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**Millimetre-wave lens aerial**

**Direct frequency synthesizer**

**Guide to light units**
Front cover shows the millimetre-wave lens aerial of new construction described in this issue. Photo by Paul Briner.

IN OUR NEXT ISSUE
Nanocomp EPROM programmer, a device designed by Bob Coates for his microcomputer published in January and July 1981 issues.

Clandestine radio, used for espionage during the war, helped in the development of portable h.f. equipment. Pat Hawker tells the story.

Cardboard clock, a fun project for the holiday period, also suitable for demonstration purposes in schools.

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Br post, current issue £1.6p, back issues (if available) £1.50, order and payments to EEP General Sales Dept., Quadrant House, The Quadrant, Sutton, Surrey SM2 5AS.

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**Electronic Kits**

Velleman U.K. present their list of electronic kits together with prices which include V.A.T. and postage and packing. They are listed in “difficulty grades”, for beginners and experienced kit-builders, with the lower skill level at 1, rising to 3. All include high-quality components, full instructions and technical data and come to you packaged in clear plastic boxes, ideal for component storage.

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<table>
<thead>
<tr>
<th>Difficulty Grade: 1</th>
<th>£</th>
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<tbody>
<tr>
<td>K607 2/2W Mini Amplifier</td>
<td>5.00</td>
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<td>K613 Dimmer 1000W (Deparasite)</td>
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<td>K1716 20W Amplifier</td>
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<td>K1771 FM Oscillator</td>
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<tr>
<td>K1803 Universal Pre-Amplifier</td>
<td>3.62</td>
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<td>K1823 1A Power Supply</td>
<td>6.99</td>
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<tr>
<td>K1861 Power Supply for 60W Stereo</td>
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<td>K2542 Single digit counter</td>
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<tr>
<td>K2569 Tape/Slide Synchronizer</td>
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<td>K2566 Coloured Light Unit</td>
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<td>K2569 Three-tone Bell</td>
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<td>K2570 Power Supply, 5-14V DC 1A</td>
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<td>K2573 Stereo RIAA Corrector Amplifier</td>
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<td>K2575 Microprocessor Doorbell with 26 tunes</td>
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<td>K2579 Universal Start/Stop Timer</td>
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<td>K2543 Transistor Ignition</td>
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<td>K2550 Infra-red Detection System (Transmitter)</td>
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<tr>
<td>K2559 Infra-red Remote Control System</td>
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<td>K2571 Light Computer</td>
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<td>K2574 Four-digit up/down counter with comparator</td>
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<td>K2545 50Hz Crystal time Base</td>
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<td>K2547 Four-channel Infra-red Remote Control (Transmitter)</td>
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<td>K2548 Four-channel Infra-red Remote Control (Receiver)</td>
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<td>K2554 High quality FM Tuner</td>
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<td>K2567 20CM Display (Common Anode)</td>
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<tr>
<td>K2576 Microprocessor Controlled EPROM Programmer</td>
<td>241.50</td>
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- L3: Effective, Digital Oscilloscope, 10MHz 100MHz: £1495.00
- L4: T320 Spectrum Analyzer: £1950.00
- L5: Spectrum Analyzer, 10MHz - 100MHz: £4000.00
- L6: Spectrum Analyzer, 10MHz - 1GHz: £6000.00

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- L9: Marconi: £395.00
- L10: Marconi: £595.00
- L11: Phase Bridge, 50kHz 10kHz: £295.00
- L12: Marconi, 282C, 282D, 282E: £750.00

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- R3: Tektronix, 1211A, 1212A: £1895.00
- R4: Tektronix, 1216A, 1218A: £3850.00

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- A2: Tektronix, 120A, 120B: £1895.00
- A3: Tektronix, 1211A, 1212A: £3850.00

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- M4: 340A DMM, 440A DVM: £275.00

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- M6: 340A DMM, 340A DVM, 3MHz - 30MHz: £275.00
- M7: 340A DMM, 340A DVM, 30MHz - 300MHz: £275.00

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- M9: 340A DMM, 340A DVM, 3GHz - 30GHz: £275.00

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- Power Supply: £70.00

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- B: Tektronix, 1211A, 1212A: £100.00

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- Tektronix: £600.00

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- HP2560/80 Ext, 3MOS/64K RAM £2995.00
- HP2860/80 3MOS/32K RAM £2562.00
- HP2860/80 Ext, 3MOS/64K RAM £2995.00

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- 4121-15 8k Frequency Option £765.00
- 4121-16 Resistor Option £765.00
- 4121-17 Capacitor Option £765.00
- 4121-18 Inductor Option £765.00
- 4121-19 Scope Option £765.00
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- 4121-22 Power Supply Option £765.00
- 4121-23 Speaker Option £765.00
- 4121-24 Cooling Fan Option £765.00
- 4121-25 Case Option £765.00

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- 4121-11 2M Core Memory £765.00
- 4121-12 4M Core Memory £765.00
- 4121-13 8M Core Memory £765.00

**PDPI 1 MOS MEMORY**
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- 4121-16 2M MOS £765.00
- 4121-17 4M MOS £765.00
- 4121-18 8M MOS £765.00

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- Apple 12, 3.5 £250.00
- Apple 12, 5 £250.00
- Apple 12, 12 £250.00
- Apple 12, 20 £250.00
- Apple 12, 30 £250.00
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**Hameg**

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- Triple Trace, DC to 20MHz, 8x8, 20A, 30A, 100A, 1000A, with mains battery. £1150.00

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W W W . F O R F U R T H E R D E T A I L S
### Carbon Film Resistors

<table>
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<tr>
<th>Value</th>
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</thead>
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<td>1G ohms</td>
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### Speaker Kits

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<td>Fanta 200/250 power kit inc.</td>
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<td>Fanta 800/250 power kit inc.</td>
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### Micro Electronic Hobby Kits

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<tr>
<td>ALLAN 2050Z</td>
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<table>
<thead>
<tr>
<th>Mobile Application</th>
<th>Fixed Station Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>SSB</td>
<td>4140** 577A** 577B</td>
</tr>
<tr>
<td>FM</td>
<td>4140** 507B 577B</td>
</tr>
</tbody>
</table>

*General recommendation: Consult equipment instruction manual for correct microphone impedance.

*Noise-canceling

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**A charter for isolation**

One small indication of the nature of the UK’s new Engineering Council is the fact that the job of chairmen will be part-time and unpaid. The high abilities of Sir Kenneth Corfield, who will be the first to occupy the seat, are beside the point. Apparently the duties are not considered important enough to require full-time attention nor valuable enough to be rewarded. Of much greater significance, though, is the fact that this creation of the Department of Industry is being incorporated by Royal Charter, rather than by statute as recommended by the Finniston Committee. As such it has the approval of the monarch, and hence of the government, with all the social cachet this implies; it is guaranteed continuance and the monopoly power to do its own thing; and there are the financial advantages of being a charity. But it has no real power to make changes: unlike a statutory body it has neither the authority of Parliament behind it nor the responsibility of having to be accountable to Parliament for its actions.

The individual British engineer may be forgiven for wondering what this cosy group of big-wigs can actually do for him — or, indeed, for the country as a whole, in the sense that Finniston had in mind (see his famous report). At the time of writing the emergent Council does not even possess the powers of that other chartered and influential council, the CEC, which at least has its own national register of engineers and the right to dub its members “chartered engineers”. But it is only fair to wait and see. We can only judge by the results. What is, however, immediately obvious from the government’s decision not to allow a statutory Engineering Authority is that the CEC, which at least has its own national register of engineers and the right to dub its members “chartered engineers”, remains virtually a cocoon, isolated from the wider world.

But it is only fair to wait and see. We can only judge by the results. What is, however, immediately obvious from the government’s decision not to allow a statutory Engineering Authority is that the CEC, which at least has its own national register of engineers and the right to dub its members “chartered engineers”, remains virtually a cocoon, isolated from the wider world.
Metal plate refractor aerials were once popular for use at lower frequencies, but have little use nowadays generally. The lens aerial described is relatively insensitive to this off-axis operation — so much so that two (or more) feeds can be used for simultaneous communication with more than one station, yet with only a small reduction in aerial gain over a considerable solid angle around the axis. The lens performance is also insensitive to small variations of twisting of this shape. (A reflector is very sensitive to this twisting.) These properties correspond to performance with respect to 'coma' and 'astigmatism' in optics.

Another advantage of the lens is that the energy is transmitted forward through the lens and only a fraction of the already small percentage reflected back is able to return the feed horn. At first sight, the required thickness of the lens would appear to be comparable to the depth of a reflector, but an aerial of this type can be 'stepped' and this reduces the thickness and therefore the amount of material used.

One small disadvantage of stepping is the slight shadowing that occurs, as it reduces the effective aperture a little. But to make a lens of this type, one should have a considerable void of feed horn or secondary mirror blocking that occurs in reflectors.

Slightly more sophisticated advantages accrue from the strongly polarizing effect of the grid of plates making up the entire aperture. This yields an aerial with a remarkably low cross polar response. Frequency re-use systems might find this of considerable value. One disadvantage of a lens aerial over others is that it is bandwidth limited (equivalent to chromatic aberration in optics), although some people may consider this an advantage. Stepping the lens profile has been found that it is the interesting effect of broadening the bandwidth.

Theoretical operation
From the simple derivations in the appendix the predicted curve on the surface in an ellipse on one side, for a plane surface on the other. Readers might think it strange that a concave lens is required to give the plane wave from a point source. The explanation is that the phase velocities of the waves are greater than the velocity of light inside the plates, which yields a refractive index less than one — hence the concave shape for a converging system. At every point where the phase of the wave increases by 360° as one moves out over the lens from its centre, that much of the lens is removed without affecting the final plate wave plane front. This is the explanation of the stepping.

The spaces between the plates form a waveguide and for this reason the spacing cannot be less than half a wavelength, or the wavelength would be below cut-off and no propagation would result. The actual thickness in terms of the wavelength sets the value of the refractive index, course, wavelength changes with frequency — so therefore does the refractive index, as can be seen from equation A3. This is what makes the lens frequency-sensitive.

Because the refractive index is determined by the separation of the plates, then care has to be taken for constructing this face. This is required. This was achieved by small accurate spacers threaded on high tensile wires, as shown in Fig. 2.

Construction
To make the project a little more challenging, the design frequency was increased to 30GHz (wavelength = 1cm). The very complex problem of developing stepped curves gradually changing plate pitch which when assembled up the lens, was obviously one of the 'acute manufacturing problems' reported in the earlier literature. It was while working out how to make this surface of revolution in one operation that the original idea in this work occurred. The material chosen, this aluminium sheet — which, of course, had an intrinsic thickness according to its gauge. By choosing the appropriate thickness and stacking twelve of these strips, one obtains the precise design spacing, a, by taking strip one, thirteen, twenty-five and so on. Eleven other lenses are obtained by taking the corresponding strips in the series.

The important advantage of this procedure is that once the strips are assembled and the template made, then by turning the whole stack on a large lathe (and engineers mentioned that the vertical-axis lathe could be used for larger diameters than this) all the strips are cut to the precise figure at each point. In practice this was fairly simple, once the strips were bolted together and bedded in wax against the faceplate. Fig. 3 shows this work in progress.

No mention has been found in the literature indicating that this method has been employed before. Most of the difficulties of making these lens aerials are overcome by employing it.

Design example
The wavelength at 30GHz is just 1cm. When the refractive index has been decided on, the spacing of the plates can be calculated from equation A2. If the refractive index is too small, reflection losses at the surface increase. On the other hand if it is too large, the lens thickness tends to become unacceptable. Gaining experience with such considerations enables a com-

Adventages over a reflector
Because both the incident and the reflected waves are distorted or scattered by any irregularity on the surface of a mirror, the figure or accuracy of the surface of a reflector has to be held quite rigorously in terms of fractions of a wavelength. But a wave passing the surface of a lens is only affected once, so that the figure of that surface can be relaxed to half the accuracy for the same performance. A reflector operated off the axis of symmetry introduces a rapid deterioration of gain, beamwidth and perform-

www.americanradiohistory.com
This is larger than the predicted size from the efficiency calculated from the gain equation. This is explained by the lack of consideration of "spillover", scattering and reflection in the calculation. Thus the aerial is more directive than the gain calculation suggests and further illustrates the difference between the ideas of gain and directivity of an aerial.

From Fig. 5 the slight asymmetry on the polar diagram shows that in all likelihood there is a small amount of astigmatism in this lens. The unequal sidelobes strengthen this assertion. The worst case sidelobe is approximately 25dB down on the main beam peak.

Concluding remarks

Building aerials is interesting work and the pleasure of obtaining such a good result was satisfying. Many opportunities for lens aerials have arisen from this work and the author would be pleased to see someone else also take on "sonic" aerials at 24GHz. Amateurs could certainly design a system from the data and example given.

But as with other applications come to mind and there could be considerable development work for interested student projects or professional applications.

We attempted to measure the off-axis cross-polarisation peaks, but no response at all was seen! A much greater sensitivity might yield some cross-polar performance figures, but these appear to be many tens of dB down on the co-polar levels. Future work is planned to find these cross-polar levels.

One advantage of lenses for repeater links is the reduction of cross-talk between transmitting and receiving aerials. This often plagues reflector systems in that the transmitting horn points towards the receiving horn and spillover is likely to cross couple. This is absent in double lens repeater stations, as shown in Fig. 6. Switched beam repeater stations can be designed easily, by erecting two or more lenses in the surface of the "bin" on the tower and simply switching round the feeds to the appropriate focal points.

An outstanding possibility exists for an experimental system to develop a "Venetian blind" erecting system for the plates of this lens system. Although this would be awkward and unacceptable on Earth with gravity and wind effects, a number of satellite people with whom we had a discussion get quite excited about the possibility. Once in orbit, the stacked plates would be pulled up from the right angled triangle.

Fig. 6. Use of lens aerials in repeater station to reduce cross-talk between transmitting and receiving aerials indicated by arrow around dishes in (a).

The phase velocity of the e.m. wave between metal plates is given by waveguide theory as: $v = \frac{c}{\sqrt{1 - \beta^2}}$ with $\beta = \frac{\gamma}{k}$ and $\gamma = \frac{2\pi}{\lambda}$.

