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Thermal semiconductors

A solid-state heat pump is being developed and manufactured in the UK by a US Army general. When Werner von Braun’s rockets became too hot he called on a major in the US Army to help provide cooling equipment. The major, now General Laurence Davis, devised an electronic device for cooling the rockets. Since his retirement from the army, he is marketing commercially the device for which he is the patentee. The device is a water made up from tiny cubes of crystalline metallic bismuth, doped to provide a semiconductor action. 245 of such cubes make up a single series, alternately P and N-type material, to produce 488 green junction diodes. The chain of diodes is sandwiched between two thin layers of a ceramic material to produce a wafer, 50 by 50mm, about 1mm thick. When a direct current is applied across the wafer, one side gets hot and the other cold. This is a similar action to that found in the Peltier bimetallic junction described in 1840, but that exercise was only of academic interest with a slight temperature difference. With a potential difference across the wafer of 6.5V, the cold side falls rapidly to -40°C while the hot side rises to 57.2°C. A wafer can be cascaded to produce even greater temperature differences. When the current is reversed, the sides reverse their functions, the hot side becoming cold and vice versa.

Applications are numerous but two of the most interesting have been postulated. A room heater could be about the size of a telephone, containing nine of the wafer. It should be able to heat an average room area and use 40% less power than conventional electric heaters. An instant ice-cube tray could freeze water in less than a minute: other domestic uses include refrigerators, freezers, plate warmers, slow cookers and some of the functions can be combined by using both sides of the wafers: for car heating or cooling the device uses practically no engine power while the conventional car air-conditioner can consume up to 30%.

IEE and IERE to merge

Members of the Institution of Electrical Engineers and the Institution of Electronic and Radio Engineers have agreed to take part in a debate on the proposed merger between the two. The councils of both institutions have welcomed the proposal but the final decision will be taken after special general meetings are held to be held towards the end of 1986. If approved there would be a transition period before the new merger which should take place towards the end of 1988.

The merger was the primary recommendation of a special working party composed of senior officers of both institutions. Their report stated that if the two institutions should come together, there was a strong case for making the new body speak with greater authority to government, the Engineering Council and other organizations and the public. The combined institution would also have more authority in the international sphere. It would offer better services and publications to its members; a strengthening and broadening of interests in electronics, communications, and information engineering; a common standard for chartered engineers’ status; and a single body to accredit training courses and programmes. The working party was set up at the beginning of 1984 to explore the possibility and recommend terms for a merger between the institutions. The IEE has about 83,000 members and the IERE just over 13,000. 111 members belong to both bodies. The joint body will be known as the Institution of Electrical Engineers. The Institution was the first of its type in the world. The 1921 charter would be maintained with procedure similar to more recent charters. However, the IEE will broaden its terms of reference to bring in the communications areas of the specialist members of the IERE.

Radio Spectrum guide

For the first time, the Government has made available a complete radio frequency allocations. In a 310-page paperback book, the Department of Trade catalogues the bands from 9kHz to 60GHz and their uses both in Britain and abroad. For each band, or sub-band, a table shows the UK assignments alongside a table of the correspondence ITU allocations. The guide describes in detail the bands plans for both the most widely-used radio services – in use for both bands by non-government users.

The new publication is one of the results of the Minister’s Committee’s pressure for greater use of the spectrum. The IEE has been used on nearly 200 projects in government departments and is finding a wider market in the private sector. It provides a coherent, integrated set of standards, procedures, techniques and tools with the aim of achieving a significant reduction in systems development and maintenance costs.

Structured systems aid efficiency

A greater understanding of the requirement of computerized tools for the support and development of data processing systems is provided by SSAE, structured systems analysis and design method. Developed for the Central Telegraph and Telephone Administration, the method has been used in over 200 projects in the public sector and local government departments.

Monitoring equipment at the Department of Trade's station near Baldock in Hertfordshire, which can cover the spectrum from 10kHz to over 12GHz.

Radio, private fixed lines, low-power systems, radio astronomy and amateur radio.

No regular update of the guide is planned, though the Department intends to revise it in event of any major reorganization of the spectrum. Minor alterations (such as the recent introduction of a 50MHz amateur allocation, which, incidentally, was too late for the present edition) will be covered by amendment sheets.

The guide, United Kingdom Table of Radio Frequency Allocations, is published by Her Majesty's Stationary Office at £12.

