tuned automatically to a free channel. For this purpose, blocks of channels are needed - too few are currently available. It is suggested that the adoption of this kind of system. More channels are needed.

The third type, the cellular system, relies on dividing the area into cells, each of which is treated as a trunked system by geographically-located cells which use the same block of frequencies, interference is avoided and the range of the chosen channel is increased to about 1200k. Blocks of channels are needed for trunking. Once again, no enough are available,56% instead of a required 300%.

The fourth recommendation is that the Government should promote the use of private mobile radio instead of restricting it.

Finally, says the report, the delay of between three and six months in the issue of licences should be reduced. Otherwise, illegal station operators will mushroom and make spectrum management very difficult.

As John Askew, chairman of the EEA's Mobile Radio Committee, points out, "if even the manufacturers of private mobile radio equipment put forward the difficulties to their customers, many would feel that the Radio Northwest of PACTEL sums up the current position as, saying: "Other countries have taken a higher degree to encourage p.m. - the UK hasn't!".

"Available at $3.00 from The Director, The Electronic Engineering Association, Leicester House, 8 Leicester Street, London WC2H 7DN".
The problem with designing audio amplifiers is that there are a number of design requirements which are impossible to satisfy completely: most things are a freedom from harmonic and intermodulation distortion, in the context of distortion or transient response, on the nature of the load resistance, and in the context of amplifier-generated signals over the whole range of signal inputs and likely load characteristics; rapid settling time and freedom from "hang-up" on step-input or overload, particularly under reactive load conditions; and complete absence of input or output-induced instability. Not only are these requirements impossible to achieve absolutely, but the work needed to improve one of these may simultaneously bring about problems in other respects, so part of the task of the designer is to choose, within the appropriate limits of cost and complexity, between conflicting possibilities and requirements. No two designers (or their commercial or advertising managers) are likely to come to the same balance of compromise in their approach to this and this leads to subtle differences in the tonal characteristics of the amplifiers. A characteristic of commercial trends in the last twenty years, which I view with regret, is the greater stress on the attainment of very low harmonic distortion figures over the whole of the audible spectrum, to the extent that many modern commercial designs attain steady-state sinewave figures fifteen or more times better than, possible under any conditions, from the signal sources which feed the amplifiers. A similar sort of emphasis is expended commercially in achieving very high signal-to-noise ratios, which would be valuable if it were made in the handling of programme material by the programme producers. The reason for this commercial interest is a simple one: the major emphasis in most equipment reviews is placed on t.h.d. and s/n ratio, coupled with, in the case of power amplifiers, power output in Watts/pound (sterling) or, conversely, Watts/pound (avoidpounds). This trend would be wholly praiseworthy if it could be achieved without impairment in other desirable characteristics of the equipment: unfortunately, it has been achieved at the expense of some quality very good, one must accept some others relatively bad. If only one knew which was which, the listener, this choice would be easy, but one by John L. Linsley Hood doesn't. Quite a lot of work has been done in the field of psycho-acoustics to try to establish the relative importance of the specific electrical effects, but this work is far from complete and impaired, from the point of view of the designer, by the omission of most of the minor performance defects practical amplifier designs are heir to.

Nevertheless, a predictable result of the accumulation of experimental findings on acoustic effects, coupled with a greater awareness on the part of engineers of the interplay of residual performance shortcomings, is there is a keen interest in new developments in components and circuit techniques, as a possible route to improved performance. Of these component developments, one of the most interesting, in the field of active devices, has been the growing availability of rugged, reliable and reasonably priced power mosfets (metal-oxide-silicon-field-effect transistors). These devices have a very much better t.h.d. and s/n ratio – almost embarrassingly so – the normal audio power transistor, and allow a considerable extra freedom in solving h.f. loop-stability problems, which compromise must always be found in a feedback amplifier design between the conflicting requirements of the negative feedback loop margins and the need to retain a high loop gain at the upper end of the audio range. These requirements are often in conflict: modern audio amplifiers, in addition, are almost completely free from charge-storage effects found in junction transistors, which tend to impair complex-signal transfer.

Unfortunately, power mosfets have electrical characteristics and circuit requirements which are very different from those of the junction power transistor, so that they cannot be used as a direct replacement for junction transistors in existing designs. One must reappraise the circuit.

Power mosfet
In a typical field-effect transistors, the device shown in Fig. 1(a), and which operate by means of a mobile layer of charge induced in an insulating, conducting region of a semiconductor, have been known and used in small-signal applications for many years – particularly in v.h.f. circuitry, where their very fast response times are of great value. However, the conducting path in these devices is, by the nature of their method of construction, parallel to the surface of the semiconductor material. It is difficult, in a single power transistor, to achieve a high power gain in a single transistor, to achieve an effective power gain which is feasible in power transistors, and this is the reason for the use of separate power transistors in power amplifier designs. In this way, the power gain per transistor stage is achieved at a lower cost and complexity than would be possible with a single power transistor.

These devices are now almost universally known, which were open to any manufacturer, and which were a major advantage in the construction of power amplifiers. However, the number of generations of power transistors has increased very rapidly, to the point where the total number of connected power transistors is now limited to a single chip, which is needed to power the mosfet. The mosfet is a simple circuit, which is connected to the transistors in a simple and effective way, to allow the mosfet to be used in the construction of power amplifiers. A mosfet is a simple circuit, which is connected to the transistors in a simple and effective way, to allow the mosfet to be used in the construction of power amplifiers.

The technical breakthrough in this type of device came about when it was appreciated that a V or V' groove etched through the junctions in a conventional junction transistor could provide the possibility of an insulator-gate, indirect-charged f.e.t. in which the current would flow would be "vertical" (as in the conventional junction transistor) rather than "lateral", (in relation to the surface of the chip) as in the normal insulated-gate component. This gave a method of manufacture of "mosfets", as

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For relatively low-power use, up to say 50 watts, this type of output stage is entirely satisfactory, and gives a good performance with low hum, and less noise. With the mosfet, any voltage drop in each component half cannot be less than the forward voltage (ref. Fig. 2) added.
Fig. 6. Internal protective Zener diode can cause inadvertent thyristor action, in which gate loses control.

to the saturation voltage \(V_{DS} \text{sat}\) of the driver transistors. During some delay involved in the gate breakdown, which will destroy the device, it is likely to be very short, the circuit may be designed to protect the gate against very brief voltage excursions beyond this limit.

This difficulty can be lessened, in the construction of the device, by incorporating a Zener diode between source and gate, as shown in Fig. 4. However, this technique in its turn leads to the problem that the device must then be protected against a reverse bias – of the order of the \(V_{DS} \text{sat}\) – which would cause this internal Zener to conduct, since this can sometimes lead to the triggering of a thyristor type action within the module, of which the gate is irrelevant. This may not destroy the device, but may damage associated circuit elements. The simplest form of protection is the use of an external germanium diode, connected in parallel with the source/gate Zener, and arranged to conduct before the internal diode. This is not a preferred solution, however, since the reverse insulation resistance of the Ge diode is much poorer than the unmodified internal diode, and is non-linear with voltage. The circuit of Fig. 3(a) is immune from this problem.

The second difficulty in the use of power mosfets arises from the very high operating frequencies possible with this technology. This leads to an effective circuit element of the form shown in Fig. 4.

5(a), when the user expects the device to behave as in Fig. 5(b): this causes immediate high-frequency oscillations, with frequently destructive effects, when such mosfets are incorporated into apparently sensible circuit configurations, and since the resultant burst of oscillation probably occurs over a range of 300-1500 MHz range – and is brief anyway – it is unlikely that it will be seen on any monitoring instruments. The unhappy experimenter is then left contemplating a defunct device, thinking that its inability to conduct in this region is as great as to render it unusable.

Happily, this internal gate-source capacitance is sufficiently high, typically in the range 600-1500 pF, that stray static current is unlikely to induce an electrical breakdown of the gate insulation. This internal capacitance, which must be over looked in circuit design considerations, also provides a convenient means to ensure that the h.f. behaviour of the internal gate carrier. Since an external 'gate-stopper' resistor can then cause a predictable roll-off in h.f. response, to bring the unity gain transition frequency down to a more manageable level. An external resistor in the range 470-47 k \(\Omega\) is normally adequate.

Given these precautions, my experience is that power mosfets may be used at as high as 100 MHz as normal bipolar power transistors, and allow a substantial improvement in circuit performance for a relatively small extra cost.

References

To be continued

LITERATURE REVIEW

Power semiconductors and d.c. power supplies are detailed in the 1982 edition of the Lambda catalogue. It includes some application notes on the various types of power supplies, and also provides a comparison chart for alternative types of power modules. This leads to an effective circuit element of the form shown in Fig. 4.

Some literature that you would like to receive may be out of print. A service is available to help you find that elusive book is provided by The Out of Print Book Service, 30 West 23rd Street, New York, New York, 10010. They do not charge a fee but ask that all requests for which substitute be accompanied with a postage stamp at the current first class rate letter and full details of the book required.

Ceramic chip capacitors for high frequency applications are described in a bulletin from Hy-Corp Ltd, 7 Shield Road, Ashford Industrial Estate, Twickenham TW15 1AV. The bulletin lists their stability, specifications and terminations.

Fig. 5. At high frequencies, stray capacitances and inductances, shown at 1(a) of the model into an oscillator, with damaging effect.

DIGITAL FILTER DESIGN

Will digital filters take over from their analogue counterparts? Accuracy, versatility and falling cost suggest they will. This second article on microprocessor implementation details a procedure for recursive filter design of Butterworth and Tchebychev response, with examples and basic programs for zero, calculation.

by B. M. G. Cheetham and P. M. Hughes

It has long been recognized that because of the high sensitivities of the roots of high-order polynomials the cost of developing recursive digital filters is best implemented as cascade or parallel arrangements of second-order filter sections. Cascading several second-order filter sections as illustrated in Fig. 1(a) is equivalent to expressing \(H(z)\) as the product of second-order transfer functions, i.e.

\[
H(z) = H_1(z) H_2(z) \cdots H_N(z)
\]

where each \(H_i(z)\) is of the form

\[
H_i(z) = \frac{1 + a_{2-i}z^{-1} + a_{1-i}z^{-2}}{1 + b_{2-i}z^{-1} + b_{1-i}z^{-2}}
\]

(1)

This is often referred to as a biquadratic transfer function and in which by it is implemented a biquadratic section. The signal flow diagram of a commonly used biquadratic section is shown in Fig. 1(b).

The filter design problem is now that of deciding how many biquadratic sections are required, and calculating the coefficients. One of solutions to this problem, and the procedures are divided into two broad groups: direct methods and indirect methods which involve the design of an analogue prototype filter which is transformed to give a suitable digital equivalent. Details of the commonly used indirect design methods can be found in the standard texts.

Butterworth and Tchebychev filters

Most filtering applications require an amplitude response that allows selected frequency bands to pass through the filter unaltered and eliminates as nearly as possible frequency components outside these bands. In many applications, particularly where a degree of phase distortion is acceptable in the passbands, Butterworth and Tchebychev-type filters are often used. These responses approach the ideal magnitude-frequency response of an ideal filter, but there are some differences between the two classes lies in the nature of the approximation. In the case of Butterworth-type filters, the magnitude of the frequency response is maximally flat over the passband, falling by 3 dB at the cut-off frequencies and decreasing monotonically in the stopbands. The rate of fall-off of gain in the stopbands is fixed and determined solely by the order of the filter. Tchebychev-type filters display an equi-ripple passband response with specific ripple amplitudes and decreasing monotonically in the stopbands. The rate of fall-off of gain in the stopbands is fixed and determined solely by the order of the filter. Tchebychev-type filters generally show an increased rate of fall-off of gain over the equivalent Butterworth-type filter of the same order. Unlike analogue filters, a number of alternative methods exist for designing Butterworth and Tchebychev-type digital filters. For a given set of design parameters, there will be a number of digital filter transfer functions which may be classified as Butterworth or Tchebychev type. A method presented here is to the squared magnitude approach, which is described in detail by Rader and Gold, and used by Ackroyd. The zeros of the digital filter are designed directly from the squared magnitude of the required response with no constraints placed on the phase response, which may therefore be non-linear. Once the pole and zero positions have been determined, it is a simple matter to calculate the \(a_i\) and \(b_i\) coefficients for each of the cascaded second-order sections. As the design procedure simply consists of the evaluation of a number of given formulas, it is particularly suitable for a programmable calculator or microcomputer. The first method presented here is to a lowpass digital filter, which also forms the basis of the highpass, bandpass and bandstop filters.

Lowpass Butterworth filters

An analog lowpass filter is a second-order Butterworth type if its response \(G(j\omega)\) satisfies

\[
G(j\omega) = \left| \frac{1}{1 + j\omega/\Omega} \right|
\]

where \(\Omega\) signifies angular frequency. This formula gives a passband which is nominally flat at \(0.048\) dB, falling to \(-3\) dB at the cut-off frequency \(\Omega\).

An example of a second-order lowpass Butterworth filter is shown in Fig. 1. The filter transfer function has the form

\[
H_2(z) = \frac{1 + a_1z^{-1} + a_0z^{-2}}{1 + b_1z^{-1} + b_0z^{-2}}
\]

where \(a_0 = a_1 = a_2 = b_0 = b_1 = 1\) and \(b_2 = 0\) if a certain lowpass filter design is required. For \(\Omega = 1\), the specification for the filter is

\[
-3\text{ dB} \quad \text{at} \quad \Omega = 1
\]

\[
0 \text{ dB} \quad \text{at} \quad \omega = 0
\]

\[
0 \text{ dB} \quad \text{at} \quad \omega = \Omega
\]

\[
-3\text{ dB} \quad \text{at} \quad \omega = 2\Omega
\]
Example 3

Design a fourth-order bandpass Butterworth-type filter with a sampling frequency of 16 kHz and cut-off frequencies of 2 and 4 kHz.

As the bandpass transformation doubles the order of the prototype filter, a second-order Butterworth lowpass prototype is required with a relative cut-off frequency \( f_s = f_c / 2 \). The two poles of the prototype filter, calculated from the expressions for \( U_0 \) and \( V_0 \) (equation 3), are \( a = 0.500 \) and \( b = 0.707 \) in equation 4 gives \( n = 0.4142 \). By equation 10 the poles of the bandpass filter are calculated to be

\[
\frac{2}{\pi} \arctan(n + \frac{1}{n}) = \frac{2}{\pi} \arctan(0.4142) = ±0.3856
\]

The zeros of the prototype filter transform to two zeros at \( ±a \) and one at \( ±1 \). The passband at \( ±0.0033 \), outside the transition band, with \( H(a) \) is a Gaussian filter.

Amplitude and phase responses of fourth-order Butterworth-type bandpass filter designed in Example 3

Highpass, bandpass and bandstop filter design

The design of Butterworth and Chebyshev filters may be carried out by transformations applied to lowpass prototype filters obtained by the methods described earlier. 4. The simplest of the transformations is that of low to highpass. A lowpass filter with relative cut-off frequency \( f_s \) is transformed to a highpass filter with relative cut-off frequency \( 0.5 / f_s \) by replacing \( a^2 \) for \( a^2 \) in the filter function \( H(a) \).