For the best sample, the efficiency is $\frac{1}{2}$ of the predicted size. This is larger than the predicted size from the efficiency calculated from the gain equation. This is explained by the lack of consideration of "spillover", scattering and reflection in the calculation. Thus the aerial is more directive than the gain calculation suggests and further illustrates the difference between the ideas of gain and directivity of an aerial.

Beamwidth and sidelobes

The same test range enables the beam pattern to be plotted by turning the lens about a vertical axis in small known angles. The drop-off in received power as the system is turned off-axis is made up by reducing the calibrated attentuator value, thus gaining a direct 4dB reading for each point. Placing a polar paper gives the beam pattern.

We cheated a bit on this measurement in that a direct X-Y plotter arrangement on Earth with gravity was used, but this luxury is not necessary for less well-equipped experimenters.

From Fig. 5 the polar pattern obtained for the 39.3dB gain aerial. The 3dB beamwidth is 14° and directly from equation A.8 the effective diameter is $d_{eff} = \frac{5.73 \times 1}{1.4} = 4.1cm$

This is larger than the predicted size from the efficiency calculated from the gain equation. This is explained by the lack of consideration of "spillover", scattering and reflection in the calculation. Thus the aerial is more directive than the gain calculation suggests and further illustrates the difference between the ideas of gain and directivity of an aerial.

From Fig. 5 the slight asymmetry on the polar diagram shows that in all likelihood there is a small amount of astigmatism in this lens. The unequal sidelobes strengthen this assertion. The worst case sidelobe is approximately 25dB down on the main beam peak.
An approach to Walsh functions from telecommunications history

by Thomas Roddam

Named after their originator, an American mathematician, Walsh functions are now beginning to find applications in electronics. This article first discusses the use of mathematical functions in general in telecommunications then goes on to illustrate how the various Walsh functions can be used through a practical technique for avoiding crosstalk between telephone wires.

The function of equations

The last group have lived happily in ignorance, and the contrasts, the tunnel vision, all the factors of our modern technology were known about the great mass who live a non-electric existence.

The last group have lived happily in ignorance...

Stranded conductors

Another way of looking at the points of the SBD was the sidebands don't exist period. The expansion of the telegrapher's equation brings up the Bessel functions, and the contrasts, the tunnel vision, all the factors of our modern technology were known about the great mass who live a non-electric existence.

Stranded conductors Alternate layers of stranded conductors:

strands of Chatterton's paper cone to the centre of end of a large horn. Looking back we can see, how could the carrier going at full power all the time the noise at the receiver could be kept down, sending a signal to use for sending a signal, a system. And it seemed to work. The theoreti
cians began to study the characteristics of

WeSECTON DECEMBER 1981 WIRELESS WORLD}

There's glory for you. At the end of the day it boils down to saying that for a partic
ticular type of line the speed of working is inversely proportional to the square of the length of the line.

At this point there are three ways to go. The first, Then, there was frequency multiplexing. The idea that by multiplexing the carrier going at full power all the time the noise at the receiver could be kept down, sending a signal to use for sending a signal, a system. And it seemed to work. The theoreti
cians began to study the characteristics of

The trouble is that he decided to neglect the heb
dull current was changed according to the curb came an inter-pulse interval, with the internal coincidence of two pulses.

Stranded conductors Alternate layers of stranded conductors:

The trouble is that he decided to neglect the heb
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Stranded conductors Alternate layers of stranded conductors:

The trouble is that he decided to neglect the heb
dull current was changed according to the curb came an inter-pulse interval, with the internal coincidence of two pulses.
of a filter. The Tchebycheff functions were a step in linkage design. Not very much relevant to our theme can be found in the history of modern filter design. Once it was seen that the problem was, quite simply, to design a finite network of defined properties, it became a matter of using well-known techniques. The vital step was the realisation that the idea was to find the best value to use in the structures which had grown up from the long line.

Softly the functions come and go, or, if your taste is more demonic, I go, I come back. The Laguerre polynomials have cropped up again, there is no need to see them around since I dealt with a chain of regulating repeaters, back in about 1950. The story began with telegraphy, with signals which were either marks or spaces, and moved on to telephony, with the signals a mixture of sine waves. In the 1930s, however, Alec Reeves was building one pulse modulation system after another, and one of him came into service the digital computer was on the way. The Boolean algebra, which we had come to associate with the use of mathematics in cleaning up classical logic, began to be a really beautiful and bitter affair.

Although Boole's logic, and the technique of maps based on it, like the Karnaugh maps, were central to the signal processing operation, the signal frequently needed to be transmitted from place to place. The available telephone channels, and the general thinking of the radio circuit designers, were based on bandwidth limitations, just chops off of the chunk of frequency spectrum. Information theory, which started well enough, got it entirely wrong, defined what could be done. Fourier analysis could be used to discover just what the circuits did to the pulses. There is a faint memory of Heaviside here. The pulse as a finite series of on and off periods, with each channel the operator can order patterned switching between audio channels in a network. We see that if Walsh functions had been with us from the start and someone had then come up with the idea of using them, we all would know what use they were."  

A fund is being started to buy ocarina for supporters this Christmas. We have already seen how important it is to keep one's feet firmly planted on the "


1 I am indebted to Mr. A. Emmerson of British Telecom for locating Fig. 1 in the book referred to.

Fig. 2. Transposition of telegraph wires for avoiding crosstalk caused by mutual inductance. On the left is the pattern employed and on the right the method of wiring at a transposition point. (Adapted from Railways Signalling and Communications, Tattersall et. al, 1946.)

The working of Fourier analysis depends on the fact that the sine and cosine wave system is orthogonal, so that

\[ \int_{-\pi}^{\pi} \cos(m \omega) \cos(n \omega) \, d\omega = \begin{cases} 0 & \text{if } m \neq n \\ \pi & \text{if } m = n \end{cases} \]

When there are more than two pairs we can start by taking two pairs as a quad, and use the same symbolic solution, which we can bracket up to be a matrix:

\[
\begin{pmatrix}
\cos m & \sin m \\
\sin m & \cos m
\end{pmatrix}
\]

This is short for:

\[
\begin{pmatrix}
1 & 0 & 0 & 0 \\
0 & 1 & 0 & 0 \\
0 & 0 & 1 & 0 \\
0 & 0 & 0 & 1
\end{pmatrix}
\]

Four pairs can be transposed according to this pattern, with the total run split into four sections. If we call this (G), we can transpose eight pairs according to the scheme

\[
\begin{pmatrix}
G & G & G & G \\
G & G & G & G
\end{pmatrix}
\]

We can go on expanding in this way, and what we are doing is working with Hada-mard matrices. Using the definition

\[ H_2 = \begin{pmatrix} 1 & 1 \\ 1 & -1 \end{pmatrix} \]

we have

\[ H_n = H_2 \otimes H_n \]

where \( \otimes \) is the Kronecker product, so that

\[ \cos m \cos n + \sin m \sin n = \frac{1}{2} \cos (m - n) \]

which goes from \(-\frac{\pi}{2}\) to \(\frac{\pi}{2}\) in the time interval \(T\). Another important feature is that the functions can be sorted out into two groups. If you imagine a sine wave and a cosine wave which have been clipped right down, a technique used, with 20dB of clipping, for some transmission systems on noisy circuits, you will see that \(w(1,0)\) looks very much like a clipped sine wave, and \(w(2,0)\) like a cosine wave. The odd Walsh functions, which are antisymmetric, are written as \(-w(i,n)\) and the while symmetric properties of the even functions give them the form \(w(i,0)\).

The sine wave we assumed to be clipped down to give \(s(1,0)\)) possessed the property of having a frequency \(s(1,0)\) which is a single cycle in the sine wave, has two crossings of the zero axis in each unit of time, while the end zero is shared with the next cycle.) The sequence of a Walsh function is thus defined as:

\[ A \times \text{crossings per second} = \frac{1}{2} \times \text{average number of zero crossings per second} \]

What have we now got? A set of orthogonal functions, and the concept of sequence. It is the switching man's equivalent of the sinusoid of the symmetries and the concept of frequency.

To be concluded in the next article, which will show how Walsh functions can be produced by hardware and discuss their use.
A 1MHz per millisecond scanning rate and absolute phase reproducibility are the essential features of this recent synthesis technique. The unit described performs entirely numerical manipulations and is ideally suited to convertor only as the final operation.

A direct digital frequency synthesizer is the hardware equivalent of a function generator control computer and signal generator and a digital-to-analogue convertor. The combination could be programmed to calculate incrementing angular values of a sine wave function and to output them via the convertor at a fixed rate. Frequency would be determined by the size of the angular step and the output rate, which might require some software/hardware simulation to hold it constant. The maximum frequency which could be generated would depend upon how quickly new sine values could be calculated or fetched from a pre-calculated data table. To push the output frequency up into the band 2MHz clocking time must be drastically reduced; a dedicated hardware processor must be built.

Figure 1 shows the basic arrangement of such a synthesizer. The d-to-a convertor is fed with numbers generated by stepping through a sine table read-only memory in fixed (angular) steps at a fixed clocking rate. The step size is chosen according to the output frequency required. For example in this synthesizer a 1MHz output is generated by advancing through the sine table by 45° every 125ns. The process need not start from 0° but if it does, the r.o.m. will follow the cycle 0°, 45°, 90°, ... to 270°, 180°, 360°, ... 0°, 45°, 90°, ... 270°, 180°, 360°, ... etc. The sine table IC 1 would therefore contain the sine values from 0° to 360°, and from 0° to 270°, etc. The new angle is shown as held high, but if you want to add a clear facility to the synthesizer then this is the place to do it. The latch outputs go back to the other set of adder input ports so that the present state of the latch outputs will always be incremented by the input frequency at the next positive-going clock edge. If the input number is simply 0 in the most significant bit (m.s.b.) then the angle will come back to its initial state after four clock pulses. In other words, the m.b.s. input corresponds to output frequency of one quarter of the clocking frequency, which in this case the m.s.b. input must therefore correspond to 2·1MHz (about 611Hz). This is done so the output frequency is defined as N·1MHz, where N is the input number.

Reflection (looking backwards through the r.o.m.) in the second and fourth quadrants is performed by the exclusive-OR gates IC 4 which invert when the m.s.b. output from IC 3 is high. Except at 90° and 270° (condition detected by the IC 9) the reflected angle is incremented by 90°/1024 so that the reflection does actually occur about 90° every 1024 clock cycles. As with the sine table, increments by the scan mantissa at a rate of 8MHz.

Fig. 1. Digital-to-analogue convertor is fed with numbers generated by stepping through a sine table read-only memory in angular steps at a fixed rate.

The input frequency number in true 16-bit binary code is, as in Fig. 1, to the 16-bit 8-to-1 adder IC 6. There is no carry input, but the carry output passes to an exclusive-OR gate IC 8 which functions as a partial adder and thence with the other adder outputs to the D inputs of 16 edge-triggered latches IC 7. The clear input for the IC 7 latch is shown as held high, but if you want to add a clear facility to the synthesizer then this is the place to do it. The latch outputs go back to the other set of adder input ports so that the present state of the latch outputs will always be incremented by the input frequency at the next positive-going clock edge. If the input number is simply 0 in the most significant bit (m.s.b.) then the angle will come back to its initial state after four clock pulses. In other words, the m.s.b. input corresponds to output frequency of one quarter of the clocking frequency, which in this case the m.s.b. input must therefore correspond to 2·1MHz (about 611Hz). This is done so the output frequency is defined as N·1MHz, where N is the input number.

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The circuit described in this article, together with scanning, timing and control logic, made up the programmable frequency synthesizer required for a Fourier transform in ion-cyclotron resonance (FTICR) mass spectrometer. The heart of this instrument is a l-inch cubed "trapped ion", see diagram, housed in a continuously pumped vacuum chamber and situated between the pole pieces of a large electromagnet. Chemicals are leaked into the vacuum so as to give a sample pressure of about 10⁻⁵ torr. The l.s.b. input must therefore correspond to magnitude information derived from the r.o.m. to form a straight binary-coded output. The d-to-a convertor is then followed by the other standard method of complementing the magnitude in IC 8 to 1 and adding 1 in IC 9.

The inverted form of the sign bit must be added to the carry output of the complementing operation if disaster is not to occur at 180°. The resultant binary number is latched again before the d-to-a convertor so that when a fast convertor is used de-glitching should be unnecessary. The output code is an asymmetrically weighted one from 00000000000 to 11111111111.

To squeeze the last bit of frequency range out of the synthesizer a sharp multisection elliptic low-pass filter is used in the circuit shown, after the d-to-a convertor. It is designed to be 1dB down at 3.3MHz and with a minimum stop-band.
attenuation of 50dB starting at 4.65MHz. The filter was designed from data contained in Simplified Modern Filter Design, by Philip Goode (Little Books, London, Table A4-4, page 146). In setting up the filter the nodes should be tuned to 7.7814 and 4.647MHz. The converter and filter have been matched to deliver 1V p.p. into a 400-ohm load.

Possible modifications

Finer frequency control can be provided by widening the angle adder, for example, a 24-bit-wide adder when used with a clocking rate of 8.388608MHz will make the l.s.b. of the input number correspond to a 0.1Hz step in the output. If only audio frequencies were required the clock frequency could be lowered and the latches around the r.o.m. discarded. Unbelievably, by using a resonator with the output phase can be achieved by placing another adder immediately after the angle adder as indicated in Fig. 3.