Von Neumann's elephants

It is fifty years since the publication of Alan Turing's seminal paper, On computable numbers, which is generally considered to signal the birth of modern computers. It embodies the system known as Von Neumann's computer architecture, which incorporates sequential programs and can still be recognised in the modern computer devices. All the major integrated circuit manufacturers have announced their 32-bit processors. These can access millions of bytes of memory and their operation is measured in teraflops — millions of instructions per second. As each of the instructions can offer the functions of three or four of the instructions on their predecessors, this makes them even faster. Because they are so fast, they can do several tasks apparently simultaneously by switching rapidly between them. All this seems very impressive. But why is there a nagging feeling that they are not as good as they seem? Perhaps it's because they are, in the final analysis, just inflated versions of the earliest processors.

At the major computer manufacturers, for some time now, most of the engineers have been working at new concepts and several have now come up with restricted instruction sets. Some of these, for example, the Cray X-MP machine, have a different structure from the general-purpose machines. Most of the high-level languages can be compiled and run on these devices and it is possible to use them exactly as if they were the universal devices of the other manufacturers. They also use very large quantities of silicon, with a similar complexity in circuitry and occupy much the same area of silicon.

So why should anyone bother with the new risc processors? The reason lies in the future. Many computer scientists have complained about the built-in limitations of Von Neumann's 'architecture'.

It may be possible to make conventional processors even larger (64-bit devices are already under development) and even faster by reducing the physical size on the silicon chip and using gallium arsenide instead of silicon. But the basis on which they are built is quite a different story. The risc devices point toward a new technology, a lateral step in the evolution of computer science.

If the early microprocessors can be likened to mice, then the new generation have grown into elephants. The escape from the limitations of Von Neumann's system heralds the 'fifth-generation' computer much more than advances in very-large-scale-integration in silicon or gallium arsenide.
**BT challenges**

The de-nationalization of British Telecom also removed its monopoly on telecommunications and we have new services which are competing to work with BT. Timefame International, who are a major information provider on Prestel, are starting to set up their own public view data service. Their database will, however, be a claim, overcome Prestel's disadvantage by eliminating delays in logging-on, and easing the routing to specific pages. There will be no page charges and information providers will be able to edit their own pages directly. The capacity of the system will be 17 million pages (Prestel has 1.5 million) and the prices will be "significantly cheaper" than those for Prestel.

Telelink magazine who reported the story says that Timefame will not officially confirm the launch of the database but that they have received undisclosed US backing to investigate such a service and that they have the capability to put it into action.

Telemessages, you will remember, have replaced telegrams in the UK. The message is delivered with the post rather than the old system of sending a boy round as soon as it is received. Microlink are planning to offer a telemessage service with which any microcomputer user can send and receive direct form the office key/ which will be delivered by the post the morning after transmission. What is especially significant is that they plan to do it at a fraction of the BT cost.

Comprehensive Communications is a company set up to market B&B approved telephone equipment under its own brand name. Their particular target is the home and small business market through a network of local authorized distributors and high-street shops. They have recruited two top salesmen, Clive Davison and Dennis Woolford, who were formerly senior managers at BT Consumer Products.

A survey by the Engineering Council revealed that less than 59% of chartered engineers now earn more than £1,500; compared with 32% two years ago. The majority of them would recommend a career in engineering to young people. The 1985 survey of chartered and technician engineers questioned 28,000 engineers, selected at random from the Council's register. Dr Kenneth Miller, director-general of the Council, said: "It is pleasing to note that earning have increased at a rate higher than inflation, and also that the level of unemployment is gratifyingly low among chartered and technician engineers - less than 1% at any time during the year."

73% of the chartered engineers were graduates and their salaries tend to increase throughout their careers, while non-graduate engineers often show no real increase in earnings after their early forties. The highest earning were found in nationalized industries where the lowest were paid to employees employed in local authorities. However just under half of the engineers surveyed were members of trade unions and over a quarter of these belonged to NALGO.

Superiory staff and management administrators received the highest incomes; next were those in commercial or consultancy areas. The top paying industries, ranked in order were steel, chemical and petrochemicals, electricity generation, pastoral services, telecommunications and broadcasting.