Applying this transformation to the lowpass Chebyshev filter in the previous example, we obtain a highpass Chebyshev filter with a relative cut-off frequency of 1/6. The resulting transfer function \( H(a) \) is

\[
1 - 2a^2 e^{-j2\pi f / f_s} + 28ae^{-j2\pi f / f_s} - 28ae^{-j2\pi f / f_s} + 1
\]

This has the effect of doubling the order of the prototype filter, and consequently each second-order section in the lowpass filter is transformed to a fourth-order transfer function in the bandpass filter. It is necessary therefore to reduce each of these fourth-order transfer functions to the product of two second-order sections. The transformation may be conveniently accomplished by considering the poles of the prototype each of which produces two poles in the resulting bandpass filter. For each pole of the prototype filter situated at \( ±a \), say, the transformed bandpass filter will have poles at values of \( a \) satisfying

\[
\frac{2}{\pi} \arctan(n + \frac{1}{n}) = \frac{2}{\pi} \arctan(0.4142) = ±0.3856
\]

The magnitude and phase responses of these filters are shown in Fig. 4.

Low to band pass transformation

A low pass prototype filter with relative cut-off frequency \( f_s \) is transformed to a bandpass filter with lower and upper cut-off frequencies of \( f_s / 2 \) and \( f_s / 8 \) respectively, by the replacement of \( a^2 \) by

\[
\frac{a^2}{n + 1}
\]

in the prototype transfer function, where

\[
\frac{\cos(\pi f / f_s)}{\sin(\pi f / f_s)}
\]

As \( \rho \) in this equation will normally be a complex number, computation of the poles of the bandpass filter involves the calculation of a complex square root, see appendix 2. The 2\( n \) poles of the band-pass filter may then be determined by substituting each of the \( n \) prototype poles in equation 10. The \( n \) poles of the band-pass filter may then be grouped into complex conjugate pairs to produce the denominators for each of the \( n \) Butterworth bandpass transfer functions which comprise the overall filter transfer function, \( H(\omega) \). The zeros of the bandpass filter are calculated from the zeros of the prototype using the same formulae as were used for the poles. By substituting \( \omega = 1 \) into equation 10 the \( n \) zeros of the lowpass prototype located at \( ±a \), transform to \( 2n \) zeros in the bandpass filter, located at

\[
\text{Amplitude and phase responses of fourth-order Butterworth-type bandpass filter designed in Example 3.}
\]

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\[
\text{Example 2} \quad \text{Design a second-order Butterworth lowpass digital filter with } f_s = 1.815 \text{ and a passband ripple of } 0.01 \text{ dB. By equation 3, } c = -0.424 \text{ and } k = 0.131 \text{ and thus calculated to be } 0.844 \text{ and } 1.2384 \text{ respectively. Subtracting these values into equations } 4 \text{ with } b_0 \text{ obtained from equation } 3 \text{ for } m = 0 \text{ and } k \text{ shows that the poles of the filter are }
\]

\[
\frac{x}{x - 0.38075} ± 0.49030
\]

Calculating now the bi-quad transfer function for the single section required gives

\[
H(x) = A_2 \left( 1 - 2x^{-1} e^{-j2\pi f / f_s} + 28x^{-1} e^{-j2\pi f / f_s} - 28x^{-1} e^{-j2\pi f / f_s} + 1 \right)
\]

Substituting \( m = 1 \) into the above shows that \( A_2 \) must be set to 0.567 for unity gain at d.c.

WIRELESS WORLD JUNE 1982
WIRELESS?

I have just bought a copy of your magazine, for the first time in some years, and after reading it without any indication beforehand that you published anything of interest, the first item to catch my eye was a long and well-written article on microprocessor-based equipment. It was, of course, an editorial note. I was, however, impressed by the ease with which you managed to present what might have been a complex subject in an understandable manner. I am quite new to microprocessors and was very pleased to find that the article was written in a way that was easy to follow.

However, I must express my disappointment that your magazine does not seem to be as well-produced as it once was. The paper quality is poor, and the printing is not as clear as it used to be. This is a shame, because your magazine has always been known for its high-quality production values. I hope that you will be able to improve these aspects in future issues.

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Example 4

Design a fourth-order bandstop Tchebychev filter with a sampling frequency centered at 20 kHz, lower and upper cut-off frequencies of 1 kHz and 10 kHz, respectively, and a passband ripple of 0.1 dB.

According to the Tchebychev lowpass prototype is required with a relative cut-off frequency of 0.1 dB and a passband ripple of 0.1. The Tchebychev lowpass prototype is designed using the following formulas:

\[
\begin{align*}
\text{polynomial} & = 1 - 2 \cos(\omega_c) z + z^2 \\
\text{zeros} & = \frac{1 - \sqrt{2} \cos(\omega_c) + \sqrt{2} \sin(\omega_c)}{2z} \quad \text{for} \quad z > 0 \\
\text{poles} & = \frac{1 + \sqrt{2} \cos(\omega_c) + \sqrt{2} \sin(\omega_c)}{2z} \quad \text{for} \quad z < 0
\end{align*}
\]

The filter is designed such that the poles and zeros are 0.0961±0.0621, with a phase shift of 0.083±0.042. The cutoff frequency of the filter is 0.5 ± 0.25 kHz.

The filter function H(z) is calculated using the following formulas:

\[
H(z) = \frac{1}{1 - 2 \cos(\omega_c) z + z^2}
\]

The procedure for calculating the second-order sections is similar to that for a bandpass filter. In this case, however, the coefficients are always real, and the zeros of the filter are at z = ±1.21. The bandstop filter can be designed using the lowpass transformation in Example 4.

 amplitude and phase response of Tchebychev-type bandstop or notch filter designed using lowpass transformation in Example 4.

MICROCHIPS AND MEGADEATHS

Steve Coleman (April letters), has taken too literally my plea for a relaxed attitude to this topic. I am always prepared to apply my competition to his widest sense, both militarily and industrially, and now in the future.

Electronic engineers in the UK, USA and USSR are sure to stand out in these areas, and the competition is sure to be fierce. This applies to those who write, design, manufacturers, and serve in armies. Where the American military is concerned, I have no doubt that the Russian military will stand up to the challenge.

The decisions of Nunn-Lugar will therefore be that obedience to orders from higher authority is no defence against charges of immoral acts.

The critics of super-powers are appealing, and give us no justification for an easing of tension with either power. Either the massacre of Kha
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POR DEAR FOR AMATEUR RADIO

I was very interested in the letter from B. Reay in your April issue. My copy was available for the first few months of the year, and I thought there was a special “All Fools’ Day” feature.

May I first of all make it quite clear, that as many of your readers will know from my cal
gin, although I am employed by the RSGB, I am not privy to any matters of policy and I do not work at the society’s premises. These comments are therefore made purely from the standpoint of an ordinary member of forty years standing and a reasonably active transmitting amateur since 1948.

Every regulator and every correspondence receives an answer to his letters, and in order to aim this up this matter with the appropriate representatives and committee members. On the other hand, however, nobody is obliged to reply to unsolicited communications which contain nothing but, unnecessary criticism or, perhaps, personal remarks, particularly from indi
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Dealing with B. Reay’s point regarding the same order as in his letter, first of all I do not agree that the RSGB has been so hostile. I am sure to feel no feeling either in this matter, but it seems to me that the society dealt with the matter fairly, even issuing a list of the actions of the unlicensed that could be held the essential dif

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The decisions of Nunn-Lugar will therefore be that obedience to orders from higher authority is no defence against charges of immoral acts.
HIGH-LOSS POWER SUPPLY?

The high-loss power supply shown on page 42 of your February issue is potentially lethal! It is essentially an imitated "Gazette" article with the Home Office that the magnitude of the problem becomes apparent. Until a few years ago companies such as mine were public about interference on radio or television at such a rate that in an average telephone area about 100 were waiting to be investigated at any time. During the past few years the Home Office department has been receiving that in the business areas has risen to the thousands, certainly overwhelming the small domestic transmission that the Home Office is prepared to pay for. In one example, I purchased a radio receiver which did not receive any radio waves or signals in the 1.6 to 18 MHz band. This interference caused you to yield to or broadcast your bands which the Home Office now knows about. By all accounts, the Home Office has not been interested in the problem and hopes that it will just go away. An example of its attitude to radio matters can be seen in the recent modification to Amater + correcting an RAE I agree that this to many people seems to be a better lottery than an examination, this being all part of the general lowering of standards. However, Mr. Reay has probably just seen the joke and not the calf in his call. If the "B" licence (introduced at the insistence of the RAE, by the way) does not give him sufficient scope, he only has to pass his Morse test to obtain extended facilities and, by his operating, may thus resuscitate a name which he may once have chucked as amateur radio.

In the mid-fifties, a radio being a technical hobby, not many people build or repair their equipment these days, and why on earth should they? There is no shortage of licences, even the old "Experimental" one, but I am afraid to say, getting communication continuous equipment, why is it, therefore, that from time to time one encounters these woe-be-damned "automatic software management" package and as an added bonus, their interface remains available on both systems for bulk storage.

On the subject of efficiency, it may be noted that two-way handshaking is in danger of becoming a deliberate policy to ensure universal compatibility, and with both components operating speeds and with their own special data transfer facilities, Transfer speed may be improved by utilizing the interrupt facilities of both systems for bulk storage.

ALIEN INTELLIGENCE

In your March, 1982 editorial you speak of the lack of response to the Japanese challenge. If one thinks about the possible implications of the Japanese challenge and its potential impact on national security, it becomes clear that the Japanese have been outpaced by the West. In particular, the Japanese are seen as a serious threat to Western interests in the region. For example, the Chinese have already demonstrated their willingness to use modern technology against Western forces. It is clear that a response is needed to this challenge.

SELMAN POWER

V. Lewis reported in your February issue that a number of people have been using self-accelerating devices to increase the power output of their transmitters. In fact, the licence fee for the use of such devices was increased on September 15th.

The main reason I chose this device is because it is safer and more efficient than the constructor. Although high-frequency devices appear in manufacturers’ catalogues, they are generally supplied to a few large companies from suppliers such as Electroclad, Maplin, or the like. The reason for this is that the use of semiconductor devices may lead to interference between different parts of the device. The Home Office may not appreciate that the use of these devices will cause interference. The Home Office requires that any interference caused by the use of these devices be reported to them. The Home Office requires that any interference caused by the use of high-frequency devices be reported to them.
LETTERS
avoid confusion, points are symbolized by some letters not customarily employed.

Position of spindle when styli is:
out of groove, no A
in contact, B
intermediate radius of high light, C
next radius (A.B etc.) included, D
inner zero tracking radius
outer zero tracking radius
Dp, spindle to pivot dist. (arc radius) Lp, styli to pivot D, offset angle
Dp/Lp > 0.5, outer zeroes are removed
Dp/Lp < 0.5, inner zeroes are removed

When applied to Lp

sin θ

Similarly with 3θ (θ=ψ2Lp)/sin O is clear from the diagram.

When applied to Cp

Now ∆ψ = ψ therefore 4π/2 = 2π

Lp

THE NEW ELECTRONICS

I have some sympathy with Hugh Jacobs article in your January issue and I certainly do not find low-loss standards in Germany an excuse for our low standards, as C. Winser’s letter in the same issue seems to imply in its conclusion.

I am now a secondary school teacher of physics and have been perplexed by the philosophies built into education; standards here are definitely falling — but a whole re-shuffle of aims and objectives and a change in examination syllabuses and in the exams themselves could do a great deal to change the drop in standard. I have often wondered whether this fall in standard was going to the standards and quality standards and higher up. Mr Jacobs article confirms my fears.

With a philosophy that views the child in terms of its needs instead of its responsibilities and society’s expectations from it — was developed the sort of approach which has the following characteristics:
1) educationally — the child considered in terms of its needs must be given automatic promotions to prevent any sense of inferiority, frustration or maladjustment;
2) emotionally — the state child must be guaranteed cradle-to-grave security lest a trauma be produced.
3) socially — the care for failure to learn is to devolvement learning and the care for social failure is to devolvement success.
4) the first concern still remains — this is to give food for thought for concerned parents and then, perhaps, lead them to action.

S. Goonatungara
Aberdeen
Ross-shire

WOODPECKER

Mr Martzilas’ letter, (April), gives an interesting and possibly correct explanation of the Russian “woodpecker” transmissions. There are one or two points arising from his letter.

The suggestion that the code auto-correlation, the “compressed” radar signals, would have virtually no sidebands may be a little optimistic. One might expect, in a practical system, that the peak signal sidebands would not be more than about 25 dB below the main lobe. One would also have to examine the ambiguity functions of these signals to determine their properties in the range-Doppler domain, because their sidelobe performance may be rather different if the radar were used to determine range rather than range and angle.

Another point arises from the statement that the compressed signal’s correlation functions are not large enough to be useful. Other applications, e.g., the equalizer, the matched filter, would be continuously changing the peak energy and its peak output would have 31 times the peak power of the uncompressed signal, not 11 times its amplitude.

Finally the statement about the radar having 31 times the “sensitivity” of a 100kHz FM receiver is the same with caution. Two radars differing pulse durations by 50% will produce a greater change in their sensitivity than pulse durations by 50%, if both are matched filters in the receivers, would have. The difference in the present context would be Mr Martzilas suggesting their resolution capability. Pulse compression, as such, does not introduce some proportionality improvement in system sensitivity, with matched filter receivers, whatever the transmitted pulse duration, the “sensitivity” remains a function of the ratio of the received signal energy to noise power density spectral.

(Strictly the cross-correlation function of the transmitted signal with that received, taking account of any “weighting” which might be used to improve signal sidebands, albeit at some expense to resolution.)

M. G. T. Hewetstone
Midhurst
West Sussex

THE FUNCTION OF FUNCTIONS

I was interested to read Thomas Reddams’ remarks (Wireless World, December, 1981) concerning the notion that a transistor is fairly prevalent, that denies the existence of sidebands in amplitude modulation. After all, with “pure” amplitude modulation the second sideband of the wave remains constant whether it be modulated or not, doesn’t it? Be it as it is the idea is not entirely dead even yet; there are still people to be found who hanker after it and may it be said that they are in tolerably good company, too, as anybody who has worked with sidebands and managed to check the file of Nature for 1930 (pp.92-3, 198-9, 271-3, 306-7, 726-7) in which for Antoine Fleming, no less which presides the existence of sidebands, declaring on the contrary that they are but a mathematical fiction, and stubbornly refusing to accept correction form his colleagues.

The curious thing about it all is that the sideband-driers have never had any difficulty in accepting that a baseband signal occupies finite spectrum space, not realising, of course, that a baseband signal it is but two (superimposed) sidebands, “centred” on zero frequency. A simple thought-experiment: place the carrier frequency progressively spaced from zero and observe the two sidebands separately emerging.

And consider further, that proper reconstruction of a baseband signal to (say) audio levels requires a series of repeated re-entertainment with the same carrier frequency, e.g. in the policing field of a loudspeaker or telephone receiver.

D. C. Sutherland
Wanganui
New Zealand

MICRO-CONTROLLED RADIO-CODE CLOCK

Several standard-frequency transmissions throughout the world provide time and data information controlled by caesium atomic clocks, with potential for automatic time and data information at reasonable cost. This design offers a reasonable cost, economy and complexity suitable for both non-critical professional applications and domestic use.

by N. E. Sand

Successful reception has been achieved with specialized equipment at over 3,000 km from the transmitter, but with simpler designs 750 km is a more realistic range. This design uses the slow code, which, for most applications, provides better results and requires less critical timing. The slow code format shown in Fig. 1 extends from second 17 to second 59 each minute. A logic zero is represented by a carrier break of 100ms and a 1 is represented by a break of 200ms. Other information, such as parity bits, is represented by a carrier break of 100ms displaced by 200ms from the parity bit.