The method for introducing frequency scanning has also been incorporated into Fig. 3. Another adder and bi-functional latch are introduced before the angle adder. In one state the data selector-latch simply passes the initial frequency to the angle adder, but when toggled to its other state the input to the latch will keep incrementing the number fed to the angle adder by the scan mantissa at a rate determined by the scan exponent. The exclusive-OR gates in the scan adder loop will enable the instrument to scan down as well as up. Unless astronomical scan rates are required the scan exponent will need to be a divided-down version of the clock rate and it may be desirable to have a rather wide-scan adder, with the scan mantissa being fed to bits which are less significant than the l.s.b. of the initial frequency number.
The British designed and made Tenvox c.b. transceiver. It is a 3D09 microprocessor system; with a step-by-step procedure for manually interpreting the circuit diagram. The library of cells is available and the cells are also printed on the Marconi-British Micro-Block schematic representations of the gates which may be stuck down onto a layout sheet, preprinted with the basic logic array. The design is then sent to Marconi who will code it into their computer which can simulate the design and run a series of checks to ensure that the circuit comes to a number of design goals. The design for the interconnection mask will then be produced automatically. This process can usually be completed in a single day, with the last write being that last step in the production of a device. If subsequently large numbers are required then the drawings can be used to produce an In-Cessown device (see WPC5000 of June issue, 1981). The same computer can also produce a series of test patterns. A table for the designer showing how to use a computer, can be sent hire at the Marconi Design Centre to the designer. This design MEDI, will also offer the CAD facility as its output. System 85 is available in a family of four devices. The MA505 has up to 560 gates, the MA530 has 960 gates, the MA531 has up to 1440 gates and the MA520 has 2048 gates fitting into a 24-pin package. All the manufacturing of the devices takes place in a brand new processing plant recently opened in Lincoln. The plant represents an initial investment approaching £135 million and is part of MEDL’s two billion investment over the next five years. Opening soon; and one day, the plant has twice that amount assigned for future expansion. The 1000,000 square feet of factory space and the company is recruiting staff at all levels from senior engineers to factory operators. The iso-cassette used in the manufacture of the devices by the Ter-Vex Semiconductors and the two companies have agreed to second-source each other’s products.

- The Department of Industry has recently announced the introduction of the C500 gate array. The C500 gate array is essentially a highly integrated monolithic control circuit which is a venture to produce a suite of design software for use with c.b. gate arrays. The C500 is available with up to 5,000 usable gates inside the software, i.e., up to 5,000 gates which are compatible with a range of metal interconnections. The software will similarly the logical behaviour of a design and automatically convert a proven design pattern generator tape from the masks for constructing the gate array design. The software can be made and automatically produce a test pattern which can be used to ensure the correct working of the device.

The organisations involved in the project are British Telecommunications and Engineering Research Council, the Ministry of Defence, ICL, GEC, STC, and TMC Ltd. They will be meeting their own project costs but the industrial members may qualify for support under the Derrell Microelectronics Industry Support Scheme.

An outline specification has been drawn up at the Rutherford Appleton Laboratory and project teams have been appointed by all the participating companies. The SERC hopes to encourage the involvement in the project by the academic community. The Derrell is providing an independent chairman for the management committee and British Telecom have provided the project manager.

Channel 4 transmitters are ready

The first pair of television transmitters for the new British Broadcasting Authority’s Channel 4 service have been connected to their channel combiners and handed over ready for use when the IBA brings Channel 4 into service during 1982.

The two transmitters, Marconi 30/5kW Type B7445 u.h.f. equipment, have been installed throughout the United Kingdom with similar transmitter sites, as well as installing a new u.h.f. channel combining unit. The two further sites throughout the United Kingdom for Marconi, with one of Marconi-designed channel combining units which will enable all the terrestrial television transmissions from isolated transmitters.

High-speed Ceefax

Waiting time for BBC Ceefax pages to appear on the screen has been halved — and now stands at only seven seconds. The improvement has been made by using advance transmission techniques. The maximum time for a page to appear after it has been selected will be up to 14 seconds depending upon whether or not the chosen page has just been transmitted.

Time to coincide with National Tetelvision Month, October, the improved system overcomes the problem of lengthy waiting times between previous, considering to be a drawback.

Colin McIntyre, editor of Ceefax, said, "We decided to use the extra time to cut the waiting time for the next page to appear in make the service even more attractive to the viewer. There is a great deal of enthusiasm in the trade for Tetelvision and the future looks very bright."

Since the start of the service in 1974 the BBC has used two blank television lines, 17 and 18, to carry data for each of the BBC 1 and BBC 2 television channels. Now, four lines are being used for each magazine — lines 15, 16, 17, and 18. The digital pulses for the Ceefax and Oracle systems are carried on the normal television signal as the receiver scanning spot returns to the top of the screen between pictures.
Three bands to open

The first new amateur h.f. bands to open since 144MHz in 1953 will become available to UK amateurs (on a secondary basis) from January 1, 1982. These are 10,100 to 10,150 kHz; 18,060 to 18,168 kHz; and 24,890 to 24,990 kHz, the new allocations agreed at the World Amateur Radiocommunication Conference in 1979. The 19 and 24 MHz bands remain allocated to the fixed and land mobile services, but amateur experiments have been transferred to new frequencies, after which the bands become "exclusive" to the new bands. These allocations are made available to the UK in the "amateur" and "amateur services" on a non-interference basis.

Here and there

Long sea-path ducting has brought about some interesting situations here and there. Interference to domestic entertainment equipment has been a continuing problem over the last few years, as a large number of domestic entertainment units, also the various forms of log-periodic arrays, poles fed from open-wire (or diamond) aerials, and mobile h.f. operation in the 18 and 24 MHz bands, have become quite popular. Therefore, it was necessary for the Home Office to consider, in addition to the first administrations to permit amateur use of 18 and 24 MHz, to restrict the use of 18 and 24 MHz the initial activity in these bands should be restricted to c.w./r.t.t.y. operation on these bands.

The simple two-transistor mirror circuit in Figure 1 is a useful circuit for many projects. It can be greatly improved by the addition of a further two-transistor mirror transistor to make the two-transistor mirror transistor to be used to design simple low-distortion operational amplifiers, the output current proportional to either input voltage. A new two-transistor mirror can be made this way, having the output current controlled by a pair of unbiased transistors (Figure 2). A single Class B with the crossover distortion eliminated by a feedforward amplifier using current mirrors.

Improving the performance and application of the basic circuit

by B. Wilson, B.Sc., Ph.D., Department of Instrumentation and Analytical Science, UMIST.

The accuracy of a two-transistor mirror circuit can be greatly improved by the addition of a further two-transistor mirror transistor to make the two-transistor mirror transistor to be used to design simple low-distortion operational amplifiers, the output current proportional to either input voltage. A new two-transistor mirror can be made this way, having the output current controlled by a pair of unbiased transistors (Figure 2). A single Class B with the crossover distortion eliminated by a feedforward amplifier using current mirrors.

In brief

The 1982 president of the RSGB will be Jack Anthony, G3KQF, of Derby, currently chairman of the Society's education committee and also of its membership and representation committee. GB2VER, a special event station operating on h.f. bands during February and March, marks the 21st anniversary of the founding of the Radio Club of America. GC7OP, set up by the Radio Club of America for the transatlantic tests organised in the UK by Wireless World. One of the signatories to that message was Howard Armstrong, whose long string of inventions included the development of frequency modulation and the superhet.

Translantic anniversaries

December 1981 marks another notable anniversary in the history of transatlantic communication: Marconi's classic, but still controversial, reception at St John's, Newfoundland on December 11, 1901 of the 'S' signals from Poldhu, Cornwall, a feat that many considered impossible. The reception by Paul Godley, ZE2, a noted American receiver designer, at Ar- drassan, Scotland, of the first message to be transmitted by amateur radio across the Atlantic, once the special station, BGC, set up by the Radio Club of America for the transatlantic tests organised in the UK by Wireless World. One of the signatories to that message was Howard Armstrong, whose long string of inventions included the development of frequency modulation and the superhet.

Fig. 1. Basic two-transistor, n-p-n current mirror

Fig. 2. Shorthand symbol for circuit of Fig. 1

Fig. 3. Accuracy of current transfer between input and output ranges on voltage output and output to h.f. Ratio Lp/V is plotted here for currents up to 10mA at the operating point Qc.

The beta term arises due to the effects of base current in an asymmetrical circuit with the Vbe term being due to the mismatch in the transistors' beta-emitter voltages. The contribution of the Early intercept voltage is best described as being due to the slope in the transistor Ic vs. Vce characteristics. Of course all these terms are dependent on current or temperature, making a general analytical evaluation quite difficult! Figure 3 illustrates the results obtained when using an RCA CA3996AE transistor array, connected as a two-transistor mirror and operating at currents of 100mA, 1mA and 10mA. Typical values for the n-p-n transistors in the RCA array were: Vbe=0.6V, beta=1000, and Vce=100V, producing error components of around 1%, 1% and 1.5% respectively for the three contributions. Clearly, the accuracy of the current mirror action for a two-transistor mirror is not very good, degenerating progressively...
The two sets of results were taken from the circuit of Fig. 5, with the currents monitored by 4½-digit digital meters. Transistor Tr4 was then shorted out to obtain the results for a three-transistor mirror. In both cases it can be seen that the current-transfer ratios are held very constant against output voltage changes. The removal of the Early inter­ceptor voltage error component (approx­imately -1% for the four-transistor cir­cuit) is evident. In addition, the current transfer ratio is maintained to higher cur­rent levels because of the incipient buffer­ing action with the four-transistor mirror. At 10mA it is still within ±0.3% of unity, whereas the three-transistor version has fallen to approximately 90%. These factors make the four-transistor configuration the best choice for circuit designs, both discrete and monolithic. For precision­driven designs the 0.1A1H electro­transistor mirror is the best choice, as it has a reduced de­gradation. Also, transistors matched in pairs (Precision Monolithics) can be used for Tr1 and Tr2 to give a current-transfer ratio of unity to within ±0.4%, due mainly to their very close VBE values.

**Current mirror applications**

In many cases it is desirable to control the output current rather than the output voltage of a circuit, especially when driving changeable or current-active transistors. For example, a controlled current mirror can be used to produce a variable magnetic field from an inductive coil. It is not always feasible to voltage drive the load through the normal series-resistor, particular­ly if a significant back e.m.f. is gener­ated. (An appropriate example could be that of a variable field in a loudspeaker and cassettes.)

Unfortunately, the standard bench test­book circuits for producing controlled bi­polar output currents from ordinary opera­tional amplifiers using grounded sources and loads suffer from serious practical problems, usually due to the extremely tight matching required for the resistors controlling the balance of negative and positive feedback. Circuits requiring non-critical resistor matching that produce superior results can be designed using four-transistor current mirrors. Both transconductance and current amplifier configurations are possible, normally required to control the current source (v.c.c.s.) and current controlled sources (C.C.S.).

Figure 7 shows the circuit of a bipolar transconductance amplifier (v.c.c.s.) using both n-p-n and p-p-n current mirrors where the output will be proportional to the input voltage. The RCA CA3096 AE three-transistor array contains three n-p-n and two p-p-n transistors, which means that two mirrors are required to construct a posi­tive and negative four-transistor current mirror pair. The current mirrors are used to sense the operational amplifier’s supply currents which, apart from the nearly constant bias currents, are proportional to the output current. A copy of the output current, whether positive or negative, is thus fed back to the inverting input terminal to be compared with the input voltage.

This forces the op-amp to generate an output current equivalent to the input voltage V1oh divided by the transconductance gain setting resistor R1. Output cur­rents up to 20 mA p-p can be obtained with very low distortion independent of the output voltage. Below 1mA the harmonic distortion is still very low, maintained at 0.03%, rising to 1% at 20mA. It is not necessary with this type of circuit to return the load resis­tor to ground: it can be terminated on any voltage as long as the resulting load voltage excursions are within the capability of the op-amp, and the voltage supplies. The recommended op-amp, frequency com­pensation should be followed, remembering that for a transconductance amplifier the equivalent voltage gain is given by R1 divided by R2: Care must be taken when using high values of R1 to avoid the op-amp popping. The input voltage gain can turn out to be surprisingly low. The circuit can be treated as an ordinary opera­tional amplifier circuit with a slightly restricted bandwidth caused by the shor­trfall in gain-bandwidth product of the p-p-n transistors in the RCA array. The equivalent gain bandwidth of the p-n-p transistors is between 10Hz and 10kHz. The output impedance figures can be improved if manufacturers provided a range of op-amps, with alternative output stages.

**Current amplifier using error feedforward**

The three previous designs, while being extremely useful at low currents, cannot readily be extended to high currents because of the restricted current handling capacity of the transistor arrays forming the mirrors. Class AB current boosters could be used but their well known thermal limitations make it desirable to operate a high-current output stage completely in Class B. In this respect, current output amplifiers can be more accurate than voltage output stages under most condi­tions, their output offset signal represents a smaller fraction of their maximum output.

Unfortunately, the crossover distortion produced by Class B output stages has traditionally made them unsuit­able for applications requiring precision low-distortion waveform reproduction.
The technique of error feedforward around a Class B output stage, often referred to as "current dumping", previously employed for a range of linear amplifiers, can be applied to current output amplifiers with very good results. An outline of the proposed method is shown if Fig. 10. A feedback voltage is derived directly from the dump voltage output current and compared to the input voltage of the system. The resulting error signal serves directly to drive the amplifier and the error feedforward amplifier. By using a suitable gain for the error amplification and a suitable phase in the gain, the system can be compensated for the errors caused by the input to output stage and its pre-amp can be compensated for the non-linearities of the error feedforward amplifier. A suitable choice of gain for the forward error loop, then the gain of the system becomes insensitive to the non-linearities inherent in the input stage and its pre-amp. The ratio of current contributions from the Class B dumper and the error amplifier is determined by the ratio of their transconductances. A better choice of open-loop gain and feedback factor will be obtained if the error amplifier normally supplies only a small proportion of the output current, as in the design of a wide range of low-distortion transconductance and current amplifiers.

Current mirror circuits offer a versatile design tool that can be employed in most applications and can be configured to generate the feedback signal for the error amplifier. However, by choosing a suitable gain for the error amplifier and setting current monitor A4, the contribution from the dumper output current is obtained at the output junction. The relevant equations for the sub-units are:

\[ I_{e} = I_{C} + I_{L} \]
\[ V_{T} = V_{I} - V_{L} \]
\[ I_{T} = I_{V} - I_{C} \]
\[ I_{T} = I_{C} \]

From these equations it can be shown that:

\[ I_{e} = V_{C} \cdot T_{c} \cdot (1 + D) \cdot (1 + y + yD) \]

This equation can be made insensitive to \( y \) and its variations (non-linearities) by setting

\[ \gamma T_{c} = 1 \]

The balance equation indicates that the transconductance of the feedback network \( y \) is made equal to the transconductance of the forward error loop, then the gain of the system becomes insensitive to the non-linearities inherent in the input stage and its pre-amp. The ratio of current contributions from the Class B dumper and the error amplifier is determined by the ratio of their transconductances. A better choice of open-loop gain and feedback factor will be obtained if the error amplifier normally supplies only a small proportion of the output current, as in the design of a wide range of low-distortion transconductance and current amplifiers.