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**Don't send the bill, just the data**

A joint venture between McDonnell Douglas Information Systems and BT is aimed at cutting the cost of business transactions. The new company, called Edinet, will provide electronic data interchange to give direct computer-to-computer exchange of business documents such as purchase orders, invoices and statements. Documents are coded in such a way as to reconcile differences between computers and the physical layout of the document. The system has been tested in the USA where more than 200 companies are already connected to the network. The UK company will initially rely on US processing resources and be connected through BT's PSS data network. Potential customers will be encouraged to conform to the international standards for document interchange as the Edinet service itself conforms.

A computer system designed specifically for training has been developed by Marconi Instruments. Mandarin incorporates an IBM microcomputer, a video screen and a mouse and moves from step to step according to the user's response.

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CIRCLE 46 FOR FURTHER DETAILS.

ELECTRONICS & WIRELESS WORLD JANUARY 1986
Remote tunable antennas for frequency-hopping

PIN-diode selection of inductors allows antenna tuning at rates up to about 1000 per second

One of the means by which military communications are rendered secure against enemy eavesdropping is the process of frequency-agility or "hopping" whereby the carrier frequency is repetitively changed at rates of up to a thousand per second, according to some pre-arranged random pattern, for example, any of the 7000 channels spaced 25kHz within 225-400MHz.

The pattern of frequency changes is not "hopped" can be varied whenever necessary to maintain security and must, of course, be known to and followed by both (or all) terminals of the communications chain. The system of hopping can be applicable whether the communications transmission be by amplitude or frequency modulation, or as a logic data.

All terminals of the communication system must be able to produce or follow the frequency-agile carrier, including all antennas used for any combination of ground and air paths. Self-evidently, the antenna requirement for frequency-agility capability is most conveniently met by fully broad-band designs, covering the full frequency range without tuning or other adjustment, in circumstances where acceptable dimensions make this possible.

Figure 1 shows the relative dimensions and form of a representative selection of antenna blade designs for airborne service. All of them are substantially two-dimensional, with cross-sections approximating to various aerodynamic standards. Outlines A and B are typical of various manufacturers' versions of well-proven solid-blade antennas which have been loss-free broadbanded across the a.h.f. band 225-400MHz, within a v.a.w.r. limit usually 3.2:1. They commonly achieve power-efficiency better than 90% which, with the radiation pattern typical of quarter-wave monopoles, is equivalent to about +2dBIL or 2dB above the response of a theoretical loss-free isotropic radiator.

The basic v.h.f. band, 116-190MHz is similarly well broadbanded but, as shown in the outline of Fig. 1B, within housing shell heights of 35 to 40 cm, which has become more or less unacceptable for fast, highly manoeuvrable aircraft. Even within this height, extension to coverage of the full v.h.f. and maritime bands, 100-174MHz, requires that broadbanding techniques be supplemented by some degree of resistive damping, to maintain an acceptable limit of V.A.W.R. The same shell example has also been used to house separate radiating elements for the 100-174 and 225-400MHz bands, usually dielectrically shielded on the outward connection via a common terminal.

More recently, the same shell example has been used to function across the tactical v.h.f. band, 30-85MHz. However, at the low-frequency extreme of this band, the height represents less than 5/8, and the resultant very low equivalent radiation resistance renders broadbanding ineffective. These designs therefore comprise a simple plate radiator to cover all three bands, fed via a frequency-dependent antenn
for which inserts sufficient resistive loss to maintain v.s.w.r. below about 2.5:1 At 440, the inserted loss reduces radiation capability to about 25 dB. It is perhaps a tribute to the sensitivity of current receivers that such small antennas perform has been even more, acceptably, but inevitable diversity of communication range has produced demands for considerable improvement. Prior to the advent of frequency-agility, the requirement was met by antenna designs tuned via miniature high-vacuum, high-voltage-tube circuits that these were quite unhappy to cope with "hopping" systems.

Extensive new building of the MBB B0105 helicopter in its PAH-1 military version provided the stimulus for first development of Tactical-h.t., antennas tunable for high efficiency, and controlled via PIN diodes for fast retuning. At this time, with only helicopter usage envisaged, the dimensional restrictions were not too severe. Two variants were first produced: a unipole design housed within a glass fibre shell 46 cm high, as in Fig. 1C) for fitting externally, and a dipole design in skeleton form to be housed within one of the two vertical stabilizers fins of the PAH-1 heli-copeter. The close-up of the port fin, Fig. 2, shows the tunable dipole detailed in Fig. 3. It is basically a hinged pair of the printed-circuit tuning assembly shown in Fig. 4, used singly in the unipole version, and which is mounted on the cabin roof.