Fig. 1. Slow-code format from Rugby MSF.

The 60kHz standard-frequency transmission from Rugby MSF now includes fast and slow time codes, both of which provide full time and date information once every second. The signal is transmitted 24 hours per day except for a maintenance period on the first Tuesday of each month. The transmitter power is 50kW e.p.i., which, with the long wavelengths, provides propagation over a range of several hundred miles. With careful circuit design, usable reception can be achieved throughout Britain, but there is a skewwave and groundwave component, certain areas can experience cancellation or addition where mixing takes place. This problem is complicated because of the areas of mixing for different time zones.

The code format is a logical progression from the slow code and the code is suitable for receiving on a time base.

Fig. 2. Hardwire block diagram.

by N. E. Sand

The function of functions

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Fig. 2. Hardwire block diagram.

by N. E. Sand

WIRELESS WORLD JUNE 1982


www.americanradiohistory.com
Fig. 3. 60Hz slow-coda receiver. The tuned transformer is wound on an RM6 pot-core assembly using LA4146 type ferrite. The long-wave receiver coil is wound on an 8 x 5/16in ferrite rod.
DIGITAL AUDIO SIGNAL PROCESSING BY MICROCOMPUTER

The author suggests that audio-frequency signal processing is the most recent area in broadcasting to benefit from digital technology. He lists the currently accepted digital sampling characteristics which limit the reduction of programme modulation noise, idle-channel noise, distortion and wow and flutter. The article includes a brief review of the development of microprocessors, compares analogue and digital processing and describes how companding is affected by the use of a microprocessor.

From the point of view of the broadcasting industry, there can be no doubt that digital technology carries with it numerous benefits to both listener and viewer, more than compensating for the additional complexity and expense of the signal origination and transmission plant involved. Those who possess or have heard demonstrated audio discs cut from a digitally recorded master tape can confirm the significant improvements in clarity and fidelity now available. This is in part due to the fact that the digital processing component here represents only a small part of the total recording/reproducing process. Further developments in laser optical recording may, in the future, finally resolve the contentious question of what truly constitutes 'high fidelity' audio by providing, for all practical purposes, absolute fidelity between recording studio and listening auditorium.

Digital audio characteristics

Reasons for the subjective superiority of digital audio over the traditional analogue equipment are its much reduced programme-modulation noise, idle-channel noise, distortion and wow and flutter. The magnitudes of these improvements are determined by the digital sampling characteristics, minimum standards for which are generally accepted to be, for broadcasting:
- Sampling rate: 32,000 samples/second
- Digital resolution: 14 bits/sample

Pre-emphasis and de-emphasis are not essential with digital audio, but give worthwhile improvements in high-frequency noise performance for signals possessing limited energy at the upper end of the audio spectrum. These standards provide for an audio-channel bandwidth to 15 kHz (provided that great care is taken in the manufacture of the anti-aliasing filter), and a signal-to-noise ratio of better than 85 dB. The needs of the recording studio, where the final output is derived from a large number of independent sources, are more stringent; hence the use of 16-bit sampling at the us between 48 000 and 64 000 per second in order to minimize signal degradation through the mixing processes.

ADC considerations

The following specifications figure under the reasons for the relative delay between the general acceptance of digital video and digital audio technology. For example, the "aperture time" required of an 8-bit, 5 kHz video sampling circuit, is only 20% shorter than that for a 16-bit 15 kHz audio sampler; but the precision of the audio circuit needs to be better by a factor of 256. Thus, although proprietary video analogue-to-digital converters (a.d.c.s) have been obtainable for the past three or four years, audio a.d.c.s with adequate performance have only recently become available. Table 1 shows the specifications of such a device. Although sufficiently accurate and sufficiently fast for broadcast-quality audio, this a.d.c. (in common with many other proprietary units) has the disadvantage of "offset-binary" digitally-coded outputs (see Table 2). This means that the most critical zone in its transfer characteristic occurs at the mid-point, where the digital output changes from 011...111 to 000...000. Since this is normally the quietest operating region, careful circuit layout and screening are essential to prevent digital-analogue crosstalk. A more suitable coding technique for digital audio is the sign-plus-magnitude arrangement, shown in Table 2, which has the effect of moving the most critical region away from the quietest operating point.

Digital-analogue converters (a.d.c.s) are usually less costly than the corresponding a.d.c.s, but can introduce non-linearity into the audio channel if their output circuits are "low-rate limited." This problem disappears if the d.a.c. output is re-sampled by a sample-and-hold device designed specifically for audio applications.

by J. B. Watson
B.Eng, M.I.E.E.

Table 1. Specification for a proprietary a.d.c. suitable for broadcast-quality digital audio

| Table 2. Comparison of offset-binary and sign-plus-magnitude a.d.c. output codes |
|---|---|
| Offset-binary code | Sign-plus-magnitude code |
| 111111111111 = -99997 volts input | 111111111111 = -99997 volts input |
| 100000000000 = 0 volts input | 100000000000 = 0 volts input |
| 011111111111 = 99997 volts input | 011111111111 = 99997 volts input |
| 000000000000 = -10000 volts input | 000000000000 = -10000 volts input |

- Independent Broadcasting Authority

The offset-binary code is easier to implement in hardware, and is the one most commonly used in proprietary a.d.c.s. The sign-plus-magnitude code may be more suitable for an audio a.d.c, but suffers the disadvantage of two equal-vality codes for zero input.
Signal processing by microcomputer

Before considering in detail the type of audio processing possible with microcomputers, it may be instructive to consider the history of the development of these devices since their introduction about eight or nine years ago. Table 3 summarizes the characteristics of three generations of general purpose microprocessors starting from a single manufacturer, the demarcation being based on the introduction of the fabrication of the silicon chip by p-channel, n-channel and h-mos technology. Details of a program of these processors are provided. Of particular relevance to audio processing are the accumulator (16-bits), instruction cycle time and interrupt response time (latency).

First generation processors (1974-1976)

Second generation processors (1976-1980)

Third generation processors (1980-present)

Digital companding

An example of the type of digital companding processing now possible has occurred in signal compansion and expansion (companding). Analogue companding is used extensively in the magnetic tape recording of music, where it provides an improved signal-to-noise ratio, as well as a high dynamic range. The wide spread acceptance of the Philips cassette as a satisfactory medium for domestic audio recording, largely due to the adoption of Dolby or similar companding techniques.

Analogical systems of this type separate the incoming audio signals into several frequency bands, each channel during recording being compressed by amounts depending upon the mean level present in each appropriate spectral band. The accuracy of the reciprocal expansion is seldom perfect, since great reliance is placed on carefully matching the filters, time constants and level-adjusting networks, in the record-playback chains.

The processes involved in digital companding are, on the other hand, accurately reversible. The degree of compansion introduced by the encoder is transmitted, together with the audio sample values, along a separate time multiplexed channel to the decoder. No gain error or constant mismatch errors occurring, but a degree of predistortion or modulation noise is introduced. The magnitude of which is governed by the type of digital companding used. Many early systems used linear companding apparently worsen the audio signal-to-noise ratio, whereas analogue companding systems of this type are characterized by the different areas of application in which the two techniques are equally efficient, i.e., the use of digital audio equipment increases.

"Near-instantaneous" companding means high quality, high dynamic range, high channel capacity, and thus achieves a lower level of modulation distortion. By deprecating the said "near-instantaneous" factor related to the peak amplitudes of groups of audio samples, rather than to individual sample values, more complex hardware configurations are available for accurately resolving the signal levels. In two systems recently proposed, groups of samples representing a duration of approximately 1 ms are examined before defining the degree of companding appropriate to the given level. Subsequent discussion of the operation of a simple 'A-Law' instantaneous companding system illustrates the point.

Table 4. 10-A law companding

<table>
<thead>
<tr>
<th>Sample</th>
<th>Factor</th>
<th>Peak Level</th>
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<tbody>
<tr>
<td>0</td>
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<td>10</td>
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</tbody>
</table>

In both analogue and digital companding, as sensitive ears can detect, the noise is there, therefore, no paradox.

Many different types of digital companding have been proposed, these being within two main categories of 'instantaneous' and 'near-instantaneous' or "quasi-instantaneous" (or "on demand") systems. In the latter category, the principle of a simple "A-Law" instantaneous companding system illustrated in Table 4 indicates the use of a 14-bit per second sample audio signal. The companding algorithm is simple and very efficient. The position of the most significant 'I' digit in the 14-bit data word is a measure of the signal magnitude, within a 2:1 A:Law code representing the number of leading (more significant) bits in each word is transmitted with the word, the leading zeros and the most significant 'I' being suppressed. The advantage of this form of companding is that a single bit word is transmitted with a precision of seven bits, with the least significant bits incurred.

The resulting signal comprises ten bits per sample, three bits of which are an estimate of the level, within a 2:1 range, and seven the more precise magnitude within that range. One of the seven bits indicates the signal polarity. Digital sample values with more than five leading zero bits are therefore expanded without loss of resolution. For signals which are close to the form of a truncation of the less significant bits, giving rise to certain error problems, certain programme modulation noise listeners accustomed to the high sound quality recordings produced on these types of systems observed that, with experience, their threshold of tolerance to modest signal levels drops, although the acceptable standards of performance based on subjective tests may, therefore, be higher.

In the measurement of a digital data stream, the sample is digitized using the 8-bit DAC and the resulting sample value is compared with the 8-bit input. The resulting sample value is compared with the 8-bit input. The resulting sample value is compared with the 8-bit input. The resulting sample value is compared with the 8-bit input.
by the 74148 priority encoder in Fig. 1. However, the usual benefits of software compensation are shown in Fig. 5. Correctness and reliability, apply to the remainder of the data processing hardware. An interesting feature of this arrangement, and one that less hardwired is required for 'near-instantaneous' compensating than for the A-law algorithm, i.e. a reversal of the usual situation.

The system operates on three distinct blocks of data, audio sample words originating from the a.d.c., stored words awaiting analysis, and output data for the expander logic arrangement (not shown), but similar in concept to the compression circuit of Fig. 1). Both input and output data streams communicate directly with memory via direct-memory-access (d.m.a.) channels. D.m.a. management is performed by the 8257 chip, which receives 'data requests' from the currently active peripheral and responds with 'data acknowledge' when the computer has disabled its bus signals. Data transfer then takes place, and the memory pointer for the channel in use is incremented. A time penalty of about one microsecond is incurred while the computer data and control buses 'freeze' during the transfer, in comparison with the several microsec-

conds necessary for conventional input/output procedures. However, because of the automatic address incrementing performed by the d.m.a. controller, new address pointers have to be entered before the selected location exceeds the available memory space. It is consequently manipulatethe audio samples in blocks, and to re-initialise the d.m.a. controller at the end each block. The execution time of the software routine controlling this function must, of necessity, be shorter than the assigned time interval, otherwise samples could be lost. This segment of code is therefore designed around register manipulation instructions which are much faster than memory accessing operations.

Software for the companding system, capable of rapidly switching between 14-bit linear (uncompressed), 14: 10 A-law and 14: 10 non-linear instantaneous companding algorithms, occupies less than 1000 words. Subtractive tests of the system have confirmed that the effect of 14: 10 digital companding, whatever the algorithm, is indiscernible within normal program material, but discernible when pure tones are transmitted. Results from other workers in the field show that 14: 10 near-instantaneous companding provides a standard of performance virtually identical with uncompanded sound. This is likely to be of great importance for satellite transmission, where significant savings in capital plant can be achieved if more channels can be accommodated within a given bandwidth.

Future techniques

Voice synthesis by microcomputer is a rapidly developing technique, especially for electronic toys and games. Most such devices currently available appear to possess American or Japanese accents, so revealing their places of origin. Economy of storage and audio bandwidth is afforded by mass-cultivating voices, but this is likely to become a minor consideration as the cost of memory chips continues to decline. Solid-state recording of high-quality musical performances is a more difficult matter, unlikely to be solved by the silicon chip for many years hence. For example, the recording of Beethoven's ninth symphony would require a digital storage array approximately 2000 megabits. Current prices of memory chips would need to fall by a factor of 100 000 to render viable any such scheme. Meanwhile, more traditional devices such as magnetic tape, hard-disc storage and the newer ' Winchester disc ' continue to improve in performance, possibly rivaling the storage density achieved by laser-optical techniques.

In the digital processing area, one of the more interesting new devices to emerge is the Intel 2920 processor. This comprises an analogue-to-digital converter, a signal processing computer and a digital-to-analogue converter, all contained on a single silicon chip. Current technology limitations restrict its operating frequency to about 14 kHz. However, speed improvements to at least five times that figure, whereby it would admirably suit the needs of the digital audio engineer, can now be expected.

References


Based on an article first published in IIRA Technical Reviews, No 13.

Fig. 1. Digital audio compression system. Compression is effected by shifting the digital samples left towards the most significant bit by an amount equal to the number of leading zeros in the data value. The 74148 priority encoder locates the position of the most significant ' 1 ' bit and produces a 3-bit code which is then decoded by the LS138 and applied to two 8 X 8 multiplier chips. These multipliers, together with the multiplier combiner, shift the input data word by the required amount.

Fig. 2. Microprocessor system for digital audio companding. Digital companding experiments can be undertaken with a relatively simple microprocessor system. The hardware configuration shown employs 1X X 8 bit d.m.a. and 2X X 8 d.p.r.o.m. 14-bit audio samples are processed as 8-bit word pairs.

Fig. 3. Continued from page 54.

The hardware shown in Fig. 4 has been kept as standard as possible to reduce the overall cost, and the memory map for this arrangement is shown in Fig. 5. Circuitry for decoding IC2 and IC4 provide 1X of r.a.m. for essential variables, the stack in pages 0 and 1, plus spare areas in pages 2 and 3. The r.a.m. is not fully decoded and appears throughout the bottom half of the 64K address space. An e.p.r.o.m. containing the firmware is assigned to the top 2 or 4K of memory with address decoding provided by IC5 for an expanded system. Wire-Oring of the address decoder outputs provides address options. Circuitry 15 is enabled at 0000 (hex.) to provide sub-select outputs for display drivers and a versatile interface adapter.

The system clock is provided by a 1MHz crystal oscillator using unbuffered c.m.o.s. gates. This also provides the timing for a back-up system and is trimmed for best results in this mode. Power-off reset is provided by two Schmitt inverters which allow the power supply to stabilize before the program is initiated. A potentially troublesome source of inrush current is in the receiver channel in use is incremented. A time penalty of about one microsecond is incurred while the computer data and control buses ‘freeze’ during the transfer, in comparison with the several microsec-

Fig. 4. The system shown in Fig. 3 has been expanded to include a ' Winchester disc ' for an expanded system. The necessary hardware additions are shown in Fig. 7. IC2 provides address decoding for one channel, and IC5 is necessary to buffer the 6502 data bus. As well as displaying time and date information, the evaluation system can be used with other equipment via an RS232C interface which transmits ASCII information. The necessary hardware additions are shown in Fig. 7. IC2 divides the 1MHz clock to provide a 2,400 baud generator, and IC9 converts the serial data from the i.v.a. to an RS232 level.

Part two of this article describes firmware, construction and testing. A complete kit of components for this design will be available from Circuit Services, 5 Elmbridge Drive, Radipol, Middx (telephone Radipol 76962).