Literature Received


Publication HG1 from Highland describes the types of microwave connector currently available. The "below-the-line" operation of mass communication is a cross reference to other makers. The guides to those who buy microwave equipment are published by Andrew Associates, Ipswich, Suffolk, KY5 9SL.

An extensive range of microwave aerials, cables and waveguides are fully covered in a wide-ranging catalogue (over 200 pages) which can be obtained free from Ferranti Limited, Hadley Road, High Wycombe, Bucks.

TIPS AND TROUBLESHOOTING

1. Failure of a single component will normally be revealed if an instrument is connected directly across the output stage.

2. Heavy current distortion is generated by the current mirrors in the error feedforward amplifier and can often be discernible disturbance in the linear waveform. The bottom trace shows the error current measured across a separate resistor for comparison. Output currents up to 1mApk can be obtained with this circuit, although the photographs were taken at a low current (15µAmpk) where the effects of crossover distortion are more noticeable.

3. Distortion measurements indicate that the second harmonic is 70dB below the output at 100µAmpk-pk, rising by approximately 50dB at 10µAmpk-pk and 10µAmpk.

4. The third harmonic is lowest around 25µAmpk, rising to 100µAmpk before falling, rising to 75dB at 10µAmpk-pk, and 80dB at 1µAmpk-pk. Second harmonic distortion is generated by the current mirrors in the error feedforward amplifier and the dumper current monitor, whereas the third harmonic distortion is produced by the crossover operation of the dumper. Higher harmonics are also present, but are significant only in the case of distortion from a source with a low output leakage (e.g., a low distortion power amplifier). The feedback factor \( R_{F} \) is set to provide the forward error loop gain, whereas \( R_{L} + R_{F} \) is used to balance the sensitivity of the system.

5. The upper trace of Fig. 12 shows a 2kHz triangular wave at 2kHz with and without feedforward. The lower trace shows the error current measured across a separate resistor for comparison. Output currents up to 1µAmpk can be obtained with this circuit, although the photographs were taken at a low current (15µAmpk) where the effects of crossover distortion are more noticeable.

6. The types of microwave connector currently available are described in a wide-ranging catalogue which can be obtained free from Ferranti Limited, Hadley Road, High Wycombe, Bucks. The technical specification and performance data of this equipment are fully covered in a wide-ranging catalogue which can be obtained free from Ferranti Limited, Hadley Road, High Wycombe, Bucks.

7. The types of microwave connector currently available are described in a wide-ranging catalogue which can be obtained free from Ferranti Limited, Hadley Road, High Wycombe, Bucks. The technical specification and performance data of this equipment are fully covered in a wide-ranging catalogue which can be obtained free from Ferranti Limited, Hadley Road, High Wycombe, Bucks.

8. The types of microwave connector currently available are described in a wide-ranging catalogue which can be obtained free from Ferranti Limited, Hadley Road, High Wycombe, Bucks. The technical specification and performance data of this equipment are fully covered in a wide-ranging catalogue which can be obtained free from Ferranti Limited, Hadley Road, High Wycombe, Bucks.
Phase locked detector

I thought that detectors such as the one described in the February issue under the title Phase Locked Detector could no more be of interest to professional engineers.

Evidence for neutrons

Before Me Burrows (October Letters) uses the success of the neutrino to prove the existence of the neutrino, he should remember that every piece of iron that rusts "proves" in the same way the existence of phlogiston.

Unified circuit theory

In his September 1981 letter, R. T. Lamb seems to think that if he establishes that we are merely discussing a model rather than a theory or a fact, he has also established that a bad model is no worse than a better model. When he writes, "... any model that shows that electric current is not even needed in that model," I would reply that the successful removal of primitives such as $\text{pro}$ and $\text{f}$ from the theory would disprove the model.

Wine bridge improvement

The dream of objectivity

I was very interested to read your March editorial, but I think your conclusion could be misleading.

Wire recorder

While Millman's theorem is highly useful, it also represents one side of the story, since the theorem only describes the output of each circuit configuration and does not consider the input.

References

axis of propagation of the wave. But the wave is then transformed (TEM) and has no such component. Electromagnetic wave theory does not consider a wave to be a column of free electrons advancing down a wire like peas down a tube. A conductor is a region with a large number of free electrons in chemical equilibrium and is therefore a positively charged model. These electrons interact with electric potentials external to the wire in a manner described by the equations of Maxwell. This can be verified experimentally.

Mr Catt's crude model is thus fundamentally wrong. The model of a wave full of free carriers is also quite crude and at least is fundamentally correct. In this model it is reasonable to describe the wavefront as the dividing line between that region where carriers have started to move and that where they are not yet disturbed by the approaching wave. It is, of course, fairly common knowledge that the approaching wave is external to the conductor (it cannot be inside, see above) and it influences the surface charges first (skin effect).

Mr Catt's contributions on e.m. theory are shot through with misunderstandings of the fundamentals: territory, to anyone outside his local (groundwave) operator talking because the tellies were off. The direction this fight took was that of more violence, more wars, more, more, easily amenable material of appeal to the less discerning. Less discernment seems to breed even less discernment, for how often does one observe an audience around a colour television apparently unaware that there is something odd about characters with green or purple hair.

I remember a case when BBC news gave minimal reporting of murder trials. What a change! Huf Wa news bulletin followed a half hour substituated programme on a mass murderer. I remember when dance music had lyrics of more than four words and was melodious, and its merit was not judged on any criteria of popular appeal, but on the basis of melody.

Many thanks to John Plow for his very interesting article in the September issue on the BBC sound broadcasting and recording at St Paul's for the Royal Wedding. I was very surprised, however, to learn that trouble was experienced from thyrister interference in the microphone cables.

In 1964, when I was in the BBC Designs Department, thyrister dimmers were known for their ultrag waves at Television Centre, and I was asked to see what could be done to prevent the interference that had already become a serious problem with standard twisted-pair microphone cables. To shorten a long story, I developed a thyrister microphone cable which reduced interference, in the worst conditions when crossing a cable feeding a 144W IP, to below the microphone amplifier limit. Since then what first became known as "blue quad" has been manufactured by the mile and has become mandatory in all television studios, both in the BBC and in true, i.e.

The blue quad has become grey, following the use of chroma key or color separation, and has itself become thinner and higher than its ancestor. You can now see it on any television picture where a microphone is in the shot.

Of these problems do not normally beset the sound broadcasting engineer. But you should be prepared that someone, somehow, will have passed the word. Virtually all thyrister interference is coupled to microphone cables inductively, and for a properly balanced pair (or quad) ordinary broad or spiral screening is adequate.

Philip D. R. Marks Bourne End Bucks

The big c.b. con

The proponents of citizens' band radio, including the suppliers of m.e. equipment, are really leading our fellow countrymen into the largest confidence trick imaginable by playing on the fact that little is known technically about types of modulation, propagation, spot cycles etc. and the desire to do as others are doing — including their mistakes.

Having monitored the 27MHz band in my area, I have yet to hear any UK operator talking to improve outside his local (groundwave) territory, although no doubt a small number do. Language is still a major barrier and Great Britain does not have many neighbours who have English as their native language, whereas the USA is large enough on its own to receive its own generated transmissions on sky-wave. I think that, apart from the shape of the nation, the final con, will be evident when sales of a.m. equipment fell off in Britain. Without assuming any detailed knowledge of electronics or computing on your part, the course shows how to approach system design, hardware and software development, prototype evaluation and final production design. As well as working through five specially prepared books, and familiarising yourself with a file of manufacturers' data sheets and brochures, you will carry out experiments designed to give you valuable practical experience with your microcomputer.

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Complete with user manual and experiment books, it interfaces with your own TV set and cassette recorder. You also get a prototype development board with such peripherals as a small DC motor, domestic light switch, video output for viewing graphs and load-speaker — which you learn to drive with your microcomputer.

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WIRELESS WORLD DECEMBER 1981

Radio amateurs' licence

Your correspondent Jock Hall (June letters) should be asked "Where are those employers producing electronic equipment of end use to society, and how many can they employ?"

After the war I returned to radio service. It was an interesting challenge to get sets from the debris and with what values and components were available to reproduce a good standard of performance. This came the new sets and disappointments; the only apparent lesson learnt from war-time developments was how to cut material to the bone. The customer set upaned down on the bench at the risk of f.f. cans breaking away from their mounting.

Then came television, and after a while real commercial. People with tears in their eyes pleaded, "Please repair it here, don't take it away, we don't know what we would do without it!" It was a queer group to get children to bed or to do their homework. Visiting friends or relatives and not being able to talk because the tellies was on.

By the early fifties the novelty had worn off, the position was worse as so many people had television. I was left helping to create morons, to drive people mad, so, at a considerably reduced salary I look work in a Ministry of Defence inspection.

The work was interesting, there could be pride in a product well made and built to last, though, ironically, meant to blow itself to bits at first use. To begin with there was reasonable hope that these devices would never be sold. If that hope has now gone then the distraction of the phantasy world of television, drawing attention away from events in the real world must take a large share of the blame.

But the advance in the field of competition with the BBC, for if one side captures the mass audience the other goes out of business. The direction this fight took was that of more violence, more wars, more, more, easily amenable material of appeal to the less discerning. Less discernment seems to breed even less discernment, for how often does one observe an audience around a colour television apparently unaware that there is something odd about characters with green or purple hair.

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Ethics in action

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**...but also a Real Time EPROM Emulator...**

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**New BBC/OU production centre opens by Donald Aldous**

In late September production started at Europe's biggest purpose-built educational broadcasting complex, the new centre of the Open University at Milton Keynes, Buckinghamshire. Robert Rowland, head of the new centre, describes the OU as 'the largest university in the Kingdom'.

The start of production at the centre is the culmination of some ten years' efforts to create and manage the physical development of the university's 70 acre campus and 13 regional properties, since the OU was established in 1969. The original production facility was at Alexandra Palace, London, and the new site will offer a more convenient working relationship for OU and BBC colleagues on the course teams that compile and produce all OU study material.

This project has cost over £8 million, funded by the Department of Education and Science, and is not extracted in any way from the BBC television licence fee, as has been bruited around by some critics. In fact, the OU's yearly fee to the BBC for production and transmission of programmes is currently around £3 million. Total floor area of the building is 11,100m² gross, 8,500m² net. (The difference is made up of corridors, plant rooms, toilets, etc.). The building is supported by 504 reinforced concrete piles, each individually driven into the ground over a period of about three months in the autumn of 1977.

The reactions of the OU staff working on the campus at that time can be imagined!

The technical areas are interconnected by 40,000 metres of cable. The power distribution cables add up to a similar total, which in combination would cover the distance between London and Milton Keynes. Electric power reaches the building's own substation at 11kV, 3-phase, where it is transformed down to 415V for distribution throughout the buildings.

The centre at Walton Hall, as it is known, consists of an office block and a technical block, joined together at a main reception area. The technical block contains two tv studios: Studio 1 has a floor space of 136 square metres and Studio 2 has 102 square metres. Studio 1 is a small production studio with four Link 110 colour cameras, and the production suite is at ground floor level to permit easy access. This arrangement is in contrast to the usual high level gallery with observation windows.

The production control suite has separate control, vision and lighting control, and sound control rooms. The desks and monitor stands are positioned so as to allow direct line-of-sight between the desk and the person seated at the desk in the production control room and the personnel in the other two rooms.

The vision control room has a Grass Valley 16-channel, 4-bank vision mixer with multiple re-entry, chroma-key and comprehensive wipe pattern generators. The chroma-key incorporates the BBC fringe suppression system. Lighting is controlled by means of a Thornlite 500 microprocessor based system with 200 dimmer channels and 200 memory files.

The sound control room has a 20-channel/4-group control desk built to a standard BBC specification, two Studer A80 1/4" tape recorders and two BBC designed disc recorders. There is also provision for adding a multi-track tape recorder and other equipment for post-production editing.

Studio 2 has been equipped for operation on a 'drive-in' basis with a colour mobile control room. The installation has been confined to production lighting and cabling to a connection point in the nearby outside broadcast van, where the vehicle will be parked when used in this mode.

**Sound suite**

There are two studios in the sound suite, one of 104 square metres and the other a small talks studio of 20 square metres. The larger studio is equipped for drama and music with a Calrec Mk. 219-channel general purpose stereo desk, the Studer tape equipment, and BBC disc reproducers. The adjacent talks studio, which also serves as a quality check room, houses two tape machines and one disc player. Control is from a Grosnond desk fitted for seven stereo and four mono channels.

*Production control room for the larger of the two studios, Studio 1. Through the window in the background can be seen the sound control room. This suite also contains three editing/transfer rooms, each with three tape machines and a linking console; a 'try-over disc room' for listening to the content rather than the technical quality of the material; a tape store; an office and a maintenance room.*

**Central technical area**

This area is divided into a number of rooms for video tape recorders, a video rostrum camera or episcope room, telecine, a quality check room, maintenance and tv apparatus rooms. Four of the six videotape cubicles will be equipped with broadcast quality machines (Ampex) and one cubicle with a rack of cassette recorders for producing copies of programmes for distribution to OU study centres and libraries.

The video rostrum camera is an invaluable help to OU's insatiable thirst for graphic material. After five years' use at AP, the video rostrum - with its computer controlled camera recording direct to video tape - remains unique to the production centre. This rostrum enables animation and caption sequences to be checked during recording.

It is noteworthy that equipment to the value of about £1.5 million has been transferred from Alexandra Palace. This was originally bought and installed in 1974/5, when it was decided that OU tv programmes should be made in colour. Without this equipment, the total cost of the new centre would have been around £8m.
Circuit Ideas

Micropower voltage regulator

In battery powered systems which require a constant voltage supply, a regulator is needed to stabilize the voltage as the battery decays. Unfortunately, most i.e. voltage regulators require several milliamps of quiescent current, which makes them impractical for micropower applications. Zener diodes may also be impractical because of short term peak current requirements.