The dipole radiates via metalized areas at top and bottom of the fin, while the unipole version radiates via a slot length of metal tubing fixed to the top of the housing shell. A later version substituted an internal plate as the radiator. Altogether, about 80% of these two antennas have been in service on German and Spanish military helicopters, for periods of up to three years.

Experiments in getting under an aircraft type with very little ground clearance, the unipole shown in Fig. 5 was produced for housing within the 22 cm shell outlined in Fig. 1D) again using only the 30-88MHz band. Several similar versions of the unipole were produced for suppression within, for example, the fincups of B.A.C. "Hawk" and Macchi MB329 aircraft.

The basic 30-88MHz tuning assembly was also fitted to externally-mounting shells large enough to house broad-band v.h.f. and u.h.f. radia-tors, either separately fed, or diplexed to a common terminal. The example shown in Fig. 6, to the outline of Fig. 1D) uses the forward tubing from the 30-88MHz radiator, with the shorter section acting as a radi-ation within the 100-174MHz band. This shell was designed with sufficient strength for service on very high-frequency aircraft, but its aerodynamic effects have been considered undesirable except on helicopters or the larger fixed-wing aircraft.

Logic favours commera-tion between equipment items fitted to the widest range of air-craft types, requiring that the larger market for helicopter antennas be met within parameters suitable for even the most manoeuvrable of fighter aircraft. This total requirement was first approximated by smaller versions of the triple-band resistive-damped antenna previously mentioned, with "gain" performance inevitably suitable to the range from -35 to -40 dB at 30MHz, which brought forth many complaints about the limited communication ranges.

Accordingly, the 30-88 tunable antenna design has been developed into a shell height around 22 cm, of the outlines shown in Fig. 1F) and 1G). Both of these include tunable coverage of the full v.h.f. and maritime bands, by 0.75MHz, with the antenna outlined as IG1 also including broad-band coverage of the u.h.f. band, both or all bands being diplexed to a common terminal. The versions shown as IG2 further includes the IFF band. Considering the antenna as a basically top-loaded monopole, a height of 22 cm results in the radiator impedance being capacitive across the 30-88 and 100-174MHz bands. Practical capacitance and dimensions of the top-loading conductor, it is 59 / 450 for the 26cm, 7"inductor ver-sion. For this latter to be ex-tended up to 174MHz, a small capacitor was added into series with the inductor, chain, to pro-duce a second group of tuning-settings from combinations of the 3 or 4 smallest inductors. The additional capacitance is shorted-out of circuit for operation below 100MHz.

This was done by the addition of a seventh inductor to provide a possible 128 combinations, and by extending tuning into the next decade, that is to steps of 0.1MHz, each now covering only 4 channels at 25MHz spac-ing. With both the 6 and 7 inductor units, preselection from among excess setting allows for optimization to suit the differing conditions of antenna mounting, particularly of ground-plane area.

With all discrete inductors shorted out-of-circuit, residual inductance restricts the current flow, the diode has no charge storage, and will conduct throughout any period when transmission power pro-vides voltage peaks which op-pose and exceed the d.c. turn-off bias voltage. Current flow during these periods will be very small, due to the high imped-ances, and will augment the bias voltage through storage in the circuit capacitances. As a result, the apparently inadequate turn-off bias does not force unacceptable levels of harmonic, although this has had to be reconsidered because of an increased severity of specification.

For the tuning settings which limited the transmission circuit, this inductor and its shunt switching diode(s) will be subject to the full transmission r.f. voltage, as magnified by the circuit Q which results from the combination of L/C ratio, distribution of strays and by the sum of radiation and all other losses of energy loss. Q is highest for the larger inductor values, it can cause the r.f. to exceed the ultimate breakdown voltage of the diode.

This voltage is therefore divided among those components, and ensuring equal divi-sion of voltage across each diode. A decrease in the effectiveness of shortening the circuit has to be rectified, since higher-voltage diodes tend also to be of less reliability, in which cases they produce a prob-lem of increased shunt resistance. Everything is compromise.

Binary selection can result in both sides of a diode being at r.f. potential, along with inverse, and requires that the biasing feed be isolated to r.f. across the full frequency range covered by the antenna. This is accomplished by groups of r.f.