Fig. 5. RS232C generator and level translator.
Clock-triggered triangular pulse generator

A double pulse is applied to the inverting input of a TL081 operational amplifier connected as an integrator and a triangular pulse is obtained at the output. The required double pulse is formed by two direct voltages -5 V, +5 V, applied to the integrator input via a pair of analogue switches. Two D-type flip-flops control these switches. The two flip-flops are triggered by the rising edge of the clock pulse applied to their clock inputs. When the clock pulse triggers the two flip-flops, the first flip-flop's Q-output becomes equal to 1 and the Q-output of the second flip-flop to 0. Consequently, one switch is enabled and the other disabled. Thus an input voltage equal to -5 V is applied to the integrator. When no input voltage is applied to the integrator, V_{out} = 0. Then, V_{in} = -5 V and V_{out} increases; when it equals the reference voltage V_{ref}, the output of the comparator goes high, and the first flip-flop's Q-output is reset to 0, while the second's Q-output is set to 1. Thus the switches change state, so that V_{in} = +5 V and V_{out} decreases. When V_{in} = V_{ref} = 0 V, the output of the second comparator goes high resetting the Q-output of the flip-flop 2 to 0. So both switches are disabled, and no input voltage is applied to the integrator. Consequently V_{in} = 0 until the next rising edge of the clock pulse triggers the flip-flops. The duration of the triangular pulse is \( T = \frac{2V}{V_{in}} \), where \( V_{in} = 1/RC \) is the time constant of the integrator.

Auto-zero for digital meters

Digital panel meters using I.C.S such as the ICL71067 already have internal auto-zero circuitry, but this is of no use when a particular instrumentation case requires amplifiers or signal conditioners prior to the d.p.m. Offset in op-amps drifts with temperature so an automatic system for correcting it is desirable. In the circuit given, box A represents circuits to switch the instrumentation amplifiers B between the input to be measured and a zero reference level. At the same time, the output of the amplifiers is switched between the sampling capacitors so that one holds the amplifier input plus offset, and the other holds the offset only. The differencing action of the d.p.m. cancels the offset voltage. Clock frequency should be higher than the sampling frequency of the d.p.m.

Preamp with no t.i.m.

Circuit shows a stable small-signal pre-amplifier with passive magnetic pick-up equalization but without overall negative feedback. At 1 kHz, the circuit has an overall gain of 50 and its input and output impedances are 47 k and 1.7 kΩ, respectively. Peak-to-peak maximum input and output voltages are 0.5 and 25 V respectively.

Shaunus Yung
National Chiao Tung University
Taiwan

24-to-12-hour clock decoder

A digital clock may have a 24-hour display, which many people would find less preferable to the more normal 12-hour display. For example, the time-coded radio signals from Rugby work on the 24-hour clock.

The circuit shown is an economical decoder of b.c.d. 24-hour information (0 0

Mr Malvar's 'Accurate motor speed control' (WIRELESS WORLD Circuit Ideas, August 1980) described a circuit in which the effect of motor armature resistance was cancelled by using the armature current to provide positive feedback to the drive amplifier.

The amplifier used a booster transistor which entailed the motor stepping under open circuit conditions.

Accurate motor speed control is often required with a fast stop/start, and this can be achieved by the addition of a transistor complementary to the booster transistor. The circuit shown as a result, this can be achieved by the addition of a transistor complementary to the booster transistor. The circuit shown as a result, this can be achieved by the addition of a transistor complementary to the booster transistor.
Digital frequency synthesis is now commonplace in commercial transceivers. James Bryant discusses the design of programmable counters and prescalers for v.h.f. and u.h.f. synthesizers using a family of frequency synthesizer ic's. He includes a description of a basic computer program which will design dividers for v.h.f. and u.h.f.

by J. M. Bryant
B.Sc.

A basic frequency synthesizer, shown in Fig. 1, consists of a voltage-controlled oscillator, programmable divider, phase detector, low-pass filter and a stable reference frequency source. The v.c.o. and l.p.f. are the most critical parts of the design, and the v.c.o. must be isolated from the output and the input to the divider. Operation of the synthesizer is straightforward: the v.c.o. output is fed to the programmable divider and then compared with the reference signal in the phase comparator, whose output controls the v.c.o. The system is therefore a locked loop acting to maintain the divider output in phase with the reference input. The v.c.o. frequency is stabilized at n times the reference frequency, i.e.

F_{vco} = n \times f_{ref}

where n is the division ratio of the programmable divider. If n is altered by unity, the v.c.o. output will change by F_{vco}, so a synthesizer can generate several channel frequencies which are multiples of the reference frequency. In v.h.f. and u.h.f. synthesizers channel spacings of 5 to 50 kHz are normally required, although synthesizers with channel spacings down to 1Hz or less can be built but these would normally use multi-loop techniques.

Although the v.c.o., phase comparator and l.p.f. can be built using discrete components, in a complex circuit such as the programmable divider the use of ic's is essential. Unfortunately, current integrated-circuit programmable dividers use c.m.o.s., n.m.o.s. or t.i.l. technology and are unable to operate at frequencies above 25MHz, a much higher limit in the case of Schottky (u.h.f.) which is not nearly high enough for v.h.f. or u.h.f. synthesizers.

One solution to this problem is shown in Fig. 2 where a fixed v.h.f. or u.h.f. prescaler with a division ratio of m is inserted between the v.c.o. and the divider. This reduces the output to a frequency which the programmable divider can accept, but it also introduces several other problems. However, because fixed dividers using c.i.l. technology are available with input frequencies up to 1.8 GHz, this system is often used in commercial equipment. Two

Fig. 1. v.c.o. frequency is stabilized at n times the reference frequency in the basic synthesizer. Several frequencies can be generated by altering n.

Fig. 2. Including fixed prescaler in divider loop allows v.c.o. to operate at frequencies higher than c.m.o.s. or r.o.l. logic allows.

Fig. 3. To avoid some of the problems with the fixed prescaler technique the v.c.o. is mixed with a frequency F_{m} and the difference applied to the divider.

system performance (noise in the reference oscillator is less important because F_{vco} is usually divided from the reference oscillator) and the system is more complex. Nevertheless, many synthesized transceivers use this technique.

A better system, known as a multi-modulus prescaler, is shown in Fig. 4. The simplest form uses a two-modulus prescaler (sometimes called a swallow counter) and when the system starts counting, the two programmable counters are reset to zero. The prescaler divides the v.c.o. output by m+1 and its output pulses increase both programmable counters. When the counter reaches a, the prescaler modulus is changed to m and the a counter stops (at this point a/m+1 is then the number of cycles which have been counted). The m counter continues to count the prescaler output until it reaches n and passes a pulse to the phase comparator. Both counters are then reset, the prescaler resets to (m+1) and the cycle restarts. In the second half of the cycle, the system counts (a-b-m) cycles of the input frequency. Therefore, a full cycle of the counter delivers one output pulse for each a(m+1)-m+1 cycles of the input, so the division ratio is m+1-n.

The complete system forms a v.h.f. or u.h.f. programmable counter, but the two programmable counter only operates at a few MHz which enables c.m.o.s., n.m.o.s. or t.i.l. devices to be used. Also, although two programmable counters are required, they are simpler than the v.c.o. and the overall complexity is only slightly greater. There are, of course, drawbacks. The division ratio of a two modulus prescaler will normally be between 10/111 and 100/101, but ratios of over 2041:1 are required at v.h.f. if the programmable counter input frequency is to be low enough for c.m.o.s. or n.m.o.s. devices.

For an m+1-n-1 prescaler the a counter

Fig. 5. Four-modulus prescaling overcomes the limitation on lowest frequency of Fig. 4.

Fig. 6. Synthesizer type NJB811 is made from n.m.o.s. to reduce power consumption but it also reduces chip size and the number of diffusions required.

Fig. 7. Although NJB811 and NJB812, above, will generally be programmed by a r.o.l. and channel switch they are compatible with microprocessor-based systems as well.

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must be programmable over a range of n and the counter must always divide by a larger number than the channel spacing. Therefore, to be fully programmable, the total system division ratio must be equal to, or greater than, n. This is a lower limit frequency for such synthesizers, for example, with 25kHz channel spacing and a 40/41 prescaler the minimum division ratio is 40 so the minimum frequency is 400kHz.

Generally, the programmable counter sets a limit which is higher than the theoretical minimum. If wider tuning is required, four-modulus prescaling can be used. A typical system is shown in Fig. 5 with two 25kHz modules, n成立 + k, where k is limited in terms of the ratio limit which are, a must count over a range of k, and n must count at least the minimum value of n or k. For a 55/56,63/64 prescaler, the division ratio limit is 512, which allows a 25kHz channel synthesis above 12.8 MHz. Again, in a practical system, the programmable counter will usually set a higher minimum. The overall division ratio of the VHF module n成立 + k is a large factor how the channel spacing is divided into the final output frequency. The counter must be programmed to avoid division overflow.
Sinclair versus BBC

When the BBC announced that they had selected Acorn to produce their microcomputer, Clive Sinclair was furious. He said that he could offer "any facilities that the Corporation might require at a lower price than any competitor." The Sinclair ZX Spectrum is his attempt to prove it and he recently launched it as "not the BBC Computer". In his promotional literature he lists features included on the Spectrum and compares them with rival colour-display computers in an attempt to prove that the Sinclair can out-perform the others, especially the BBC model A, at less than half the price.

As he has invited the comparison, it is worth taking a closer look at both the BBC model A and the ZX Spectrum. The first obvious difference is the keyboard. The BBC has a conventional typewriter layout with 73 keys including ten user-definable function keys. The Spectrum has 40 keys and some have six functions which involve extra shift keys to get the required function. This is easier by the more compact keyboard entry of all the basic keywords available. Unlike the miniature keyboard of the ZX81, the Spectrum has multiple keys at type-writer pitch, but instead of concrete full-sized keys they are in the flat, calculator style.

The Spectrum offers eight-colour graphics with a resolution of 256 pixels x 192 pixels modes are user definable. The BBC A has a choice of modes with four-colour graphics, 160 x 200 pixels and 30 x 32 characters. Higher definition is possible on the BBC A at the expense of using fewer colours.

The Sinclair has overcome one of the major bugs in the BBC A, the flaw in the keyboard and saving programs and data onto a cassette recorder. The Spectrum has a cassette interface that records a tone onto the tape whenever the computer automatically adjusts to the tone so that the correct input level is set. This overcomes the automatic recording level fluctuation problem. The BBC A uses a test tape to tell the operator when the recording level is correct after it has been adjusted manually. Spectrum can have a program faster at 100 baud compared to 1200 baud.

Using a BEEP command, the Spectrum can generate sound which may be controlled in pitch and volume. The program can be written in BASIC to allow music synthesis with full envelope control. The ZX Spectrum offers much the same high resolution and graphics capabilities, without the costs, as the BBC, and can reproduce anything displayed on it.

Model A has no printer interface – it is only available on the enhanced model B. An input/output port is available for the Spectrum and not for model A.

The BBC computer uses a version of Basic with a very large number of keywords. The ZX Basic is an extended version of the ZX81 but has fewer keywords than the BBC. Some of the more useful keywords available to the computer are AUTO for automatic program line numbering and GOTO, which is stored on the program that has been released from memory by NEW. There are about 30 other keywords which are not available on the Spectrum. However, there are some on the Spectrum which are not available in model A, especially VERIFY which can compare a program which has been saved with the original; and MERGE which can combine a program being loaded with another in the memory. The BBC seems to have more powerful file-handling facilities. In practice, both computers will be able to perform similar functions but the Sinclair may need some additional steps in the more complex programs.

The memory (r.a.m.) capacity of both machines is the same at 16k and, while the BBC may be expanded to 32k, the Sinclair can have 48k. The Sinclair claims to have more efficient memory 'packing' so that more r.a.m. is left available when using high resolution graphics.

BBC model A may be enhanced to model B and then has a very wide choice of extra facilities, analogue inputs, serial and parallel ports. An 8-bit Centronics printer port, teletext and teletext buffered extension box, Red, Green, Blue, and sync, outputs and a disc memory filing system. So far the Spectrum will operate the ZX printer. An RS232 serial interface board is to become available soon, as are the Microdrive – miniature microdisk drive devices which will hold up to 1024kbytes of data. Eight of them may be linked together. Each Microdrive will cost about £30. The prototype Microdrive demonstrated by Sinclair recently was only about 7mm wide, so the disks are very small.

When we come to compare the prices, the Sinclair has the distinct advantage. The basic model costs £125 and the 48k memory model, £175. BBC model A costs just under £300 and model B, £400. The Sinclair ZX81 attracted a wide variety of peripherals from other manufacturers: at a recent computer fair there were demonstrations of high resolution graphics, interface for all kinds of equipment including full-size parallel printers, music synthesizers and even colour graphics. If the ZX Spectrum attracts similar support from these manufacturers, or others, it seems there could be few limitations to its abilities while remaining within the price-range set by its rival.

Meanwhile, Sinclair Research will continue to produce and sell the ZX100. 400,000 have been sold in a year and Mr. Sinclair believes that it is still the best introduction to computing for those unwilling to undertake a higher financial commitment. The price of the add-on 16k r.a.m. has been reduced to £30 but the ZX printer increased to £60. Despite the high profits of Sinclair Research over the last year, Sinclair is looking for more capital to finance some of their other activities including Clive Sinclair's pet project, an electric car. For this he is investigating the possibility of selling some shares in the company.

Sinclair may not lead the low-cost colour computer market for long. It is rumoured that Acorn, the makers of the BBC computer, are to produce their own colour device, the Electron, for about the same price as the Spectrum.

Flat-screen scope

It is often forgotten that liquid crystals are a British invention and that their development at the Royal Signals and Radar Establishment earns the UK royalties from all over the world. The earlier 'twisted nematic' LCD used in digital watches and calculators needed polarized light to make them visible, but the new 'phase change' LCD always use the optical properties of dyes, which are dissolved in the liquid crystal, which makes them brighter and not subject to the banding effects which are visible in the earlier type. The development of these displays has enabled them to be made much larger. This, however, has led to problems in addressing and driving the display elements. Time division multiplexing may be used but the limit has been achieved in a message display with four lines of text.

Oscilloscope displays are functionally similar to produces in the information displayed is similar in form than that presented on message displays. It is usually necessary to distinguish only one element in each column for a waveform to be displayed. The method invented by Dr. has Shanks of the RSRE uses row and column drive waveforms which are divided into discrete time.
periods. In each period the drive waveform is either on or off associated with the logic states '1' or '0' respectively. The drive waveform is therefore binary and the sequence of logic states may be repeated every 30mS. The waveform can be supplied by standard c.m.o.s. logic circuits, unlike magnetic displays which need special decoder/drivers. Unfortunately direct voltages cannot be used to drive liquid crystals. They would cause chemical decomposition. This problem is overcome in the 'scope display by generating pseudorandom binary sequences in the drive waveforms. A different waveform may be applied in each row of the display. Any of these a different set of waveforms are also applied to the columns. Only when the same waveform is applied to both row and column in the matrix will there be no voltage difference and so that element will be 'off'. As there will be a voltage difference on all the other elements in the column, they will be 'on' and therefore distinguishable. The vertical height of the 'off' element is determined by the choice of waveform for that column and this is in turn determined by the value of the sample taken from the input signal waveform. As the 'off' element depends on zero voltage difference, the device is not sensitive to voltage changes caused by temperature and full performance is maintained under a variety of conditions.