Instead of the traditional bipolar approach, this regulator uses a f.e.t. as the series pass element which does not require pre-regulation because the drive comes from the regulated output. Also, the gate-source is isolated from the drain line, which provides high line regulation. This is not the case with p.n.p. pass elements where the emitter is the input.

The emitter-base breakdown voltage of Tr3 is used as a reference (≈7.2V) in conjunction with Tr2 to form a shunt regulator. Shunt current drives a current mirror, Tr2 - Tr3, which produces the gate-drive voltage for the f.e.t. The value of the shunt current is determined by R3 and VGS of the f.e.t. (VGS=Vzz drain). High load currents will reduce the shunt current because VGS is lower. Temperature stability is achieved by cancelling the VGS drift of Tr2 and Tr3 with the VBG drift of Tr7, which results in a negative drift at the base of Tr2 and the output of imV/dég.C. The f.e.t. VGS should be much greater than the load current at all temperatures (VGS has a temperature coefficient of a ≈ 0.7mV/dég.C) and the breakdown voltage should be greater than the maximum input voltage. Linear operation requires the f.e.t. drain-to-gate voltage VDD to be greater than the pinch-off voltage VPP. By operating the f.e.t. at currents much less than IFSS, the gate-to-source voltage will be close to VGS which allows small drain-to-source voltages. Therefore, for linear operation + BVGS (1+R1/R2) and can be trimmed by adding a potentiometer at the base of Tr2, R2, Tr2 base junction to eliminate BVGS variations or to make the output variable over a limited range. Temperature stability can be improved by replacing Tr7 with an 8.2V Zener diode, whose temperature drift of +4mV/dég.C will nearly match the combined VBG drift of Tr2 and Tr3. Quiescent current with the values shown is about 4mA.

J. Maxwell
Santa Clara
U.S.A.

Improving converter efficiency

The efficiency of a simple converter can be improved by using a rectified output derived from the input winding. This simple addition reduces the input current for a given output current and increases the output voltage. Also, the output short-circuit current approaches the input current. This form of converter is well suited for variable voltage inputs such as solar-cell panels, especially as no reverse-current input diode is required when the cells are in darkness.

The mains transformer can be used in its original form, but a higher output current can be obtained if the low voltage winding is rewound with 20 turns of 26swg enamelled copper wire. The number of turns on the higher voltage winding can be reduced to lower the output voltage and increase the output current. Performance details are shown in the table.

Simple voltage control can be achieved by connecting a suitable high value resistor between the rectifier negative and negative rail.

R. C. T. Stead
Hampton
Middlesex.

<table>
<thead>
<tr>
<th>Voltage</th>
<th>Current</th>
<th>Efficiency</th>
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<tr>
<td>1.5 V</td>
<td>3mA</td>
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<tr>
<td>1.5 V</td>
<td>800mA</td>
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<tr>
<td>3.0 V</td>
<td>6mA</td>
<td>72%</td>
</tr>
<tr>
<td>3.0 V</td>
<td>1500mA</td>
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Contributions for circuit ideas should be typed and include a daytime phone number if possible. We now pay a minimum of £20 for all ideas which are accepted for first publication in Wireless World.

Fusible-link p.r.o.m. programmer

Fusible-link p.r.o.m.s such as the SN74S288 and SN745588 can be programmed directly and, by adding up to three more address lines from the counter and using a larger socket, the following devices can also be programmed.

- ST5702
- ST5111
- 741S288
- 74S188
- 74S387
- 74S54

The +12V supply should be rated at 1.5A, and the only important constructional note is to ensure that a low resistance path exists between the emitters of the eight transistors, 0V on the p.r.o.m., and the +12V ground, so that the programmed bit is held low and a 750mA current pulse flows through it. N. Kirby
Huddersfield.

Wireless World December 1981

WIRELESS WORLD DECEMBER 1981

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www.americanradiohistory.com
What light units are you dealing with stage illumination, with the notion of light flux. To put into the right place every single one of them, you will have grasped the basic concept of flow: think of the water flow of many per hour? Think of the water flow of your Company's cash and other talbots, without mentioning the moulded light units, to make them tangible to specialists. How then do we get the idea on how bright an area appears to us. For example, a television screen which is clearly perceived and firmly rooted in the mind for the remaining three of the basic concepts of light measurements: illumination, irradiance, and luminance. Equipment with these you will be able to put into the right place every single one of the two dozen or so existing units. Articles dealing with stage illumination, with camera sensitivity, with the light performance of L.e.d.s, c.r.t.s, incandescent and other red, may be transmitting equal time-rate of the flow of this energy through a certain area or out of a source. The idea of flux is closely identified with that of flow: think of the water flow of a given direction per unit area, the illuminance/irradiance. This is what is expressed by saying the sun is hotter midday than morning and evening.

Before going onto the next units of the basic four it is of utmost importance to emphasize that neither illuminance (lux) nor irradiance (W/m²) gives the slightest idea on how bright an area appears to us. Consider Fig. 2. The illuminance of a source 20 cm from a plane at 25° from it is 100 lux, the illuminance of a source 20 cm from a plane at 25° from it is 50 lux. To form a steradian, take an orange, cut it into six as if sharing an apple and cut it into six as if sharing a spherical chocolate. This spatial angle is unfortunate: a steradian is a three-dimensionally a flat angle unit such as the degree will not do here. A space angle unit must be instead: the steradian. As the unit of flux is a lumen, the luminous intensity will be measured in luminous steradians. For brevity a single word without inverted commas! They alone represent genuine power - they alone are let me take you out of the jungle, to the jungle? Simple. By going straight to the jungle...

Luminous flux

The first and truly fundamental concept is associated with that of flow: think of the water flow of 900 nm. Some, such as the degree will not do here. A space angle unit must be instead: the steradian. As the unit of flux is a lumen, the luminous intensity will be measured in luminous steradians. For brevity a single word without inverted commas! They alone represent genuine power - they alone are let me take you out of the jungle, to the jungle? Simple. By going straight to the jungle...

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The fact that citizens’ band radio is now legal gives little relief to those who are suffering from interference because of the illegal use of a.m. sets on unauthorized channels. The Selective Paging interference is very insidious. When affected, a premises for maintenance and security urgent call with direction.

Independence must not be taken for granted, as most devices and materials are not lambertian. Their luminance varies with direction.

Finally, the radiometric measure of luminance is radiance and I think that nobody will puzzle more than the fact that it is usually measured in W/m² × m².

The Observer is interested to those who have built a kit but cannot interest to those who have built a kit but cannot

Figure 5. Spatial angles may be alternatively visualized as that conical fraction of a sphere whose surface area is equal to the square of its radius.

Figure 6. Values of both radiant and luminous intensity are independent of source distance.

Figure 7. Luminance expresses brightness of source. Large lamp, as expected, gives less bright than smaller bulb for the same power and flux. Luminance is luminous intensity per unit area (which is the same as flux per steradian per unit area).

British Telecom have said that they are getting more than 1,000 complaints each week about c.b. interference. These refer to interference on tv and radio, breakdown on h.s., interference on emergency services and other mobile services, such as taxis. Mobile c.b. control is lost, can become lethal, unmanned mines.

The chopper effect is that the interference is very insidious. When affected, all the workings of the receiver and not the interference. When one considers that paging systems are used in hospitals, on industrial premises, in public places, and on the road, then it becomes apparent that if an urgent call is not received, then there could be very serious consequences. A report by Tom Davis in The Observer is that a patient has died because a doctor could not be paged.

What the Selective Paging Committee proposes is that radio paging should be shifted to a different frequency band with a width of 50kHz, between 30 and 43MHz. This band was allocated at WARC to fixed and mobile services. 31.7kHz to 31.725kHz is already allocated in the UK to on-site radio paging. The majority of the band, however, is allocated for military use.

The surface area, the second constituent, is intensity, one of its two constituents. Intensity must be taken as the projection of the physical radiation area on the plan perpendicular to the direction of the source. Large lamp appears four times less bright than smaller bulb for the same power and flux. Luminance is luminous intensity per unit area (which is the same as flux per steradian per unit area).

Overall design aims of the digital recorders were set out in the first two parts of this article, which continues with a description of the additions to the audio cassette deck for multichannel digital recording.

All the logic used in the design of the digital circuitry in c.m.o.s. and is specified by the Home Office with a nominal +15V; the analogue circuits use the same +15V supply and one of +15V.

Many of the logic circuit diagrams are complicated, and to keep them as simple as possible, not all the pin connections to a particular logic device are shown: only those necessary to define the function of the device are indicated. For example, the interface inputs are shown. Again, a divide-by-10 counter (i.e. type 4017) may only be shown with its clock inputs, carry output and enter connection, it being left to the reader to appreciate that other inputs may need to be connected to +V or ground, or left unconnected as appropriate. Another example is the use of a D-type flip-flop (i.e. type 4013) as a divide-by-two counter; it is assumed that the reader knows that the Q output must be go to the D input for the device to work correctly. However, whenever it is thought that a particular device may be unfamiliar to readers, a more detailed description of the pin connections is shown.

Temporary storage buffers, control circuitry

Figure 2 in part 1 of the article showed the two 72-bit temporary data storage buffers, the 8-bit sync. word buffer, a 2-bit shift register, the Miller encoder and associated control circuitry. Figure 12 shows the detailed circuit diagram of the first three and their interconnection via logic switches. The two 72-bit storage buffers are made up from two shift-register ICs, types 4014 and 4031, the 4014 type being an 8-bit serial or parallel-in/serial-out device. Since it is used only in the serial-in/parallel-out mode, all eight parallel inputs go to ground, as does its parallel-in/serial-out mode input. Serial data input advances the shift-register on the positive edge of the clock pulse. The 4014 device is a 64-bit, serial-in/serial-out shift register with the facility to recirculate its internal data, depending on the state of a ‘mode’ input. To function correctly as a serial-in/serial-out device, the ‘recirculate’ input goes to +V and the ‘mode’ input to ground. As for the 4014 device, the serial data advances through the shift register on the positive edge of the clock pulse.

The sync. word buffer is an 8-bit shift register (another 4014) operated in the parallel-in/serial-out mode, into which the 8-bit sync. word, permanently present at the parallel inputs, is entered on the positive edge of the clock pulse when the PS input is high. It is shifted serially out on the positive edge of the clock pulse when PS is low. To produce a sync. word sequence of 1, 0, 1, 0, 1, 0, 1, 0, the parallel inputs are simply repeated.

Filling and emptying of the two 72-bit buffers and operation of the sync. word buffer is under the control of the circuitry detailed in Fig. 13(a), interconnections between the two circuits being made as illustrated.

The logic sequence of the control pulses is clearly shown in Fig. 13(b), with a time-expanded picture of the B and sync. word PS & 2°, control pulses shown in

The general idea of the digital additions to the audio cassette recorder for multichannel digital recording.

Design of the digital additions to the audio cassette recorder by A. J. Ewins, B. Research Laboratories, London Transport

News in Brief

Powertran specialist in selling kits from magazine designs, including some from Wireless World. Unfortunately, they have had difficulty in maintaining a construction and servicing facility. They were relieved when they heard of Circole, an electronic company in Tooting, South London, who were willing to undertake some of the more complicated and, to keep them as simple as possible, not all the pin connections to a particular logic device are shown: only those necessary to define the function of the device are indicated. For example, the interface inputs are shown. Again, a divide-by-10 counter (i.e. type 4017) may only be shown with its clock inputs, carry output and enter connection, it being left to the reader to appreciate that other inputs may need to be connected to +V or ground, or left unconnected as appropriate. Another example is the use of a D-type flip-flop (i.e. type 4013) as a divide-by-two counter; it is assumed that the reader knows that the Q output must be connected to the D input for the device to work correctly. However, whenever it is thought that a particular device may be unfamiliar to readers, a more detailed description of the pin connections is shown.

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The logic sequence of the control pulses is clearly shown in Fig. 13(b), with a time-expanded picture of the B and sync. word PS & 2°, control pulses shown in
Fig. 13(c). Starting from the moment that the A control pulse goes high, the sequence of operation is as follows. Under the control of the data-clock, DC, the temporary data store, N1, is filled with serial data — 72 bits in total. Simultaneously, the tape-clock TC empties the temporary data store, N2. After 72 TC pulses, the control pulse, A, B, goes low and control pulse, B, high. Eight further TC pulses empty the sync. word buffer into the data stream before the control pulse A, finally goes low.

Due to the presence of a high 2-bit control pulse during the eight sync. word TC pulse, the sync. word present at the parallel inputs of the sync. word buffer is re-entered simultaneously with the last bit of the previous sync. word being clocked out. Control pulses A and B now go high and B goes low. In a similar manner to that described above, temporary data store N2 is now filled with serial data under the control of DC and temporary data store N1, is emptied under the control of TC.

Again, the sync. word buffer is serially emptied into the data stream during the last 8 pulses of TC before A goes low. Thus, as described above, the 8-bit sync. word is inserted into the serial data stream every six data words of 12-bit length without interrupting the serial data flow.

Apart from a time-expanded picture of control pulses B & 82, Fig. 13(c) shows the passage of the 8-bit sync. word, as part of the serial data stream, through the 2-bit output shift register. Producing a 2-bit delay in the data stream results in the & 2 control pulse occurring at the centre of the delayed 1, 0, 0, 1 sequence of the sync. word. The & 2 control pulse is thus also used as the 'blanking pulse' of the Miller encoder. (The purpose of the 'blanking pulse' was described in Part 1.)

Three circuit blocks of Fig. 13(a) are shown in greater detail in Figs. 14(a), 15 and 16. The divide-by-9 circuit, Fig. 15, and the clock oscillator and divide-by-8 circuit, Fig. 16, need no further explanation and are drawn separately purely for detail. The divide-by-12 circuit, Fig. 14(a), is a little more complicated and needs some explanation. Firstly, it was not only required that the divide-by-12 circuit should produce an output pulse every twelve clock pulses, but that its duration should be for exactly one DC cycle and occur at the eleventh DC pulse. The pulse so produced is referred to as PS and controls the parallel/serial mode of the 12-bit shift register used in the analogue-digital conversion of the input stages (see Fig. 4 of Part 1). Secondly, it was required to produce another similar pulse, referred to as B4, to control the sample/hold circuit of the input stages and to initiate the a-d conversion. Divide-by-10 counters, i.e., type 4017, produce ten sequential output pulses every ten clock pulses that last for exactly one clock cycle. By combining two of these counters under the control of a flip-flop, each is made to divide by 6, producing an overall divide-by-12 counter with twelve sequential outputs that last for exactly one clock pulse. The addition of three 2-input, diode OR gates was found essential to determine the correct sequencing of the two-counters with relation to each other and the reset pulse.

The exact logic sequence of the two counters is shown in detail in Fig. 14(b). Upon examining the circuit of Fig. 14(a), it may seem a little odd that output 7 of both counters is used to clock the flip-flop and note, what might more reasonably be expected, output 6. This is done because a negative transition of the clock — enable input, CE, clocks a counter in the same way as a positive transition of the clock input. (A fact which has caused many a de-
The Miller encoder, which is shown in detail in Fig. 17. Two inverters, 1 and 2, produce a high on output A1. The first inverter is inverted, hi-phase-encoded data stream at the output of NAND 4. The outputs from both NAND 3 and NAND 4 contain glitches due to the combination of the two outputs from NANDs 1 and 2 and the inverted blanking pulse. To remove these glitches, a 200pF capacitor is connected from the output of NAND 4 to ground to remove the glitches by increasing the rise time of the encoded waveform. A further inversion of the signal by inverter 4 reduces the encoded data and increases the rise time to give a true hi-phase-encoded output, modified by the presence of the blanking pulse. This signal clocks a divide-by-2 flip-flop to produce a Miller-encoded data stream at its output. Finally, the Miller encoder output data output from the flip-flop sequence. The influence of the blanking pulse, in suppressing the transition that would normally take place at the centre of the 1, 0, 0, 1 sequence of the encoded word, is also shown.

Together with the predicted performance, the Miller encoder has both wind and sun generators with back-up storage batteries and, as at Bossiney, there is no saving in remote time delay fuses. Details are available in IEC 9000/CECC 100010.

Test equipment includes that for the simulation and testing for shock, vibration, bump, extremes of temperature, solderability and so on. Ashcroft Electronics are at Somerford Road, Harpenden, Herts AL5 4U. Telephone: Harpenden 63141. Telex: 25559.

News in Brief

Colour codes for miniature fuses. There has been much confusion in the past about marking fuses; a variety of colour dots or single colour bands have been used with no recognised coding, each manufacturer deciding arbitrarily how to do it. The British Electrotechnical Approbation Board had recommended a three band system which met with some success. The International Electrotechnical Commission's members have now come to an agreement that a four band system should be used, with the recognised colours as used for resistors and capacitors, where the first two bands represent the first two digits of the current rating of the fuse, the third band indicates a decimal multiplier and the fourth, wider than the others, would be the time-current characteristic, such as fast blow or time delay fuses. Details are available in IEC Publication 127A.

Transmitter powered by nature

We have received verbal reports of naturally powered transmitters, both claiming to be the first. The first that we had notice of is the IBA equipment at Bosinney, Cornwall. It will provide programmes to just under 300 people and marks a development in the design of low-cost, relay stations capable of serving communities of less than 500 people. The experimental use of combined wind and solar generators is designed to last for several years during which data will be taken daily for computer analysis. It is hoped that the experiment will be compared with the predicted performance obtained from a study of the Meteorological Office's daily sun and wind records over the past ten years. All power for the Bosinney station will normally come from the wind or solar generators, or from a bank of 36 large lead-acid batteries that will be charged by power from the generators.

The other report was of the BBC transmitter in Duchycombe, Argyllshire which will help to bring pictures to 600 people in Dalmally and Lochawe in the Strath of Crerche. It does not broadcast direct but receives the signals from Forsay on the Isle of Mull and retransmits them to the relay station at Dalmally. This station has both wind and sun generators with back-up storage batteries and, as at Bosinney, is monitoring separately to record the performance of each generating system. Analysis will help towards the design of cheaper, more efficient wind and/or solar powered stations. The BBC points out that as the consumption of the transmission transmitter is very low, there is little saving in energy, but it has saved considerably by avoiding the cost of bringing mains power to this remote Scottish site.

The wind and sun powered transmitter installed by the IBA in Bosinney, Cornwall.

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Performance to spare. With the D1000 series, Telequipment regard specifications as lower limits, not maxima. For example, the D1016A bandwidth is specified as 20MHz. The typical figure is actually in the region of 23 to 25MHz and the usable bandwidth nearer 35MHz. Input attenuator tolerances are now specified as +2% for all D1000 series oscilloscopes, a considerable improvement over the previous ±5%. But again, the user may well find the true figure closer to ±2%.

More Accurate Time Bases

The time bases, too, have been upgraded. All new D1000 instruments have been equipped with thermal compensation which tightens time measurement accuracy to ±2%, with improved stability in the ±0.5% range. To match these improved time base specifications, trigger bandwidths and performance characteristics have been substantially enhanced.

Better Display

The D1016A also has a new CRT. The size is just the same easy-to-view 10 x 8cm but with an internal graticule and a quick-heat cathode. It has a "G" phosphor which is a near equivalent to the F3 but it is more efficient circuitically at low beam currents and high writing speeds.

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A field theory approach

by Lawrence A. Jones, M.Sc. (Eng.)

A study of a capacitor as a transmission line by Cart, Davidson and Walton in the December 1978 issue contains, in the author’s opinion, inaccuracies, mainly due to the subject being treated as a circuit theory. This article presents an analysis from a field theory viewpoint and shows the importance of the concept of displacement current.

Displacement current is perhaps one of the most difficult field theory concepts and it has been suggested that Maxwell developed it by direct analogy with his equation only, using the following formulas:

\[ \frac{dE}{dt} = \frac{1}{\varepsilon_0} \frac{dQ}{dt} \]

Therefore:

\[ \int \frac{dE}{dt} \, ds = \frac{1}{\varepsilon_0} \int \frac{dQ}{dt} \, ds \]

Thus, if the electrostatic energy in the electric field changes, the energy change has to manifest itself in some way. It does so by producing an external flow of current in the conductor connected to sphere B.

It is important to realize that this displacement current does not have the significance of a current in the sense of being the motion of charges. After all, free charge cannot exist in free space, and hence, there cannot be a force proportional to 1/E, which is the displacement current in empty space. In order to examine the effects of time-changing electric fields three examples will be considered.

For the first example it is required that the charge on a conducting sphere be measured by discharging it to a large conducting plate connected to an oscilloscope. The resulting voltage pulse is measured, and, since the input capacitance of the oscilloscope is known, the charge on the sphere can be calculated. When the resulting pulse is measured and the charge calculated, a serious discrepancy is found to exist between the actual charge on the sphere, which may be found by direct measurement in a Faraday cage, and the charge measured on the oscilloscope; the explanation is interesting.

The energy stored in the electric field is given by

\[ W = \frac{1}{2} \int \frac{dE}{dt} \, ds \]

As the sphere approaches the plate, the volume of the field is decreasing, so the energy stored in the field has been reduced; but where has the energy gone? As the sphere approaches the plate more negative charge is induced on to the plate and thus more positive charge will flow to ground. As the instant of discharge a pulse is registered on the oscilloscope. This pulse is simply the charge that has been neutralized by the induced charge on the large conducting plate. If there was originally +100C on the sphere and only –50C induced on the plate then the +20C would flow into the oscilloscope, hence the discrepancy.

The method illustrated in Fig. 2 was used to confirm this theory. In this set-up an extra electrode connected to the oscilloscope’s second channel is inserted through a hole in the conducting plane. A protective sleeve insulates this electrode from the plate. Once again the sphere is brought towards the plate but is now allowed to discharge onto the needle. In this case, only –10C has been induced on the needle. Discharging it to the large conducting plate, i.e., if there had been neutralization, +90C, would flow into the oscilloscope. The positive pulse measured on the oscilloscope will be almost equal to the charge on the sphere. Similarly, when the discharge occurs, the –8nC induced on the plate will be released since the electric field has collapsed. A pulse of –8nC will be measured on the second channel of the oscilloscope.

The consideration of a capacitor as a transmission line has been discussed in the proposal that displacement current is erroneous. Consider the capacitor in Fig. 3(a) at time t = 0, the switch is closed and the capacitor starts to charge. A capacitor cannot charge up instantaneously: it will start to charge with the formation of field line, and, thus, charge, etc. Hence, the initial
current flow, $i_1$, will be

$$i_1 = \frac{\varepsilon_0}{\mu_0} \int \text{d}E$$

This current flow until field line ab is formed. At a time $t$ seconds later, a current $i_2$ will flow shown by establishing field line cd and so on. Figure 3(b) shows this diagrammatically.

From the above explanation it may be deduced that the transmission line capacitor is in effect an infinite number of small capacitors. I would suggest that this is the reason why it has never been possible to measure inductance in a capacitor, because each capacitor will acquire an infinitely small charge. Obviously this very small amount of moving charge will have an associated magnetic field, but this field will be so weak that it will be undetectable, hence the absence of inductance in a capacitor. It is important to realize that this situation can only arise in a capacitor, because all the applied electrical energy is used in establishing an electric field.

In a standard transmission line with a resistive load the situation is somewhat different. The conductors are spaced well apart from each other so the electric field will be negligible and all the electrical energy will be transferred into the load. In this case electrical energy is transported from one point to another, whereas in the case of the capacitor the energy is distributed over a large area. Inductance now becomes important as a constant time-changing current will produce a changing magnetic field, i.e.

$$\nabla \times \mathbf{E} = \frac{\varepsilon_0}{\mu_0} \frac{\partial \mathbf{B}}{\partial t}$$

or in circuit terms,

$$\nabla \times \mathbf{E} = 0$$

Finally, in considering the effects of displacement current, it is worth discussing the problem of a charged capacitor being connected to an uncharged capacitor (see Fig. 4) and the mystery of where the 'missing' charge goes. The usual explanation is that the closure of the switch initiates the transfer of energy, producing an oscillation of charge between the two capacitors which finally decays to a steady state. Consider these two equations for the charge and energy in a capacitor;

$$Q = CV$$

and

$$E = \frac{1}{2} \frac{Q^2}{C}$$

which would imply an energy loss. A more thorough study of the equation for the energy stored in a capacitor provides some interesting information. The total energy stored in an electric field is

$$E = \frac{1}{2} \int \mathbf{D} \cdot \mathbf{E} \, \text{d}E$$

A parallel plate capacitor is an approximation of a true field, which is represented by two infinite spheres. There are two ways of increasing the capacitance value. One is to move the two spheres closer

continued on page 81
Table 2. Table 3 below

1. Using timer (2) to count 10 pulses on pin 7 of port B

<table>
<thead>
<tr>
<th>Use aux. cnt reg. to select</th>
<th>Pulse count mode</th>
<th>Set</th>
<th>Configure T1 to count pulses on PB6</th>
</tr>
</thead>
<tbody>
<tr>
<td>LOA 80B</td>
<td>STA 400B</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2. Using timer (1) to produce a square wave

<table>
<thead>
<tr>
<th>Use aux. cnt reg. to select</th>
<th>Pulse count mode</th>
<th>Set</th>
<th>Configure T1 to count 1000H on pin 7 of PB6</th>
</tr>
</thead>
<tbody>
<tr>
<td>LOA 80B</td>
<td>STA 400B</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Counting starts here

Set T1(1) to FFFF (i.e. the state of PB7 will change every 65536)

<table>
<thead>
<tr>
<th>Use aux. cnt reg. to select</th>
<th>Pulse count mode</th>
<th>Set</th>
<th>Configure T1 to change the state of PB7 every 65536s (i.e. 50Hz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>LOA 80B</td>
<td>STA 400B</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

In this example p86 and p87 are linked and timers (1) and (2) are used together to produce time intervals of ~ 1 min. A simple counter is used to display the time elapsed in minutes on the microcomputer screen.

Table 4

1. Generating a sawtooth waveform

<table>
<thead>
<tr>
<th>Assembler</th>
<th>Acorn Basic</th>
<th>Apple Basic</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>LOAD X=0</td>
<td>FOR X=0 TO 255</td>
<td>FOR X=0 TO 255</td>
<td>(1) Assembled subroutines shown are for Amstrad E43 clear screen. E46 displays time to a 2 digit hex number.</td>
</tr>
<tr>
<td></td>
<td>PEEK 52110, 224</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>PEEK 52100, 86</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>PEEK 52120, 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>PEEK 52104, 60</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>PEEK 52130, 195</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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<table>
<thead>
<tr>
<th>Assembler</th>
<th>Acorn Basic</th>
<th>Apple Basic</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>LOAD X=0</td>
<td>FOR X=0 to 255</td>
<td>FOR X=0 to 255</td>
<td>(1) d-to-a converter lies at 4000H (i.e. 0hex)</td>
</tr>
<tr>
<td></td>
<td>PEEK NL4XLX</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>JMP Again</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>GOTO 10</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
74 illustrates the generation of synthesized waveforms using Basic and assembly language where the highest frequency is produced by the low-level language.

A-to-d converter

The power of this section of the interface depends on the signal conditioning that precedes it. For example, it can be used directly as a 16-channel data-logger provided the input signals are in the range 0 to 5.25V. However, many transducers provide smaller signals. Some applications might need to be handled as a 16-channel data-logger. For laboratory applications the signal conditioning can be simple; e.g. temperature and light measurements can be made using semiconductor devices which deliver current proportional to the measured parameter. Such an output only requires a shunt resistor to convert the signal into a voltage.

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This article describes data-decoding and processing sections of a system for receiving high-resolution picture transmissions from NOAA-6. Before this description, however, the receiver section of the first article is concluded.