A display using this system was incorporated into a prototype oscilloscope at the RR&E, Malvern, with a 100 x 100 element matrix. In 1977, the NRDC advised Sopdet to see the world at Malvern and this has eventually led to the development and production of the first commercially available set of oscilloscopes. The Scopex Voyager has a 125 x 256 element display with a graticule - for convenience. The backplane is 6.1c in 1590Enter explored eight times for each cycle of the waveform and the backplane is set at digital using a successive approximation method. The bit digital words so produced are written into a r.m.a. in a location which is selected in position in relation to the timebase of X-axis of the instrument. The contents of the r.m.a. in particular addresses are used to define the pseudo-

random binary sequence waveform for the column corresponding to that address and thus the vertical level of the display element. Waveforms can be up-dated or held in the r.m.a. This gives a stable image to the display which does not flicker or fade. A 'cursor memory' function allows a waveform to be stored after the instrument is switched off. Waveforms from the instrument may be compared using the dual-trace function. There is also a pre-trigger function. The use of an external timebase or X input converts the oscilloscope to an XY plotter. At the analog input end of the scope, Scopex have retained their 'easy to use' philosophy, making it smaller and with lower power requirements than conventional instruments.

The Datakey contains an e.a.r.o.m. chip on a keyring, it is virtually indestructible and the content of the memory is not affected by electromagnetic fields.

The Scopex Voyager oscilloscope is the first commercially available to include a flat f.t.c.d., making it smaller and with lower power requirements than conventional instruments.

Memory key

Plastic credit cards can be damaged or stolen, the magnetic strip information can be copied and is limited in the amount of information that can be stored. An alternative has been produced by a manufacturer of plastic cards, Data Card International, which is a plastic key incorporating an electronically alterable read only memory (e.a.r.o.m.). The memory has a capacity for 300 characters and the key is used in conjunction with a keyholder or 'Keypilot' - a micro-controlled interface unit which allows the contents of the key to be communicated to a host computer. The Keypilot also 'manages' the data so that the most efficient use is made of the memory.

The system is inherently secure as the details are entered at random. Sections of the data may be protected by access codes and the memory is sufficient to contain a variety of details or personal data known to the keyholder. If anyone were able to copy the key, it would be no good without the knowledge of the appropriate codes.

The Datakey, as it is called, can be used for access to areas or machines that are secure against unauthorized users in much the same way as a plastic card. It has many additional uses as it can contain a programme for almost any type of operation. This could be used for work and time logging, monitoring patients or scientific test results, etc. A particular advantage of the system is the ability to store the data in the contents of the memory. It can hold details of staff, staff or patient medical history, etc. Other tokens may be added to or subtracted from in the same way. In the same way, it enables it to be used as a credit card to be used with a variety of vending or dispensing machines. An example is the dispensing of petrol at a pump controlled by the key.

A further example of the use of the key is the storage of instructions for a machine tool. A change of key instantly changes the instructions set without the need for re-programming or loading punched tape. Keys may be used in combination with one key specifying a product type while another may hold details which may vary within the type.

A Dendsley development system, including a number of the keys and a keyboard-display programing unit, is available to OEM customers.

In brief

80% useful energy conversion is claimed for NASA's latest fuel cells. Forty-five fuel-cell plans each housed in cabinets 2.7 x 1.5 x 2m and capable of generating 40kW, are to be installed experimentally in various locations around the U.S.A. The fuel cell power generator produces electricity from hydrocarbons by first converting to a hydrogen-rich fuel and then feeding it to one electrode in a cell of phosphoric acid electrolyte, while the other electrode is fed with oxygen. The cells produce heat as well as electricity and if the heat is used for heating homes or commercial buildings, the combined output of electricity and heat represents an energy conversion factor of about 80%. This compares with about 30% energy conversion from conventional electricity generators.

In brief

Home Radio (Components) have moved to 169 London Road, Mitcham, Surrey; their address for postal enquiries remains at PO Box 92, 215 London Road, Mitcham. They may be contacted by telephone at 01-648 3077.

Thomas-CSF claim the world's fastest integrated circuit operating at room temperature, an 11-stage ring oscillator with a gain delay of only 22 picoseconds. Scrounged from gallium aluminum arsenide/germanium arsenide junctions, the molecular-beam epitaxial process used is capable of controlling the crystal growth of the various layers down to the thickness of a single atomic layer.

On 5th April, a 'magazine' called Electronic Insight appeared on Prestel. This intention is to provide news, comment, product information and advertising concerning electronics and associated technologies, for users. The potential exists to update the magazine - 24 hours a day - and readers can pass from product news to product feature to manufacturer's chart to stockists and retailers quickly. The magazine's editorial and comment "maintains a fully independent view", says the publishers.

Intelsat VI - a new series

Five new Intelsat telecommunications satellites will offer three times the capacity of the current series V, and will be in operation by 1987.

The satellites are to be built by the Hughes Aircraft Company who will be joined by an international team of subcontractors. British Aerospace has a major role with about £50 million worth of orders over a seven-year period. After the initial five there is an option for double additional spacecraft.

Each satellite will be nearly 12m tall and 4m in diameter with a weight of 1,800kg. The solar panels will generate 2,000kW to power up to 33,000 two-way telephone channels and four to six television channels.

The spacecraft has been designed for launching by both the ESA Ariane and the NASA space shuttle. As the shuttle does not reach the required altitude for geostationary orbit, there needs to be an additional booster stage and a system for launching the satellite from the shuttle. NASA will design and build the payload for launching the spacecraft in the shuttle bay. This will include electronics units and the power and signal interface which connects the shuttle and spacecraft. They will also design and build the C and Ku band dish reflectors, other structures and wiring harnesses.

British Telecom has the second largest share in the International Telecommunications Satellite Organisations of which there are 16 members. The new satellites will help BT meet the demand for international telephone calls which grows at a rate of more than 20% each year.

Sir Kenneth Corfield (right) receives the Royal Charter of the Engineering Council from John Wakaham, Under-Secretary of State for Industry. The Council was set up as the result of the Finston Report to act as an engine for change in shifting national attitudes and priorities. The new Council will take over most if not all of the executive functions of the Council of Engineering Institutions, especially the supervision of the training and qualifications of engineers. The C.E.I. has agreed that 'when the time is right it will seek agreement of its members to transfer the Engineers Registration Board. The right time depends on the Engineering Council's situation, and is likely to be in about two years. If the new Council assumes all the functions of the C.E.I., then the C.E.I. is 'undoubtedly wind itself up', according to Bryan Hildrew, the retiring Chairman of the C.E.I. in his foreword to the C.E.I. Annual Report.
LEAKY FEEDER COMMUNICATION INTUNNELS

Since the earliest days of radio – and certainly before the advent of broadcasting – attempts have been made to apply it in many local communication apparatus on the days of natural propagation of the waves. All these efforts were doomed to failure, and the reasons are now well understood: radio waves cannot propagate usefully in such conditions by any natural means.

Radio waves cannot propagate naturally to any useful extent, but there is a limitation of waves to penetrate rock or other strata. This property has recently been thoroughly investigated in the United States and exploited in the development of equipment intended for possible communication with scattered miners from the surface.

Through-the-earth ranges of up to 300 m have been demonstrated, but speech modulation is not practicable at the very low frequencies necessary and so the system used was short-wave radio-frequency carrier system (for the 'downlink') and a coded carrier (for the 'uplink'). The system has not yet been fully studied but demonstrated for British mines, where average depth is greater and mining conditions are highly variable, with equipment operating at slightly higher frequencies and using speech modulation.

Wyke and Gill themselves drew attention to the possibilities of inductively coupled communications, which had been discovered in the search for radio waves in the range 15 to 150 kHz and relying on 'guiding' by any conductors present, such as power cables and telephone lines. Suitably equipped was, overall, developed over the next decade or so and became a standard attachment to underground locomotives and cable-hauling m.s.e. trains. Generally, it was found sound while to install special well-positioned conductors or guide-wires for the purpose. This means, reliable communication over distances of a kilometre or so could be obtained, especially if the conductor wire were galvanically connected to the base station and only relying on part coupling existing there.

While fulfilling an important mine communications, the inductive equipment never achieved any success as a two-way personal system. The reasons for this were that the oscillators were uncontrolled, having a large range, and the frequency. Wave conditions were for the oscillator and receiver powers required (about 5 W and 500 mW respectively), resulting in fewer types of couplers and common loop or frame systems being used, and the need for fairly close coupling. The oscillator was a key factor in this.

In 1955 Wyke and Gill reviewed the situation in the United States and their communication papers and their paper gives many interesting references to the earlier experiments. One such investigator, in the absence of a technical scientific attitude, found the inductive coupling 'as useful means of communication'.

The key to the revolution in underground communications came in 1956 with the publication by Monk and Wainscoat. In this paper, they showed how v.h.f. radio communication had been successfully maintained with a moving train in a long railway tunnel. Following a logical idea, they first installed a standard coaxial cable (RG-8U) through a section of the tunnel, connected to a normal base station at one end and having dipole aerials bridged onto it at frequent intervals. This worked extremely well and so the spacing between the aerials was then increased gradually until they had all been removed; good communication was still maintained throughout the length of the tunnel, although it had not been possible before the installation of the cable. It became clear then, that the communication was through the stray fields of the cables and waves, not through the use of what is now known as the 'feeders' or 'leaky cable' principle.

The realization that the cable itself was providing the necessary fields, the obvious next step was to substitute the cable known to have a higher leakage, and so a change was made from the coaxial to an unscreened two-wire line, a rather heavier version of the 'ribbon feeder' or twin lead.' Then in common use for television downleads. This was also a more economical type of cable to use in terms of longitudinal attenuation for weight of copper.

Following this pioneering work of Monk and Waiscoat, the leaky feeder principle was applied for communication in several American underground railway systems, notably the New York Subway. Subsequently, the author has been involved in applying leaky feeder systems in the UK and internationally, with the leaky feeder concept being used in the UK since the 1950s.

The author

Since graduating as a physicist at King's College, University of London, R. Martin has run the gamut of the spectrum. He joined the National Coal Board (BNR or the Sile Institute) he developed new techniques in low-level d.c. electronics. He was appointed to the National Coal Board, BSNL (now the Sile Institute) he developed and used new techniques in low-level d.c. electronics in the design of base stations and control systems for the National Coal Board's radio telephone network. In 1955 he was appointed to the National Coal Board, BSNL (now the Sile Institute) he developed and used new techniques in low-level d.c. electronics in the design of base stations and control systems for the National Coal Board's radio telephone network. In 1955 he was appointed to the National Coal Board, BSNL (now the Sile Institute) he developed and used new techniques in low-level d.c. electronics in the design of base stations and control systems for the National Coal Board's radio telephone network.

The leaky feeder principle

The basic leaky feeder principle is illustrated in Fig. 1: It is a conventional two-way telephone system, however, the feeder, installed throughout the tunnel or environment where communication is required and connected to the base station in lieu of a normal aerial; M is a conventional two-way mobile or personal radio system, communicating with the base station through the leakage fields of the feeder. Thus, to add to the base station and the mobile is made up of two components: (a) the transmission loss with feeder loss, and (b) the coupling loss which is measured between the base station and the region of the feeder in the vicinity of the mobile; and (b) the 'coupling loss', which is measured between the same region of the feeder and the aerial terminal of the mobile set.

Note that no assumptions are made here about the direction of transmission; the overall path is truly reciprocal, and so the principle is valid equally for mobile-to-base as for base-to-mobile communication. However, the processes involved are perhaps easier to visualize as operating in the base-to-mobile direction, and so consideration of them is most usually from that point of view. Much of the theoretical work on the subject is similarly oriented; experimental observations, on the other hand, are often more conveniently based on the reciprocal path, with a mobile source inducing signals into the feeder. Reciprocity, of course, applies to the signal transmission only, and excludes the effects of any external interference or internal noise sources in the path; this, of course, is important when system aspects are considered, and will be covered in Part 2.

It may also be noted in passing that a leaky feeder may be used to allow direct communication between mobiles, without the intermediate of a base station. In this case the feeder operates in a purely passive way, and no transmission losses are involved in the path. This form of use was the basis of the pioneering Belgian work.

Consider now the separate loss components as in Fig. 1. The feeder is basically a transmission line, in spite of its leakage, and so the signal within it will decay exponentially with distance, i.e., the loss in dB will be directly proportional to the distance.

Generally, the transmission loss will still be largely determined by the inherent copper and dielectric losses, the loss is contributed little, and so a heavier and thus more expensive cable will give correspondingly better performance in this respect. It may also be noted that the attenuation rate is a stable characteristic which can be closely predicted or specified in the design of the cable.

The coupling loss, on the other hand, is a vague and variable quantity, being a function not simply of cable leakage (however defined) but also of the cable mounting, the environment, the characteristics and polarization of the mobile serial, and its distance from the base station. In a tunnel or any enclosed space pronounced multipath effects will inevitably occur, causing the 'instantaneous' value of the coupling loss to vary by 20 dB or more. Figures for coupling loss attributed to manufacturers to their cables, usually in unrealistic conditions, should be taken only as a very rough guide; an experienced system designer will prefer to work with more meaningful data, and a consideration of the environment and application concerned will be much more useful than a guide.

The longitudinal attenuation of the feeder, again, is a well-established increasing function of frequency, which on this account should be set as low as possible.

The leakage fields are generally considered to be substantially independent of frequency; however, other factors such as cable type and design may affect the availability of suitable equipment or the need for compatibility with surface systems. For example, the availability of underground systems at 30 MHz. One therefore expects to encounter the leaky feeder principle operating in the standard v.h.f. mobile radio bands, with a minority in the u.h.f. and ultra-violet ranges.

Bibliographic information

For a decade or so following the original Monk and Waiscoat publication, un-screened cables or 'balanced' types of line were used exclusively as leaky feeders, and were shown capable of giving very satisfactory performance. It is now the author's view, in fact, that the high field strengths being
encountered in practice were far higher than would be expected theoretically from balanced cables, and this led to the conclusion that dry impurities or imbalance was the key factor in the success of the schemes. Such imbalance, in turn, resulted in inevitable asymmetry and irregularities in the mounting arrangements and in proximity effects, and led to the postula-
tion of a continuous or continual inter-
change of energy between the low-field balanced mode and the high-field bal-
anced or ‘monofilament’ mode; the balanced or ‘bilateral’ mode provided the longitudinal transmission, while the monofil mode provided the coupling to the mobile set. It was shown experimentally that improving the balance by twisting the feeder, as might be expected, improved the longitudinal transmission at the expense of the leakage field, while ‘careless’ installation of an unbalanced line close to metal structures or other cables would enhance the field locally to the detriment of the longitudinal transmission.

Deryck\textsuperscript{c} has extensively studied the use of bilinear lines as leaky feeders, and has devised discrete ‘mode converters’ for intro-
troducing a controlled interchange of energy between modes.

Bilinear lines were initially considered for the first UK coal mine system, commissioned at Longniddon in 1970; the require-
ment there was for a radio system to serve a single 9 km tunnel linking four mines underground. But conditions there are extremely wet, and precautionary test showed that there was no significant longitudinal attenuation of the simple ’ribbon feeder’ proposed for use dras-
tically and became extremely unstable. In the following years, evidence also came to light that bilinear feeders installed in the early railways were suffering from the effects of build-up of grime on their sur-
faces, and some were having to be cleaned regularly.

Coaxial feeders

For the Longniddon system, further tests were made using a standard low-loss coaxial
television system in which the outer conductor braid was applied in a ‘loose weave’ for cheapness and which could thus be presumed to have a high leakage. It was confirmed that this cable had broadly suit-
able characteristics for a leaky feeder: the longitudinal and coupling losses were both less favourable than those of the ribbon type, but this was more than compensated for by the fact that the inter-
dielectric interference standing wave being set up was more nearly sinusoidal, thus reducing the leakage with a wavelength several times the free-space wavelength. Fortunately, it de-
creased rapidly, the monofil mode was not nearly so well as attuned, reducing the serious of any ‘dropouts’ which might entail in theory, it would be possible to suppress the launching of the interfering wave, or to launch another in phase with the signal, but in any case the wave could be regenerated subsequently by any discontinuity, such as in mounting ar-
senals, and might occur further down the line. The effects have not proved to be as detrimental to the open system as those found in installations now being installed by Lon-
don Transport.

A typical long standing wave effect at the beginning of a line is illustrated in Fig. 2, which also shows the advantage in coupling obtainable through using a cable with a semi-airspaced dielectric (\(\varepsilon_r = 0.87\)) at specific points in a feeder. Both curves are for a frequency of 72 MHz, and assume coaxial-mode and monofil-mode attenuations of 0.706 dB/km and 0.3 dB/km respectively. The monofil-mode velocity ratio is taken as 0.95. It is clear that a feed-
er would be served to discount early fears expressed that any attempt to introduce isolation into a line of this nature to the feeder would risk instability through feedback between the outgoing and incoming signals by the unbalanced non- leaky feeders if there were introduced. In fact, it can be confi-
dently shown that with a typical feeder, an NCB-open circuit will achieve a type, repeater gains of well over 100 dB would be necessary to incur such risk. This is because the impedance is high enough to cause the standing wave to be much larger than the line. The field intensity is therefore greater than the critical value, and the system will suffer from instability.

Field characteristics

An additional factor quickly arisen over the use of the terms ‘monofil mode’ and ‘mode conversion’ in the operation of coaxial system. In the early days of coaxial feeder, the treatment the present author looked upon the monofil mode as being the whole of the field external to the cable, and upon mode conversion as a continuous process which was essentially that of extending the standing wave at the source as seen as a natural process of establishment of the monofil mode. Workers\textsuperscript{12, 13} have taken the analysis a step further and consider the individual field into two major components. One of these is identified as the true leakage or ‘spilling out’ of the inner mode, travelling at coaxial-mode velocity and reaching its full amplitude immediately at the source. The other is identified as the leakage wave, launched at the source and at every discontinuity, and travelling at the coaxial-mode velocity, also decaying at the higher monofil rate. ‘Mode conversion’ becomes a discrete process, occurring only at the launching points of the monofil mode.

Resolution of the wave on the line into two monomode components is thus a prediction of the nature of the resulting fields. It is thus the conclusion pointed out that the true monofil mode will have a larger effective radius from the line, and the coaxial mode by virtue of its higher phase velocity.

The relevant relationship approximates to

\[
\epsilon_r = \frac{1}{1 - (1 - \mu^2) \left(1 - \mu^2 \frac{c}{v_c} \right)}
\]

where \(\epsilon_r\) is the effective radius, \(\lambda\) the free-space wavelength and \(\mu\) the velocity ratio (in comparison with free space). Thus, the leakage field of a typical solid
dielectric cable (\(\epsilon_r = 0.67\) at 85 MHz) would have a radius of 1.14 m. Of a foam dielectric cable (e.g. ‘Radius’, \(\mu = 0.74\)) the radius would be 0.58 m. Changing to a semi-airspaced type (e.g. NCB standard, \(\mu = 0.87\)) would increase it to 3.8 m. Against these figures, the veloc-
ity ratio of the monofil mode is very close to unity and its effective radius will be several times greater.

In fact, the experiments in the Mersey (No. 1) tunnel have shown the field at 170 MHz to be reliably maintained across the full width of the 12 m carriageway from a feeder of semi-airspaced type installed along one side. This suggests that in such practical situations of larger tun-
nels (or higher frequencies) the monofil mode resulting from ‘inadvertent’ mode conversion is less important and can be safely used in practice, usefully to the observed fields, though in smaller tunnels the effects are probably detrimental.

Whichever mode is considered, the physical picture of the field is that of a TEM wave with the outer conductor of the cable forming the inner conductor of a larger coaxial structure having a metallic wall as its outer conductor. At low propa-
gation velocities or higher frequencies, or in larger tunnels, the dielectric wall will tend to curve and eventually will break away from the tunnel wall and return to the cable, in the manner of a Guobow wave supported entirely on the cable. The field propagation is essentially through induction fields, and so the use of the term ‘radiating cables’ in respect of leaky feeders in general is incorrect. It is true that any discontinuity which causes mode conversion may in the same process invoke ‘inadvertent’ radiation; this may be useful or even necessary in larger tunnels or at higher frequencies. The idea of extending the field in the same manner as the monofil mode, but otherwise the effects are more likely to be detrimental by setting up long standing waves.

The simple picture becomes complicated by several distortions in the fields, caused by irregularities and obstructions in the the tunnel and by the inducing radiation into the tunnel. The latter can cause radiating modes, while signal amplitudes can vary locally by the 20 dB or so that is normal for conven-
tional mobile radio schemes in heavily built-up areas. But, as will be seen later in discussions on systems techniques, there need be no problem in accommodating such variations.

Practical feeders and their installation

Bifilar feeders have the advantage of being comparatively cheap and lightweight, but their use should be considered only in clean conditions. In poor conditions where they can also be installed at least 20 cm clear of walls, structures and other conductors; even then, their variability makes them unsuitable for use in long repeated systems. A solid dielectric type at 86U, has in fact not been manufactured for years.

A bifilar type could, however, meet a need for a more protected system in a dry and clean underground environment, such as the worked-out stone quarries that have been used as more deposits in Wales, or for a temporary use during maintenance of a dry tunnel. A good choice in such a situation would be 30011.

![Fig. 3. Types of feeder used in underground communications. At (a) is a foam-dielectric open-ended coaxial type (oil filled) at (b) and (c) and two kinds of bifilar feeder for use in clean conditions. A solid-dielectric cable with an open braid is seen at (d). The single-dielectric coaxial type at (e) has a 'thread-and-tube' semi-airspaced construction and (f) shows an early design, with a continuous slot in the outer. Two kinds of cable with discrete wires are (g) with the outer conductor of thread-and-tube and (h) and (i) Hasta, which have filled holes in the screen and foam dielectric.](http://www.americanradiohistory.com)
Leaky feeder installed in a coal mine. A line-powered repeater of early design is visible at the top of the picture.

'ribbon feeder', such as BCC type T3101 or T3129. However, it may well be found that this has to be made to order; in any case, for reasonably long unbroken lengths it is usually necessary to place a special order with the manufacturer.

In the type of use envisaged, a bifilar line can be suitably installed by suspending it in loops of nylon cord below existing cables or from any convenient brackets or fixings. Suspension from a tunnel roof, rather than attachment to a wall, will normally render the necessary clearances more easily but otherwise will not substantially affect the performance. Such an installation can be used, simply in paranoid fashion, to enhance the communication between two distant points, and there is, therefore, no evidence that the thread-and-braid dielectric might be quoted.

Like coaxial leaky feeders, braided leaky cables do usually give a better coupling performance if spaced away from continu- ously conducting surfaces and other cables. On the other hand, an occasional or sporadic proximity of metal (as might occur in the future arrangements) will in- tense the coupling between the cables and therefore reduce the bit-and-braid dielectric might be quoted.

Leaky cables are usually supplied with a polyethylene sheath, either alone or with a pvc outer sheath for flame retardance and mechanical protection. The polyethylene itself is usually considered necessary for waterproofing, though the use of a thread-and-braid dielectric might be quoted.

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A popular type in the USA and Canada has discrete holes drilled in an otherwise solid core of conducting material (Rumor). In mode of operation it is closely similar to the open-brayed type. However, there is some evidence that with theoretical support, that 'hole size' is the key factor in determining the susceptibility of the longitudinal attenuation of a cable of the mounting arrangements and surface current, a given parameter for the effect of a small number of tiny holes. As a result, this hole size must be correspondingly more or less effective in reducing the surface current at the given hole diameter. This diameter is found to be a reliable indicator of coupling efficiency, and is not in question here.

The millied-hole type has a foam dielec- tric, which is slightly less favourable than the thread-and-braid construction in response counter to the main purpose in such circumstances, that of reducing field and noise. The cable itself is a conventional non- leaky type; the true leaky field is thus abandoned and a model exists only for the electrically closed tunnel. The field is entirely through the closely regulated monolayer field. The model has been used to simulate the behavior of the main Instruct National Des Industries Electriques.

The main advantage of this "INEX-Del- oge" system is that the interference of energy between coaxial and monolayer modes is entirely under control of the system designer and thus can be optimized for the tunnel. It also has a higher care and design of the monolayer system, in particular that an enormous amount of work was spent on the leaky feeder design, and the whole system is entirely regulated (by law). The system is a product of the INEX "Monolayer" committee. It is a product of "INEX-Delo" and "INEX-Deluge". It is a product of the INEX "Monolayer" committee. It is a product of the INEX "Monolayer" committee. It is a product of the INEX "Monolayer" committee. It is a product of the INEX "Monolayer" committee. It is a product of the INEX "Monolayer" committee. It is a product of the INEX "Monolayer" committee.

It is also worth noting that the inter- action between electrical and magnetic properties of the cable means that the energy in the cable is not completely closed off, and a small amount of energy is radiated into the environment.

A braided conductor, LC-braided cable, and similar systems have an advantage in the sense that they are more likely to be used in such an environment. However, they are usually used in conjunction with an additional layer of shielding material. The system is a product of the INEX "Monolayer" committee. It is a product of the INEX "Monolayer" committee. It is a product of the INEX "Monolayer" committee. It is a product of the INEX "Monolayer" committee. It is a product of the INEX "Monolayer" committee.

Further reading

Other authors who have contributed sig- nificantly to the theory and practice of leaky feeders include J. B. Cool, G. V. Davis, P. Degnen, D. J. E. Maguire, P. J. F. Nand- andes, J. Fontaine, R. Gaballah, D. A. Hill, K. M. Krennies, J. R. Shaffer and A. M. Schmid.
Before discussing the operating software used in the lighting system, its relevance is best understood by considering the layout of a typical control desk, as shown in Fig. 1. and how such a desk is operated. The desired lighting pattern is set on the channel faders (presets), and this pattern is stored in the processor-system memory by pressing the 'record' button associated with a particular master fader, or 'master preset'. This pattern will be recalled and sent to the dimmer modules whenever its associated master preset is not zero.

Assuming for the moment that only one master preset is at a non-zero setting at any one time, any other master preset may now be used and another lighting pattern set in the same manner. Hence, a complete lighting pattern may be stored for each master preset.

There are two ways in which these stored patterns may be controlled by the master presets:

- **Scaling** - the equivalent of analogue control-desk processing - in which each preset level is multiplied by the master preset level and the resulting signals sent to the dimmer channels. Relative levels of the channels are maintained at all times.

- **Stepping** - where the master preset level is compared with the stored preset levels and the lesser of the two levels used for output. This type of processing is used to build up a lighting pattern, i.e., all dimmer outputs rise according to the level of the master preset and then stop at their predetermined levels. In an analogue control desk, this type of processing would require very complex circuits. By using more than one master preset at a time, lighting patterns can be gradually changed from one stored pattern to another. As the operating program endlessly polls all the faders and record buttons, any lighting pattern produced by a combination of master and channel presets may be recorded by simply pressing the appropriate master preset record button.

**Operating Software**

The operating program and the 'look-up', or equalization table, are contained in the microcomputer. Around 256 bytes are required for the operating program and to store the required lighting pattern temporarily, before the levels are converted to output signals for the dimmer modules, using the equalization table. The equalization table performs two important functions. Firstly, the scaling process carries the multiplication of numerous channel and master preset levels. Without an external multiplier unit, most microprocessors carry out multiplication relatively slowly (some recent microprocessors, such as the 6809 and 9995 have such a multiplier internally). The multiplication problem could have been solved by using a logarithmic a-to-d converter, but in this case, logarithmic-law faders were used together with a look-up table containing base 2 anti-logarithms for the 256 possible levels - hence, multiplications become simple additions.

Secondly, the table provides compensation for the non-linear relationship between the fader position and the subjective brightness of the lamps, mentioned in the first article. This code transformation is fairly difficult to formulate, and will be of more general interest than the code transformation used in the prototype system which combines both this subjective brightness compensation and the logarithmic conversion, so this coding is given in Table 1. The operating program is not listed because it is specific to the processor used and consists of only eight short sub-routines and three core-routines for lighting pattern recording and processing. However, using the flow-chart of Fig. 3, it would be possible to program microcomputer systems to provide the facilities described. The program for data present on the data bus to decide whether scaling/stepping processing, or recording mode is required. The hardware needed for this is described in the next section. Note that, to reduce processing time to a minimum, there is a number of conditional branches dependant on channel or master levels being zero.

**Process/record select circuits**

The operating program must test whether scaling/success processing, or pattern recording is required. This could be achieved by connecting the control desk's record and process keys, through some form of keyboard encoding, to a programmable i/o device (such as the 8155/6). However, since mapped-memory techniques are used for all other data input and output, a single i/o port can be connected directly to the data bus which is enabled when the IOM status line goes high. Figure, 4 shows the process/record-select circuit. When the 'record enable' key is pressed, the octal encoder (74148) is enabled and its output will stay high until a master-preset record key is pressed. The three RS flip-flops connected to the octal encoder are reset, and hence the 4-bit binary counter (74163) is enabled. The counter outputs are connected, through a 4-to-16-line demultiplexer (74154), to sixteen cross-lines in the master-preset 'record' key-matrix. When a key is pressed, at least one of the encoder's outputs goes low and enables the counter. The three-state buffer is enabled when either E, WR or MR is low, and the input data is transferred to the processor data bus. Also, the four inputs to the NAND gate (7430) are high, and on the rising edge of the system enable, E, a 'W' is clocked out the D-type flip-flop and the four RS flip-flops are reset. The next E pulse will enable the system again. The output of the octal encoder is not used, as a low level on this input will cause all three outputs to be high (i.e., equivalent to no key being pressed).
Table 1: Code conversion for subjective brightness correction: $I$ is input, in hexadecimal form, $O$ is output, also in hexadecimal form and $L$ is relative luminous intensity.