The balanced mixer feeds two V.H.F. amplification stages, constructed using dual-gate m.o.s.f.e.ts in a standard commonsource configuration. Many examples of this type of amplifier (for use on 144MHz) can be found in amateur-radio publications.11 A further dual-gate m.o.s.f.e.t., with the local oscillator fed into its second gate, provides final frequency conversion to 10.7MHz. Local-oscillator drive is provided by a crystal oscillator and tripler circuit. The signal bandwidth is about 5MHz so high-Q circuits should not be used; hence, a heavily-damped tuned circuit follows the mixer, and a wide-band i.f. amplifier with SL600 range (Plessey) r.f. i.c. is used as shown in Fig.8.

Care must be taken to keep leads short and extensive decoupling is required to prevent spurious oscillation. Also, stray pick-up may occur if the amplifier is placed near other r.f. sources.

Fig. 8. Block diagram of the phase demodulator.

Phase demodulation

Referring to the transmission characteristics given in the first part of this article, it can be seen that phase demodulation with an index of ±67.3° is used. This means that instantaneous phase changes of ±67.3° and -67.3° represent a binary one and binary zero. To demodulate the changes, a fixed reference is required. Assuming that over several cycles there is an approximately equal number of ones and zeros, the reference may be generated by averaging the carrier frequency and phase. This assumption is applicable here because of the type of digital coding used, as will become clear later.

Fig. 9. Block diagram of the phase demodulator.

This complete receiver section of the system and to sum up, Fig. 11 shows an overall block diagram.

Decoding split-phase data

In order to decode the data stream from the detector into images, two processes are required

1. Converting the serial n.r.z. stream into parallel words, each 10 bits long. These processes are completely separate and the first problem to deal with is the split-phase data. This type of coding is probably most easily understood by analyzing the coding process. In split-phase data a binary one is defined as having a negative-going transition in the middle of the bit while a zero has a positive-going transition in the middle of the bit. Figures 12(a) and (b) show a random serial-bit stream and its equivalent split-phase data. An interesting case occurs when a continuous series of ones or zeros is transmitted: the s.p.l. code for these is a single frequency of twice the bit rate. This type of coding is particularly useful by making signal-to-noise power-ratio measurements.

Fig. 10. Circuit diagram of the phase demodulator. Oscillator phase noise at the detector output degrades signal-to-noise ratio so an LC variable-impedance v.c.o. is used.

Fig. 11. Complete block diagram of the receiver.
cause the clock rate can be determined even if either all zeros or all ones are received. As can be seen from Fig. 12(c), each data bit can be viewed as having two s.p.l. "bits" associated with it. These are marked α and β.

In order to decode s.p.l. data, the clock must be extracted: this is done using all the transitions, Fig. 12(e), to trigger an oscillator operating at twice the original bit-rate clock, Fig. 12(f). This frequency is then divided by two to provide the clock frequency, Fig. 12(g). Because of the frequency division, there is a phase uncertainty which will be dealt with later.

The simplest way to decode s.p.l. data, Fig. 12(c), is to sample the logic value in the middle of the α period, timed from the extracted clock. This regenerates n.r.z., although fractionally later than the original, and the method works well, providing there is little noise on the signal.

In this case, however, there is considerable noise and a better method must be found. Because of filtering, the received signal will resemble that shown in Fig. 12(d) and will contain random amplitude and phase perturbations from noise in the data-frequency band.

Suppose the extracted clock were processed to provide pulses that divide the received signal into α and β periods. If the signal were integrated over period α and the result stored and then compared with the value integrated over period β, the result would be the original data displaced by one n.r.z. bit.

Using this method, the decision level is continually updated, so avoiding much of the amplitude noise, and signal integration reduces both amplitude and phase noise. This system resembles a fully synchronous demodulator with its associated improvement in output signal-to-noise ratio, the mathematics of which may be studied elsewhere.

The remaining problem involves the recovered clock-signal phase uncertainty. As can be seen from Fig. 12, if the phase of the clock becomes shifted by 180° after frequency division, the demodulator will not function correctly. This situation is detected as follows; a second output of n.r.z. is generated by checking whether integration over period α exceeds a preset limit, usually half the maximum possible period for a full 'one'. If the clock phase is incorrect, this output is simply inverted, but the integrated output not only becomes

---

**Fig. 12.** A random example of s.p.l. data in its original form, (c), and as it is received (d). In (e), the data transitions used to trigger an oscillator operating at twice the original clock frequency (f) are shown. The signal of (f) is divided by two to provide the clock (g).

**Fig. 13.** Block diagram of the bit-conditioner and s.p.l. decoder.

---

**Fig. 14.** Circuit diagram of the decoder circuit in which raw s.p.l. data is amplified and fed into a comparator and v.c.o. The unmarked p-n-p transistors are complementary to BC108C.
The comparator is used to generate transition oscillations that form the twice clock-rate oscillator. The output of the oscillator is fed into a comparator and a voltage-controlled oscillator. This method can work well where short integration and comparison times are required.

**Table 1: H.r.p.t. data-frame format**

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</tr>
<tr>
<td>12</td>
<td>Receive flag</td>
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</table>

**Displacement current**

continued from page 70

Together, causing the charge to move (via the displacement current) as shown in Fig. 5. This method uses much electrostatic energy, so the masses of the electrodes are very large compared with the mass of the charge. The weight of 0.02 coulombs is 3.12 x 10^-17 kg.

The second method for increasing capacitance is to find the charge by the conductance current. This method is much more "energy efficient", as the only losses are those associated with the collision of the charges with ions. Resulting ohmic losses are negligible in short conductor leads.

The author disagrees with the previously mentioned oscillation explanation, despite the fact that the differential equation for a discharge can be very complex and asks why the same charge is measured before and after the switch is closed. If the circuit did oscillate, the oscillation would obviously decay and the charge would be neutralized by recombination with an equal and opposite charge.

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**Conclusion**

The energy equation for a capacitor assumes that any change is brought about by the field that does the work. Charge cannot be created or destroyed, although equal amounts of positive and negative charge may be simultaneously created, obtained by separation and lost by recombination.

**References**


The address from which references 1 and 2 of above are obtained will be given in the next article together with a list of references to the references cited. Reference 13, which should have been added to last month's list, is "Antenna and Receiving System Data in Temperature Calculations", L. V. Blake, US Naval Research Laboratory, Sept. 1961.
WIRELESS WORLD DECEMBER 1981

Educating engineers

An ecological viewpoint

by Peter Hartley, Ph.D Colorado School of Mines, USA

This article argues that engineering education is on the wrong track and should be changed. Because it is rooted in the concept of the "technical society" and "the conquest of nature" it is having disastrous results in the world around us. Its aim is the conquest of nature. This is not a problem of technology, but of competence. The second, says Peter Hartley, is to turn education to education systems analysis - a method it already possesses - to examine the assumptions that have dominated engineering so far.

The development of modern technology has been a great adventure that many people think the rate at which it advances as the conquest of nature. Until recently, most engineers have prided themselves on making this conquest possible. Many, perhaps, most, still do. What other attitude is possible for them? Can engineering be anything else? Of course, not. It doesn't have to.

Perhaps it is obvious from my tone that I find the conquest of nature question at best. Yet I must immediately make clear that I am not speaking from a superhuman standpoint. Rather, I am speaking from the human-level standpoint: can we rationalize to one side the "two cultures" approach, which completely blocks any resolution of the question? Can we do so without discomfort that the past attitude of engineers has been a human one, not to the vocabulary or preoccupations of those who consider themselves as being committed to responsibility, to those who consider themselves humanists, but to the humanists, and the environmental problem as usually conceived, in the most immediate practical sense. The resumption of human nature as its effect on human nature of human life, making a general assumption of humanism's inherently non-ecological character.
main relationship then is to the general productive mechanism rather than to other people as such. The mechanism requires engineers to think not only about the requirements of mass production, but also about the requirements of individual and institutional stability. Their relationship with each other becomes one of mutual support and common interest, rather than one of clear-cut conflict and opposition. This fundamental change in the nature of the relationship between the profession and society is reflected in many aspects of social organization, such as the creation of professional associations, the establishment of codes of conduct, and the development of ethical guidelines. By recognizing the need for such changes, engineers can help to ensure that their work is guided by a sense of responsibility and accountability, and that their actions contribute to the well-being of society as a whole.

Engineering must be a social science

The point is that engineers do not master technology; they are trained to manipulate social systems. The professional engineer is a member of a social organization which brings him into significant conflict with the social organization that brought him into existence. Engineers are to be fully professional, they must take a serious role in the development of industrialization. In contrast to the traditional view of engineering as a technical activity, modern systems analysis is a basis for ecological study, which the ecologist tries to make as integral part of engineering instruction, we have only the technical skill to perform as technicians, a functionary not fully professional, an operation of the professional engineer, and we must give engineers an education that prepares them to cope with the social implications of their work.

Fundamental changes to curriculum needed

The system, which we could also call the social system, is complex; it is up to the engineer to understand the implications of the various elements within the system or to contribute to the analysis of systemic context and systemic processes. From a systems point of view, the engineering education is in need of reform, and we must give engineers an education that prepares them to cope with the social implications of their work.

Professional view is process-oriented

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New Products

Communications test set

The latest addition to GADC's communications test equipment is the 7022 testable test set with synthesised generator for level, noise, signal-to-noise ratio and frequency measurements to the relevant CCITT standard. A charac­
ter alphanumeric display shows control settings and measurements and gives indications from the instrument's self-test circuit. Plug-in cards are available for the following 7-level impulse or level, i.m. distortion, instrument's self-test circuit. Plug-in cards are available for the following

20MHz oscilloscope

Sensitivity of Hisch’s V-202 dual-channel 20MHz oscilloscope is 1mV/div. This relatively low-cost instrument (3200 exc. v.a.t.) has 20MHz maximum sweep speed and shares a test set the CCITT standard. A

Temperature controller

Digital-readout temperature controller from Electronic Controls and Automation Ltd are available in 12-pin sockets. Dimensions of the measuring head are 100 by 72 by 4.4mm. Electrically, these devices are identical to their stan­
dard counterparts except in power dissipation. Both industrial and commercial grades are available. A self-calibrating 16-bit

Visible-light laser diodes

Laser diodes with a peak wavelength of 780nm and 5mW max­i­
mum output power are manufac­
tured by Hisch. These devices can be used as light sources in pho­
tocell for various con­

Coaxial cable assemblies

Flexible p.f.e.-dielectric coaxial cables and cable assemblies can be supplied by Parnell for use in their array systems, computer networks, microwave links and other such applications. A coaxial assembly 500mm long, designed by Aulah, Inc., which is compatible with 1GHz and has an outer diameter of 10 mils. Loss of the 0.018 diam­
ter 2032 type cable is 22dB/100ft. V. i.e. 1.5% at the point of connection and the type of connectors used but is typically less than 0.015% at 12GHz using SMA and TNC terminations. Both cables have female p.f.e. outer sleeves and can be bent to an inside radius of 3mm. R.F. leakage is given as 14dB minimum. As­

Through-line power meter

Frequency response and power­

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Versatile optical video link

No adjustment or alignment is needed, giving a range between the two ex­
tremes. Without h.f. emphasis, the equivalent ranges for the two

Data concentrator

The technique of data multiplexing is used to achieve the equivalent ranges for the two

Audible alarms

Two alarms from the American So­
tire and pressure gauges are contin­
continuous or pulsing tone at 2-4kHz. SBM 614CP is a 16oz deep, 42mm diameter device for board mount­

Small linear op-amps

Most of the popular op-amp and comparator types such as the 741, 1458, 4558, 324 and 399 are in­
cluded in NEC’s Miniflex line i.e. 20mW

Lightweight video recorder

Seen at last September’s Berlin radio show, Grundig’s VP100 portable video recorder uses a cas­
etype only slightly larger than an audio cassette. Made by Funk (Funtex Technology) of Amsterdam, it weighs 2.3kg

WW301

WW302

WW303

WW304

WW305

WW306

WW307

WW308

WW309

WW310

WW311

WW312
Adding up to a matter of time

The other day I was looking at a 1978 number of Reader's Digest. It would have been a more recent issue, but my suppliers — the church junkie sales that stand in our neck of the woods — tend to lag a bit behind W. H. Smith.

I had just finished a captivating piece on the courtship ritual of the pink-eyed ladybird when it struck me that RD must be full of things to all men. It offers tales of adventure on land, sea and air, stories of people triumphing over adversity with word-power, tests, jokes, philosophical riddles... you name it. What's more, it doesn't take up a lot of room.

Additionally, it carries some of the best ads in the business. One in particular caught my eye. It was for a 'luxury leather briefcase for executives wishing to aspire to company chairman.' Now just you show me the chap with fires of ambition in his belly who could resist such a come-on. I almost succumbed myself.

Certainly it seems that manufacturers of electronic products, too, rate RD highly as an advertising medium. The digital watchmen, for instance, were there in strength, each trying to outdo the rest. One was rapturizing about a timepiece (which looked a trifle too wrist-spraining for my delicate structure) which embodied no less than six main functions, including an audible signal to mark the passing of every hour on the hour. You could, if you felt the urge, convert it into a stopwatch. But the most confidence-building claim of all was that it was water-tested to 30 metres.

This made me wonder who the advertiser was aiming it at. Obviously it was not me. But why not? After all there are no old lad on the street who only wants to know how long the pubs are open. So just how many people are there around who really need such a detailed measuring device? And who would spend more any appreciable time fully or partially immersed in all that H2O?

Another interesting claim also went distinctly bananas over his up-market combined digital watch and ballpoint pen. It was the Chinese who came up with their bamboo-rod abacus as an alternative to taking off their shirts and whacking them to count up to 25. Or when clocks first gave sundials the big elbow. Nevertheless, I can't help feeling there's an urgent need for sweet reasonableness in these matters. Otherwise things are going to get worse. We may even reach the stage when you're out of date unless you're sporting a combined bath thermometer/pollen counter with a v.d.u. readout — worn on the wrist.

So let's not lose the capability of calculating with the most sophisticated device of all — the human brain. Nor let an obsession with hyper-accurate timing grab us so firmly by the forelock. Neither above nor below zero.