<table>
<thead>
<tr>
<th>$I$</th>
<th>$O$</th>
<th>$L$</th>
</tr>
</thead>
<tbody>
<tr>
<td>00</td>
<td>FF</td>
<td>78</td>
</tr>
<tr>
<td>01</td>
<td>00</td>
<td>92</td>
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<tr>
<td>02</td>
<td>30</td>
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<tr>
<td>03</td>
<td>60</td>
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</tr>
<tr>
<td>04</td>
<td>90</td>
<td>96</td>
</tr>
<tr>
<td>05</td>
<td>C0</td>
<td>97</td>
</tr>
<tr>
<td>06</td>
<td>FF</td>
<td>91</td>
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<tr>
<td>07</td>
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<td>92</td>
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<td>08</td>
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<td>09</td>
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<td>0A</td>
<td>90</td>
<td>96</td>
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<tr>
<td>0B</td>
<td>C0</td>
<td>97</td>
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<tr>
<td>0C</td>
<td>FF</td>
<td>91</td>
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<td>0D</td>
<td>00</td>
<td>92</td>
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<tr>
<td>0E</td>
<td>30</td>
<td>94</td>
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<tr>
<td>0F</td>
<td>60</td>
<td>95</td>
</tr>
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<td>10</td>
<td>90</td>
<td>96</td>
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<td>11</td>
<td>C0</td>
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<td>16</td>
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<td>17</td>
<td>C0</td>
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<td>18</td>
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<td>00</td>
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<td>1D</td>
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<td>97</td>
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<tr>
<td>1E</td>
<td>FF</td>
<td>91</td>
</tr>
<tr>
<td>1F</td>
<td>00</td>
<td>92</td>
</tr>
</tbody>
</table>

Hence up to seven modules may be used, each with 16 master presets.

Processing-mode keys are simply latched by an RS flip-flop and connected to D7 of the data bus. Unlike the record-key data, they do not form a destructive read circuit.

**Conclusion**

For the 8085A microprocessor used and with a system clock of 1MHz, Fig. 5 shows the experimentally determined relationship between processing speed (that is, the time taken for all the output channels to be updated) and the number of master presets in use at any one time. Assuming that the minimum acceptable update frequency is 20Hz, a 60-channel desk will operate fast enough, provided that less than about 20 master presets are in use. This limitation will not usually effect operation as the maximum number of master presets in use at one time is normally from four to eight.

There are a number of ways in which this prototype system could be extended. In most stage applications, the control desk and dimmers are remote from each other, and the system described would require an expensive 40-way connecting cable. Some form of high-speed serial interface, with high noise immunity, would be of greater practical use. Because the major cost of most installations is in the dimmer modules, the replacement of an analogue control desk with a digital one would most effectively be achieved by providing a low-cost interface between the digital output data and the existing 0-10V, direct voltage-controlled dimmers. More permanent lighting pattern storage could be easily achieved by providing either battery back-up for some of the r.a.m., or a tape interface. In exacting situations where the colour, or hue, of lights has to be maintained as their luminosity changes, the software could be extended, and lighting sets with three primary coloured gels used.

Estimates of the cost of a digital control desk compared with a conventional analogue desk suggest that the former solution is the cheaper alternative for systems with more than 40 channels and 20 master presets. The fixed cost element of the microprocessor system is offset by the absence of a diode-matrix board and the large reduction in the number of faders.

The authors are grateful for the use of the microprocessor development facilities provided in the final-year Electronics laboratory at the University of Keele, and the technical help provided by B. W. Cornes and E. J. T. Greasley.

From page 46

**Computation**

The calculations illustrated may be carried out with the aid of a pocket calculator. Access to a computer is clearly advantageous and Fortran programs have been previously published for the procedures required. For convenience, four simple Basic programs are presented on page 46 for the pole and zero calculations constituting the most difficult part of the computation. These programs may be readily incorporated into a complete digital filter design package for a desk-top computer. The programs have been developed and listed on a Hewlett Packard HP 85 microcomputer which allows several statements per line, separated by @. The command DISP may have to be replaced by PRINT in may Basic implementations.

Bibliographical references have had to be held over and will be included in a third part of this series.
THEORIES AND MIRACLES

Enormous gaps exist in our understanding of Nature, and many of our fundamental theories are not very credible. In a controversial review of current doctrine in nine instaments, Dr Murray investigates the electromagnetic theory, photons, duality, quantization, matter-waves, indeterminacy and hazzines, and reviews the state of physics today.

Many thousands of professional radio engineers can design television transmitters, and almost anyone can build a radio receiver, but there is nobody who can explain in a plausible and watertight way how radio energy comes to be transferred conjugate to the Crystal Palace to summoning tower to the H-Aerial on the roof of my house. This transfer of energy - the radiation process - is a perfectly well defined "miracle" as a physical occurrence for which we cannot offer any physical explanation. (I'll just say that again: a miracle is a physical occurrence for which we can offer no physical explanation). It is just over 100 years since James Clerk Maxwell gave us a good working description of what happens - the equivalent of saying that if you lie in hot sunshine you will get sunburned - but he did not claim to understand why nobody has explained it since.

Here, then, is a fine example of modern science: a miracle, because we cannot build a radio transmitter and we can calculate very accurately what will happen when we tune a receiver. How do we generate a transmitter and receiver at the speed of light - or any other speed - in a single-voton of time? How do we arrive and make use of whatever it is for our convenience and entertainment? Is it more than a wonder of physical energy, or at least that it may carry physical energy with it, we have no one would ask.

Confronted with this true statement of the human ignorance, ninety-nine percent of the outh of every hundred will probably say they do not care. The radio is for listening, the television for watching, wondering about something such things is a job for scientists. But now we come to the crunch, for we have to make a critical decision, for we are faced with a decision of the scientists themselves. Nine out of every ten physicists today would also say they didn't care - they are far too busy to be bothered with such abstract, impractical matters. On the other hand, the real physicists in ten who care about such things is likely to be seriously worried.

If they had any complaints about this minority, their concensus view would al-

bigger or smaller electrons, or parts of an electron. Now: to the question "Why is thermal radiation a function of temperature, not spatially stable?" current doctrine returns the answer that this is merely a small trick that the electron is so small that its structure must be indeterminate, which means that the ques-
tion itself is a physical and not a philosophical problem. We do not ask that this arise. That question is a non-question, an irrelevance that does not require an answer. It is one of the few questions that is not to call this the Doctrine of Hazziness: "Nothing is basic, everything is limited, and one should not ask old-fashioned questions of about them," Personally I am very suspi-
cious of this sort of thinking, and I know of no good reason to be just a little too flexible in its application to be intellectually honest. For instance, in answering the question:

**Theories and Miracles**

**by W. A. Scott Murray, B.Sc., Ph.D.**

Most certainly be that vast gaps exist in our knowledge of physics. The phenomena that take place not only in complex laboratories and remote galaxies, but also right on our doorstep. - which of which we can understand - show the breadth of understanding in understanding such things should have come to a grinding halt in 1920. (This is the time that fundamental hazziness was electrostatically By Einstein in 1907, and that for the laser in 1917). Of the new of which in which the current in the present in physical theory is based for physical theory that made very much even to this day. Indeed, there might be some reason for the failure. In our present view, the matter is even more likely to happen: things are ad hoc, and the wrong kind of hypotheses. Let us examine these two possibilities.

There is a doctrine of modern physicists, however, which we will identify later and criticise, which says that scientific theories are limited in their application to providing answers. To be sure, it does not claim a logical or to a logical impasse. Nowadays, for reasons that we will explore in the next chapter, we cannot accept a dichotomy between a scientific hypothesis as we should, but instead we tend to retain it on the pragmatic basis that this dichotomy is a reasonable one.

The question of the nature "what happened?" may be a descriptive question - in a number of different, and of course the substitute question - of the characteristics of the nature "why?" cannot be answered, or why it is an indeterminate phenomenon and therefore are improper questions which should not be asked.

To take a very simple example: suppose you're not in a position to know anything is wrong with our current theories and doctrines, but I believe that the scientific model has been on track for years, but our scientific model is not the hazard of a tropical fruit, and therefore is not the alternative which is still valid. And what advance that to be proven? One of its earliest consequences was Newcomb's failure to measure time.

We may perhaps read that experience across the area of fundamental physics where our research has been sufficiently explored, and consequently, the problem may be important. For the time being, the alternative is still valid. And what advance that to be proven? One of its earliest consequences was Newcomb's failure to measure time.

To sum up: every scientific theory is somebody's particular path. Rather than attacking the established theories of physics - which would force their doers owning to rush to their defence, and lead to quite untenable positions - it seems to us that we should examine a selection of miracles. A miracle, you will remember, is a physical occurrence for which we have no physical explanation. There are many miracles in the field of scientific research, and it is important to be selective. We shall find that our miracles have a certain hallmark about them, from which we can draw some positive, perhaps clear conclusions towards understanding. The next step will be clearly to the point: that is, a selection of miracles.

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Continued on page 87
Software solution avoids complexity of convolutional coding; program computes error signal which would have been the output of a convolution decoder.

In digital equipment a single parity bit is often added to a word to increase reliability by detecting an erroneous read. For words which are recorded in blocks as on paper-tape, floppy discs, cassette or magnetic tape we can time-share the single parity bit over a number of words. Fig. 1 shows the idea. Here the parity bit is taken from the data bits of the current word and one data bit per channel staggered to produce a successful parity-checking area as shown.

Errors would be detected. This fact signals an error has occurred. The procedure described here is a form of convolutional code. This can be seen by converting the parallel characters to a serial bit stream using a serial shift register. This is given in Fig. 6 for the template of Fig. 1.

Now the convolution approach is far more complicated than the technique described here, but the theory of convolution coding does show that the defining polynomial of Fig. 1 is

\[ X_1 + X_2 + X_3 + X_4 + X_5 + X_6 + X_7 + X_8 + X_9. \]

Hence the software approach described can be useful in investigating convolutional codes where here the template, i.e. the polynomial, can easily be changed. The prompts given by the program and the inputs required in response are shown in Fig. 7 while Fig. 8 shows the notation used for the template data.

The parity bit can be any multiple of bits. Thus we could use 3 zeros as parity, 4 zeros as parity and so forth, provided there is at least one redundant bit, i.e. the parity bit, to share of the data bits. An example of a template of Fig. 1 together with the single error signature is given in Fig. 5(a) and 5(b) which although detected gives an error signature which would have been the hardware output of the convolution decoder, that is it computes the parity of the error pattern within the template area. The output is a one if an error is detected and a zero if no error is detected.

The program assumes that even-parity is transmitted and thereafter an error signal results from an odd parity in the template.

Software solution avoids complexity of convolutional coding; program computes error signal which would have been the output of a convolution decoder.

Fig. 1 shows a data bit per channel staggered to produce a successful parity-checking area as shown. The parity bit can be any multiple of bits. Thus we could use 3 zeros as parity, 4 zeros as parity and so forth, provided there is at least one redundant bit, i.e. the parity bit, to share of the data bits. An example of a template of Fig. 1 together with the single error signature is given in Fig. 5(a) and 5(b) which although detected gives an error signature which would have been the hardware output of the convolution decoder, that is it computes the parity of the error pattern within the template area. The output is a one if an error is detected and a zero if no error is detected.

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Software solution avoids complexity of convolutional coding; program computes error signal which would have been the output of a convolution decoder.

Using a technique described in Wireless World, "Improved parity checker" Jan 1981, p. 81/2, multiple errors can be detected, although only a single parity bit is employed. Fig. 2 illustrates how eight errors would be detected.

If error correction is required then this problem can be overcome still employing only one redundant bit, i.e. the parity bit, by applying more complexity to the time sharing of the data bits. An example of a more complex template is given in Fig. 5(a) together with the single error signature.

This template was formed almost at random — any multiple errors are detected and it appears single errors give unique signatures. Armed with this fact we can detect multiple errors and correct single errors.

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This template was formed almost at random — any multiple errors are detected and it appears single errors give unique signatures. Armed with this fact we can detect multiple errors and correct single errors.

Using a technique described in Wireless World, "Improved parity checker" Jan 1981, p. 81/2, multiple errors can be detected, although only a single parity bit is employed. Fig. 2 illustrates how eight errors would be detected.

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Radio-frequency or data processing?

Modern radio communications, it is often observed, are a kind of data processing with traditional radio-frequency information as the method of transmission. The problem is to determine which is the dominant partner. The r.f. engineers often feel themselves being overshadowed by the embrace of the systems-approach of the computer people. In an analogue environment, the circuit design and circuit optimization tend to be admired more than the r.f. techniques, the art of the circuit designer. Digital technology has advanced spectacularly, tending to obscure the r.f. techniques which, in fact, still form the basis of many modern devices, radios of great dynamic range and the opening up of a whole new world by low-noise microwave amplifiers.

Glancing through the technical papers programmes for Communications 1982 (still at the time of writing in the future though already over when these notes appear) one sees a large emphasis — a little appallingly — that relatively few of the 80 or so papers cover the more traditional r.f. subjects of receivers, transmitters, aerials and r.f. propagation. The themes are mostly allied to computer communications and signal processing and data communications. "Data communications," with networks, switching, multiplexing, electronic (telephone) extension and similar changes, is changing faster than the open spaces of the sky.

Thought-provoking antennas

Most of the books published by the amateur radio organizations are stronger on theoretical issues, and only a small part of the information searching and thought-provoking look at ideas that have been accepted by amateurs (and not professionals) over a number of years. Once an idea has been widely accepted it tends to be viewed as dogma and the thought experimentation is not encouraged. But a new book (which is to be read by all concerned with r.f. communications and indeed for microwave receivers) is a notable exception to this rule.

"HF antennas for all locations" is by L. A. Anderson, published by GORN Publishing Ltd in April 1982. It is aimed at readers of World Radio — who has a highly professional, comprehensive background and combines theory with practice to a rare degree, with specialist knowledge of antenna theory and practice, some of the first persons in the U.K. to recognize the important implications of Affolter's work on chionals. The book is clearly well written and the honeymoon period and seems to be a well thought out book on the subject. But r.f. must be careful not to be dominated by the intrusive dights.

In real life there are the appearance of practical r.f. power equipment with devices such as the "high performance" or "T" or "W" vertical channel structures where the rather difficult V-groove is replaced by a gate within a straight service. This has given the designer of m.f., h.f. and v.h.f. transmitters new scope, and has been made of the freedom of such devices from conventional broad bandwidth media. Although the process is still being perfected, the old r.f. engineers can often feel that some of the new techniques are being ignored or are not being seen by the layman. In r.f. the problems are many and the methods of solution are complex, but it is an excellent area to take a look at the "Microstrip" antennas. It is a good idea to look at the "Wireless Telegraphy Acts" but there are solid regulations to be followed and it seems a bit risky to make a "closed-circuit" system without first being sure that it is not going to be used for illegal purposes. There is a lot of work to be done in the area of microwave systems, particularly in the area of microwave frequency bands. The new technology is very much a part of the future and will be a major part of the future technology of the future.

The dBW carrier power

Although many of the technical anomalies and the problems of the radio-frequency power field have been cleared up, the "dBW carrier power" issue remains a hot topic. The dBW carrier power format is in place to replace the traditional "decibel input power," i.e. total direct current input power to the anode of the circuit of the valve (or) any other device energizing the antenna, as used in previous editions of this book. Measured in the factory, the dBW carrier power is a direct measurement of the power that is being transmitted. A dBW is defined as the power delivered to a load of 1 ohm. A dBW is defined in terms of a reference level of 1 microwatt, which is the power that is delivered to a load of 1 ohm. A dBW is defined in terms of a reference level of 1 microwatt, which is the power that is delivered to a load of 1 ohm. A dBW is defined in terms of a reference level of 1 microwatt, which is the power that is delivered to a load of 1 ohm. A dBW is defined in terms of a reference level of 1 microwatt, which is the power that is delivered to a load of 1 ohm. A dBW is defined in terms of a reference level of 1 microwatt, which is the power that is delivered to a load of 1 ohm. A dBW is defined in terms of a reference level of 1 microwatt, which is the power that is delivered to a load of 1 ohm. A dBW is defined in terms of a reference level of 1 microwatt, which is the power that is delivered to a load of 1 ohm. A dBW is defined in terms of a reference level of 1 microwatt, which is the power that is delivered to a load of 1 ohm. A dBW is defined in terms of a reference level of 1 microwatt, which is the power that is delivered to a load of 1 ohm. A dBW is defined in terms of a reference level of 1 microwatt, which is the power that is delivered to a load of 1 ohm. A dBW is defined in terms of a reference level of 1 microwatt, which is the power that is delivered to a load of 1 ohm. A dBW is defined in terms of a reference level of 1 microwatt, which is the power that is delivered to a load of 1 ohm. A dBW is defined in terms of a reference level of 1 microwatt, which is the power that is delivered to a load of 1 ohm. A dBW is defined in terms of a reference level of 1 microwatt, which is the power that is delivered to a load of 1 ohm. A dBW is defined in terms of a reference level of 1 microwatt, which is the power that is delivered to a load of 1 ohm. A dBW is defined in terms of a reference level of 1 microwatt, which is the power that is delivered to a load of 1 ohm. A dBW is defined in terms of a reference level of 1 microwatt, which is the power that is delivered to a load of 1 ohm. A dBW is defined in terms of a reference level of 1 microwatt, which is the power that is delivered to a load of 1 ohm. A dBW is defined in terms of a reference level of 1 microwatt, which is the power that is delivered to a load of 1 ohm. A dBW is defined in terms of a reference level of 1 microwatt, which is the power that is delivered to a load of 1 ohm. A dBW is defined in terms of a reference level of 1 microwatt, which is the power that is delivered to a load of 1 ohm. A dBW is defined in terms of a reference level of 1 microwatt, which is the power that is delivered to a load of 1 ohm. A dBW is defined in terms of a reference level of 1 microwatt, which is the power that is delivered to a load of 1 ohm. A dBW is defined in terms of a reference level of 1 microwatt, which is the power that is delivered to a load of 1 ohm.
NRZ RECORDING FOR SMALL COMPUTERS

The majority of small computer recording systems use the Kansas City cassette recording format, with a data rate limited to a few hundred baud. L. Hayward proposes a non-return to zero recording system for the Nascom 1 and 2—the circuit should be adaptable to others—and compares performance with that of the Kansas City interface.

Most small computer systems, in particular those machines offered to the amateur user, have adopted the audio cassette as a convenient method of data storage. Cassette players are readily available at low cost, the only reasonable alternatives being open reel recording or expensive disc drives. The Kansas City recording standard, developed to use the audio cassette, works well and has become popular due to its tolerance of tape-speed variation, typically 30%. This allows users to exchange recordings between machines of almost any type. But this speed tolerance is the only significant advantage of the system—its disadvantages are substantial in terms of tape dropout and slow data speed. Some systems optimistically offer a data rate of 1200 baud, but using cheap cassette decks the best that can normally be attained is 300 baud. The encoding and decoding circuitry involved is fairly complex, using as many as seven or eight large-scale integrated circuits, and enables the user to adapt either the existing audio cassette recorder, or use a "bare-bones" deck, with only a mechanism and record-playback head.

By using one of the worst cassette decks I have encountered reliable recording was achieved to a rate of 1200 baud, with fair operation to 2400 baud 1½ in. The only disadvantage of this is its tolerance of speed variation: 5% instead of the 30% offered by Kansas City cassette, assuming that the usual unit (universal asynchronous receiver-transmitter) is used in the computer. This speed restriction will normally only be a disadvantage if tape transfers from one recorder to another are to be made. A recorder having a cyclic speed variation of greater than 0.5% would be totally useless for musical reproduction, and most cassette recorder mechanisms can achieve better speed regulation.

The n.r.z. system is well known, and has been used in computing systems for years. No f.h. head bias is used, and the tape is magnetically saturated in a negative or positive sense, depending on whether a zero or a one is written. There is no condition of zero flux, hence the name: non-return to zero. As the tape is saturated no erase head is required, and the system is less sensitive to tape drop-out or variation between various types of tape. Ideally, the system should use heads and tape designed specifically for this type of operation; practical results have shown however, that ordinary heads and tape are quite suitable. The use of certified digital cassettes such as the Scotch type 834A is recommended for the most reliable operation. The circuit shown was specifically designed for use with Nascom 1 and 2 computers, but should be suitable for most other computer systems with little change.

Principles of operation

Reproduction. The output from the n.r.z. recorder, applied to a 4049 buffer, has a rise and fall time of about 5 μsec. The coupling capacitors were made large enough to keep this low, considering the frequency involved, to permit the lead to short-out the amplifier input at low frequencies and prevent hum pick-up by capacitive stray coupling. The high frequency response of the amplifier is rolled off to avoid possible pick-up from the nearby clock generator and dividers in the computer. As the voltage output from the head is proportional to the rate of change of flux in the amplifier output will consist of narrow pulses coincident with the timing and direction of the data. In between these pulses the amplifier output falls to 2.5V. A Schmitt trigger circuit using part of the 4049 is used to hold the state of the previous positive or negative excursion, and thus output restored data to the n.r.z. Hysteresis is used to make the output insensitive to spurious small outputs from IC2. The n.r.z. requires that the receiver input terminal remains high until the data transmission begins. An inhibited input is provided, which when high prevents IC2 from changing the Schmitt trigger output. This point is conveniently connected to the drive l.d.e. transistor collector in the Nascom, thus making the computer ignore all data until the 'c' Load' or 'R' command is executed. The suggested divider circuit is useful if the standard data rates of 300 and 1200 baud are required from the Nascom 1. Power supply required is a single +5V supply; current drain is so small that an existing computer supply should easily accommodate it.

Summary

I suggest circuits such as this be included in small computer systems as an alternative or addition to Kansas City. It should be unnecessary for manufacturers of ready-built systems to offer a complete cassette system as part of the package. If such devices are made available with accurate speed control, thus giving interchangeability, it is likely that the more logical n.r.z. will be adopted universally. It should be fairly easy to produce a machine with a speed correct to within 5% for reasonable cost. A normal diesel engine with a crude mechanical governor can meet 5% variation of speed, so why not a simple cassette drive?

Heretics guide to modern physics

Continued from page 81

to judge the physical credibility of any new hypothesis, providing us with a criterion which is in recent times has been woefully lacking.

The first miracle we shall examine will be the one I mentioned at the beginning, namely the mechanism of the transmission of light energy through empty space. Our first philosophical conclusion will be consequential and closely related to it: an understanding of the true function of "waves" in modern physics. We shall have to go back some 200 years in scientific history to find a suitable starting point. Our route will take us from Newton to Heisenberg: via electromagnetic theory and the acute distress it suffered when denied an ether; via practicable photons, quantization, non-existent matter-waves, and a reversed Principle of Indeterminacy; and ultimately to an affirmation that the Law of Causation is obeyed in physics not only statistically but in all circumstances. In each of these areas I will present ideas for your consideration which although far removed from conventional scientific doctrine are yet strictly in accord with the findings of experiment. These ideas will add up eventually to a self-consistent whole, but not yet, I regret, to a fully-developed Theory.

All that I have to say is very simple, and indeed I hope to show how simple Nature really is when the dust of man-made confusion has been swept away. William of Occam said that fundamental assumptions should not be multiplied unnecessarily, and I am a follower of William of Occam.

C.B. frequency synthesis

In Fig. 4 of the article on 40 channel c.b. frequency synthesis, which appeared in the November 1981 issue of Wireless World, there should be a 1nF capacitor in the line between the bottom end of L4 and the MV2110 variable-capacitance diode. Without this capacitor the a.c. is inoperative.
France's foremost electronics exhibition — Salons Internationaux des Composants Electroniques — this year attracted over 1700 exhibitors representing 31 different countries. Held for the last time at Paris's Parc des Expositions, the 25th annual Paris Components Show, despite slight increases in the number of visitors from outside France and the total number of exhibitors, saw a fall in attendance. According to the French Trade Exhibitions office in London, there were just over 85700 visitors, as opposed to last year, when 95240 permanent passes were issued. But considering current economic conditions, the figures in 1982 are quite impressive.

In 1983, the show is to be held in November, instead of early April as it has been the tradition, at the North Paris Exhibition Grounds, and after that be becomes interlaced with the Munich exhibitions. A more specialized exhibition will be held at the North Paris site each year.

Surprisingly, perhaps, the current 'world's fastest' 16-bit c.m.o.s. static r.a.m. has been developed in Britain and is, it is at least, to be manufactured there. Access time of the HM65161 2K by 8-bit memory system is 55ns (maximum) and its power consumption is 50W/cm in standby mode or 50W while enabled. This device is the outcome of joint efforts by Harris and the exhibition exhibitor, Martin Harris, who was working on the HD6409, a c.m.o.s. Manchester II encoder/decoder for full duplex operation up to 1Mb/s, the HM65160 100MHz gate array with 1200 gates each with a propagation-delay time of between 2 and 4ns, and the HM6048 microcontroller together with its c.m.o.s. counterpart.

A computer-aided design system shown by EIE, a Swiss company specializing in the manufacture and distribution of printed-circuit board design equipment since 1974, has its limitations. Firstly, boards greater than 232mm and containing more than 360 i.c.s cannot be designed. Further, only 15 i.c. types and a choice of 4096 may be used, restricting the system's use to designing boards with no more than 15 layers. But the 2516 boards and printed circuits with more than 15 layers are hard to find, further comment is justified. The computer can resolve layout tolerances down to 0.0025mm and, when combined with the company's drum plotter-printer, be used to produce art work accurate to within ±0.1mm. Dimensions may be displayed on the screen in two ways, either from the board's pole to the corner or between two points on the 'drawing', and commonly used component forms may be selected from a permanent memory. The system itself looks like a large desk with a keyboard, swivel-v.d.u. and joystick. A 32-bit, bit-wise processor coordinates the graphics, supplemented by a 1.5M byte of semiconductor memory, an LSI11 for handling its and arranging data files and two 8in disc drives. Options other than the drum plotter-previously mentioned include: 20M byte hard-disc drives, a printer and GPIB pen plotter interface — so one can imagine the further limitations.

Still on the same subject, but at the other end of the price scale, Colvern had a microcomputer with a 68000 processor adapted for computer-aided design on their stand. The company isn't moving into this area yet and is only showing a 122MHz clock and 2.4A, 2.2A version has a 41.2cm holding torque. The 1.8V motor is 62mm long and the 24V version, 51mm long.

A more specialized show will be held at the North Paris site each year.

By far the majority of contemporary exhibition stands consist for the main part of nooks, often formed by sagging partitions, the most effective of which are erected diagonally across the podium. Often, traders without visitors will step away from their stand waiting for certain of their potential pray's species, move in from behind and weave their web. This show is no exception, but as it is so large, one can still find many of the more modest exhibitors with stands where one can brood without being pounced upon.

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DIGITAL STORAGE OSCILLOSCOPE

Two 100MHz 4-bit converters, one for each 250MHz bandwidth channel, are used in Good's 4500 storage oscilloscope. Shown for the first time in the UK at the All Electronic Show, this instrument can be used to store and display single-shot or repetitive waveforms and is suitable for bench use, when it will be operated by means of its front panel controls, or as part of a test system under GPIB control. It can resolve 5.1 bits at 35MHz, introduces a maximum absolute voltage error of 2.6% FSO over the recorded range and, after 40ms, responds to transitions with a relative error of 25.4%. Setting up the front panel is aided by software-generated menus displayed on the screen; once a setting has been made, it may be stored for later use or comparison. With these menus, the operator can select control functions for signal averaging, cursor positioning, trigger source and filtering options and plotter digital interface operation. Mathematical comparisons of reference and acquired waveforms are possible. For waveform comparisons, the 4500 has a 4Kbyte reference memory and for acquired waveforms, a 1Kbyte per channel (or 2Kbytes in single-channel mode) memory. A floppy disc will be available for storing up to 11 waveforms for later use either with the oscilloscope or with an external computer/printer. The 4500's price is around £11,500, and it can be obtained from Instruments Ltd, Roebuck Rd, Hainault, Ilford, Essex E11 3TX.

GPIB COMPONENTS

units of Hewlett-Packard's HP8901B 4000 measure ±20μm high, including shielding and connectors, and function at temperatures within the range –20 to +85°C. The receiver transmitter, control circuit, connector, cables, adaptors, specification and other data pertaining to these buses for enthusiasts, manufacturers and designers alike. A booklet describing the service is available on request. Wesc, 45 Hurtwood Rd, Sutton, Surrey, SM1 3JF.

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MICROCOMPUTER FOR EDUCATION AND CONTROL

Some 12Kbytes of Basic tailored for control applications is a feature that Middlewood Computer Co. hope will bring their MC system into educational establishments and laboratories. If a separate control board, called an experimental unit, is connected to the 280-based computer, combinations of an analogue-input board, analogue-output board and digital-input/output board may be used with the system to perform many complex control applications. The computer has 160Kbytes of r.e.m., a 300 or 1200 baud RS232 interface and a 300 or 1200 baud cassette-recorder interface with motor switch. Binary, octal, decimal and hexadecimal numbers can be handled by the interpreter, which also has facilities for simplifying communications between Basic and machine-code routines, and real-time interrupt handling and nested scheduling facilities. A machine-code monitor is included. Prices are, £395 for the Microcomputer computer, £145 for the experimental unit, £55 and £35 respectively for analogue and output boards and £55 for a digital I/O board. Discounts on the computer are available for educational establishments. Middlewood Computer Company Limited, Hewins House, Northape Street, Rugby St Edmonds, Suffolk IP35 9QO.

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The CINTEC FREQUENCY & VOLTAGE STABILIZER is also available for supplies of 100-125 volts, 45-65Hz with an alternative output of 50Hz or 60Hz at 115 volts or 230 volts and to a dual frequency model with a selectable output of 50Hz or 60Hz.

The Stabilizer may also be used as a frequency converter for example, the supply to it can be any frequency between 45-65Hz and the output can be switched to either 50Hz or 60Hz.

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Microprocessor Applications Handbook

Programming the PET/CBM

By D. F. Stout

£31.00

Electronic Components and Systems by W. H. Dennis

£13.50

Practical Techniques of Electronic Circuit Design by R. B. Bonebrook

£25.00

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WIRELESS WORLD JUNE 1982
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**Communications Division**

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If you're interested, call Ref. ROK 426, to Malcolm Craig, Senior Personnel Officer, Allied Medical Group, 18 Grosvenor Gardens, London SW1W 0DZ. Alternatively, call our 24-hour answering service on 0171 725 5339, quoting reference number 0409.

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Managing Editor
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Wireless World June 1982
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Applications forms and further information are obtainable from Scottish Officer Personnel Division Room 101, Holyrood Place, Edinburgh EH1 2HP (quote ref PRH190). Closing date for the receipt of completed application forms is 14 May, 1983.

To: The Engineering Recruitment Officer, BBC, Broadcasting House, London W1A 1AA. Reference No. 82.E.4029/W.

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Applicants should set out details of positions applied for, present position, qualifications and experience. Applications should be addressed to:

The Director, Personal and Administration Branch, Overseas Telecommunications Commission (Australia), G.P.O. Box 7800, SYDNEY N.S.W. 2001.

Applications will be supplied with an information leaflet giving full details of the positions and conditions of employment. GEC Representatives will be conducting interviews in the United Kingdom.

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Electronic Engineering

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GCHO, Oakley, Priors Road, Cheltenham

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Salary scale £8,800-£9,700 p.a.

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**Wireless World**

June 1982

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