Waves

By Ariel

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### COMPUTER COMPONENTS

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### Support Devices

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</table>

### Special Offer

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<td>PSU 190</td>
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<tr>
<td>74LS00</td>
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<td>74LS07</td>
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<tr>
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<th>Price</th>
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<tbody>
<tr>
<td>280R01</td>
<td>8-bit dynamic RAM, 280R01</td>
<td>£28.50</td>
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<tr>
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<td>8-bit dynamic RAM, 280R01</td>
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<tr>
<td>280R02</td>
<td>8-bit dynamic RAM, 280R02</td>
<td>£23.00</td>
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YOUR WIRELESS WORLD December 1981

**Memories at Micro Prices**

**PRINTED CIRCUITS FOR WIRELESS WORLD PROJECTS**

<table>
<thead>
<tr>
<th>Item</th>
<th>Quantity</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tape recorder</td>
<td>1</td>
<td>£2.00</td>
</tr>
<tr>
<td>Audio compressor</td>
<td>1</td>
<td>£5.00</td>
</tr>
<tr>
<td>F M tuner (tuned)</td>
<td>1</td>
<td>£4.25</td>
</tr>
<tr>
<td>Cassette recorder</td>
<td>1</td>
<td>£2.00</td>
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<tr>
<td>Audio compressor</td>
<td>1</td>
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<tr>
<td>Tape code clock</td>
<td>1</td>
<td>£2.00</td>
</tr>
<tr>
<td>Data alarm (1 second) dial switch</td>
<td>1</td>
<td>£2.00</td>
</tr>
<tr>
<td>Additional circuits</td>
<td>1-2</td>
<td>£5.00</td>
</tr>
<tr>
<td>Stereo decoder</td>
<td>1-2</td>
<td>£4.00</td>
</tr>
<tr>
<td>More taping head and motors</td>
<td>1</td>
<td>£2.00</td>
</tr>
<tr>
<td>Dual-track 10K ohm, 3K ohm dubbin and record (20 x 100&quot;)</td>
<td>1</td>
<td>£14.00</td>
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<tr>
<td>Low distortion dial (amplifier) for September 1979-2.5</td>
<td>1</td>
<td>£2.00</td>
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<tr>
<td>Low distortion amplifier</td>
<td>1</td>
<td>£2.00</td>
</tr>
<tr>
<td>Technicolor 11 m. grayscale</td>
<td>1</td>
<td>£2.00</td>
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<tr>
<td>Monitor</td>
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<td>£2.00</td>
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<tr>
<td>Module</td>
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<tr>
<td>Disclose waveform system (October 1979-8.2)</td>
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<td>£3.75</td>
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<tr>
<td>Register for cutaneous use</td>
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<tr>
<td>Broadcast noise reduction (November 1979-6.2)</td>
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<td>Versatone voice generator (January 1979-1.2)</td>
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<td>200MHz frequency meter</td>
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<tr>
<td>High performance power monitor</td>
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<tr>
<td>Audio oscillator (May 1980-6.2)</td>
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<td>£2.50</td>
</tr>
<tr>
<td>Moving coil preamplifier</td>
<td>1</td>
<td>£2.25</td>
</tr>
<tr>
<td>Multi-mode equalizer</td>
<td>1</td>
<td>£2.50</td>
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<tr>
<td>Ceramic tuning fork</td>
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<tr>
<td>Aerial filter (Oct. 1979-3)</td>
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<tr>
<td>Digital experience meter</td>
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<td>Colour graphics system (April 1980-5.2)</td>
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<td>Audio limiter (May 1980-5.2)</td>
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<td>£9.50</td>
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<td>Moving coil preamplifier (August 1979-5.2)</td>
<td>1</td>
<td>£2.50</td>
</tr>
<tr>
<td>Microphone</td>
<td>1</td>
<td>£3.50</td>
</tr>
</tbody>
</table>

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- **BAUD RATE GENERATOR**

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- How c.b. works
- SWR your c.b. radio
- Setting up a Home Based c.b. unit
- Setting up a mobile c.b. unit
- c.b. fault finder guide
- 10-code
- Q-code
- Phonetic alphabet

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function
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We are looking for seasoned professionals – technicians with experience of HF, MF, VHF and UHF, and engineers familiar with Microwave Transmission, Multiplexing and Scada Systems (and with HNC qualifications under their belt).

In the North Sea, earnings are up to £14,000, while overseas positions could be worth up to £20,000, plus tax concessions and generous home leave.

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Return this coupon to John Progder, Marconi Instruments Limited, Newport, St. Albans, Herts WD2. A.G.E. Marconi Electronics Company.

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Due to its continuing expansion programme, Television International has openings for broadcast Telecine Engineers in both operational and maintenance departments.

The selected engineers will be operating or maintaining Rank Cintel M/AIDs with Toppy and Digiscan, and consequently only people with the necessary experience and skills need apply.

Salaries within the range £10,511-£11,793, according to experience, plus the opportunity for a considerable amount of overtime working. The Company benefits from an attractive contributory Group Pension Scheme, which includes free Life Assurance.

Please write or phone for an application form to:

Alan Edwards, Director of Operations
Television International Operations Limited
9-11 Windmill Street
London WIP 1H.
Tel. (01) 637 2477

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Racal-BCC are members of the highly successful Racal Electronics Group and are world leaders in the design and manufacture of tactical radio communications equipment. We require a number of radio communications test engineers to fill a variety of grades within the Test Department. The department is responsible for the manual and automatic testing and fault finding of the Company’s equipment at various stages of manufacture.

Applicants should be qualified to HNC/HTC level and have experience of radio communications equipment.

We offer excellent conditions of service including good basic pay and a Group Productivity scheme.

Due to an expanding range of products and increasing sales, the company now wishes to appoint an experienced Production Manager. Reporting to the Operations Director the Production Manager will be responsible for meeting production output requirements to maintain quality standards; will be expected to contribute substantially in such areas as production engineering, industrial engineering and quality monitoring procedures, and will be capable of instituting and developing the necessary systems for the effective management of the department.

Candidates will ideally have had a number of years’ experience in electronics and light mechanical assembly. This experience having been gained in production line management or through production engineering/quality control.

Salary is likely to be in the region quoted but would not be a limiting factor for the right candidate and normal benefits will apply.

Applications in writing, giving personal and career details, should be sent to the Managing Director, Peak Technologies Limited, Sunley House, 57 High Street, Edgware, Middlesex, HA8 7XA.
**TELECOMMUNICATIONS ENGINEERS**

**MULTIPLEX/MICROWAVE ENGINEERS**

**Saudia Arabia • Nigeria**

- or on offshore

Experienced in either HF/VHF/UHF or Troposcatter/Teleradio

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Preferably with electronic exchange experience.

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For further information and to arrange immediate interview, telephone Windsor (07535) 57204, or write to: The Broadcast Company of Philips, Abbey Park, George V Place, 4 Thames Avenue, Windsor, Berks.

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Experience in design and construction of prototype moving-coil direct-radiator loudspeaker drivers and a thorough understanding of their operating principles are a major requirement.

The successful candidate will be largely responsible for the development of loudspeaker driver designs and their transfer to production, within guidelines laid down by the department Director. Dedicated and self-motivated, initiative and team spirit are essential.

Salary is negotiable. Please apply in writing to Dr G. J. Adams, B&W Loudspeakers Ltd, Meadow Road, Worthing, West Sussex BN11 2RX.

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**Opportunities in Oil - Libya**

Oasis Oil Company, one of the world's major producers of oil, is expanding its communications facilities in Libya. To this end the company is now seeking to recruit suitably qualified Engineers and Technicians for the following positions to work either at its headquarters in Tripoli or in developed sites in the field. Company salaries are on offer to fill these vacancies.

**SYSTEMS SUPERVISOR (MAINTENANCE)**

(Tripoli Based) £20,000

Applicants should hold a bachelor degree in Electrical Communication Engineering and at least ten years experience in operation and maintenance of communications systems. A knowledge of troposcatter, multi-hop microwave, S.B.B. outside telephone cable plants and electronic PABX's is also necessary. Your responsibility will also extend to diverse multiplex channels for telecommunication, telefax and computer networks.

**SENIOR ENGINEER (TELECOMMUNICATIONS)**

(Representative) £20,000

To apply you should have a degree in Electrical Communication Engineering with at least ten years experience in the design and maintenance of microwave, troposcatter, microwave, S.B.B, outside telephone plant and related channel network equipment, inside and outside telephone cable plant, cable plant design and installation.

**COMMUNICATION MAINTENANCE SUPERVISOR**

(Field Based) £16,000

The post demands a qualification from a recognized technical training establishment and fifteen years' experience in the maintenance of communications systems. The successful applicant will supervise the maintenance of personnel who will be responsible for performing preventive and repair maintenance and repair of many types of equipment. These will include microwave, troposcatter, multi-hop microwave, S.B.B, outside telephone cable plant and related telecommunications equipment upon which your appointment will be responsible to perform preventive maintenance and repair.

**COMUNICATIONS TECHNICIANS**

(Tripoli) £7,600

You must possess a qualification from a recognized technical institute and have had at least five years experience in the maintenance of communications equipment such as microwave, base and mobile transceivers, satellite earth stations, PABX.

**TELEPHONE TECHNICIANS**

(Field) £7,600

Applications are invited from experienced technicians who should have at least five years experience in the maintenance of electronic PABX's, cable plant and related telecommunications equipment upon which these appointments will be responsible to perform preventive maintenance and repair.

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Free furnished marital single housing in Tripoli town.

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13/16 Jacob's Well Mews, George Street, London W1
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The minimum qualification acceptable for this post is a City and Guilds Full Technological Certificate in Electrical or Electronic Engineering.


Further details and an application form can be obtained by writing to the Vice-Principal enclosing a self-addressed envelope. Completed forms must be returned within 14 days of the appearance of this advertisement.

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(ELECTRONICS)

A Technician is required to work in a small but busy department which provides a comprehensive medical electronics/physics service at this large teaching hospital.

Within the department, the technician will be engaged mainly in electronics work but other scientific or engineering skills would be an advantage. In addition the technician will be required to work in clinical areas, trouble-shooting and advising staff in the use of equipment.

Salary will be according to experience within the range £5,527 - £8,014 inclusive.

Informal enquiries to Mr. P. Butler, Chief Technician, Medical Electronics Department, tel: 01-352 8213, Ext. 452B. Further details and application forms available from Miss J. A. Jenks, Personnel Manager, Brompton Hospital, Fulham Road, London SW13 9NB. Tel: as above, Ext. 452B. Application forms to be returned immediately.

MPC
Medical Research Council Centre

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Salary on a scale from £1,069 p.a. up to £1,500 p.a. depending upon background and experience.

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Villa Road, Cambridge CB2 2DH

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There are some seventy production studios in Broadcasting House and elsewhere in London concerned with programme making for Radio 1,2,3 and 4. These studios are maintained to a high standard and, to do this, we need Engineers to train to look after the very elaborate equipment we now use in the production and distribution of radio programmes.

At the Television Centre in West London we require Engineers to both operate and maintain the vast array of complex electronic equipment, both analogue and digital, associated with the origination and distribution of television programmes. Much of the work is related to the recording of programmes and distribution to client stations. If you are interested in the above posts, please apply in writing giving details of your background, training and experience.

The Engineering Recruitment Officer, BBC, Broadcasting House, London W1A 1AA.

Name: ...........................................................
(Mr/Mrs/Miss) Address: ...........................................

Tel No: ..........................................................

Qualifications: .......................................................

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VTR Engineer

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As part of Philips Industries, Mullard Blackburn offers usual large company facilities and a generous relocation allowance where applicable.

Blackburn is an industrial town in the Lancashire and has several miles’ relevant experience. Blackpool and Lytham St Annes are the largest towns in the area.

Please phone or write to Lindsey Murdock, Personnel Officer, Mullard Blackburn, Philips Road, Blackburn, Lancashire, BB1 5RZ. Tel: 0254 56249. Ext 209.
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TJB Electrotechnical Personnel Services is a specialized appointments service for electrical engineers. We have clients throughout the UK who urgently need technical staff at all levels from Junior Technician to Senior Management. Vacancies exist in all branches of electronics and allied disciplines - right through from design to marketing - at salary levels from £400 to £1200 p.a.

If you wish to make the most of your qualifications and experience and move another rung or two up the ladder we will be pleased to help you.

All applications are treated in strict confidence and there is no danger of your present employer (or companies you may be working for) being made aware of your approach.

TJB ELECTROTECHNICAL PERSONNEL SERVICES
12 Mount Ephraim, Tunbridge Wells, Kent. TN4 5AS.
Tel: 0622 39388

Please send me a TJB Appointments Registration form:

Name ____________________________
Address ___________________________

TJB

The Hatfield Polytechnic School of Humanities
Senior Technician/Chief Technician
required as soon as possible.
Grade Technical 3 (£5,811-£7,296) dependent upon qualifications and experience.
Duties are mainly connected with three Language Laboratories. Applicants should be experienced and well qualified in Electronics and be capable of servicing and repairing a wide variety of electrical and electronic equipment, tape recorders, answering machines etc. Duties will include full responsibility for recording, cataloguing and storing materials. This is a supervisory position, and close liaison with academic staff is necessary.

Applications and further details from the Staffing Officer: The Hatfield Polytechnic, PO Box 109, College Lane, Hatfield Herts.

Please quote reference 644.
Closing date: 27th November, 1981.

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**£43.70 inc. VAT**

Size TL100 19"x 14"x 6"

The TL100 has been designed for the professional electronics, TV or instrument technician who needs to carry a large number of specialist tools. Constructed from hard wearing ABS with strong aluminium frames, twin handles and toggle locks. A moulded tray in the base, a comprehensive 2 sided tool pallet that is reversible with space for over 40 tools. There is space for documents and a heat sink for a hot soldering iron to prevent any damage being caused.

Also available is the TL99 which is a smaller version of the TL100.

TL99 17"x 12"x 6" £39.90

**£13.75 inc. VAT**

TLW4 Tool Wallet measures 11"x14"x2½" when closed. Made from reinforced PVC with a heavy duty industrial zip.

*Discount structure for multiple users only*
*Custom Made Tool Pallets (only for long runs) tools will be required for measuring but will be returned.*

**Mail Order**

Please send

Enclosed my cheque £

Name

Company

Address


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