---

**Fig. 3. Tunable dipole assembly to fit inside fin.**

**Fig. 4. Printed-circuit tuning assembly.**

**Fig. 5. Unipole version to fit in low-profile shell, covering 30-88 MHz.**

**Fig. 6. Broadband u.h.f. and v.h.f. antennas.**

**Fig. 7. Conductance characteristic of suitable PIN switching diode.**

**Fig. 8. Capacitance and shunt resistance of diode at varying frequencies, with bias voltage as parameter.**
Fig. 9. Basic bias-feed circuit.

Fig. 10. Partly constructed antenna for 30-88 and 100-174 MHz bands. Metal coating provides excellent capacitance.

Fig. 11. Low/medium-band version of Fig. 10.

Fig. 12. Gain or sensitivity of tuned and untuned antennas.

Fig. 13. Some useful selectivity is provided, in-band, by tunable antennas.

Fig. 14. Inductor printed-board assembly.

ELECTRONICS & WIRELESS WORLD JANUARY 1986
trol. In the case of serial data code, a single line encircling the aircraft carries data for numerous different items of equipment, and the antenna code converter must include the facility to recognise and act upon only the applicable information. It also includes facilities to avoid loading the data line, even under fault conditions.

In present units, turn-off bias (positive to ground) derives directly from the 28 volt line, after filtering. Turn-on bias derives through a d.c.-to-d.c. converter, providing 5 volts stabilised for up to about 1 ampere current. In later units, both bias outputs are derived through converters, the turn-off supply being increased to about 60 volts (at negligible current) and the turn-on supply increased to 61 volts, stabilised for up to 11 amperes. Both these increases are directed at improving either or both of power rating and harmonic generation.

The turn-off bias is permanently applied to the antenna diodes via relatively high-resistance feed paths, and can therefore be over-ridden by turn-on bias applied through low-resistance paths.

All the antenna designs described in this article are already in service in varying quantities, but the basis of tunable design is being extensively developed for further applications, whether frequency-hopping or otherwise, particularly in connection with suppression into the airframe contours.

**Fig. 15. Circuit of seven-inductor antenna tuning assembly.**

---

**Breaking into the print**

The Editor always welcomes contributions from readers, and a quick and easy way to send them is via our Bulletin computer. But there is no need to plunge your way in, like the unsuccessful hacker who showed up bright in our system log recently.

The routine is very straightforward. All you need is a terminal and a 200 bits per second modem: the data word length is seven bits plus an even parity bit, and a synchronising pulse 56 usec long. Dial the number 01-661 8979 or 01-661 8990, type EWW in capital letters, the address code for this magazine, and wait for the response.

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CIRCLE 8 FOR FURTHER DETAILS.

Data conversion

An introduction to analogue-to-digital and digital-to-analogue conversion.

Digital processing power has greatly increased over the past decade. In the latter part of 1985, famous chip manufacturers such as Intel, Motorola and National Semiconductors all announced new or upgraded processors.

Domestic digital video and audio playback, recording and storage is now readily available and digital techniques are used in much of the broadcast chain. On the instrumentation side, digital-to-analog oscilloscopes are becoming cheaper because of falling IC prices, and digital meters are commonplace.

These advances in digital processing are calling for more diversity in the types of converter available — and for lower prices. Faster processors with wide data buses mean the production of more fast, high-resolution converters with microprocessors-compatible inputs and outputs. Already there are devices that connect directly to a linear circuit at one end and to a microprocessor bus at the other with little more than address-decoding.

Progress in digital audio and video has led to the design of special-purpose converters. These include video converters with 750 input and sync. inputs, and fast audio converters with high resolution and low t.h.d. New and improved IC manufacturing processes have allowed the production of microprocessors and controllers with on-chip converters, and monolithic digital meters with linear inputs and display driver outputs.

Fast and accurate data converters are available for many years in the form of expensive hybrid devices or circuit boards full of ICs. Cheaper monolithic converters have typically had lower accuracy and needed external circuits for buffering, references, data latches, clocking, etc.

But despite the problems of manufacturing high-speed digital circuits and high-accuracy linear elements on the same chip, there are now many complete monolithic converters being produced for a few pounds that are equal to or better than older hybrids and modular products. This doesn't mean a decline in hybrid circuit sales though; hybrid manufacturers have simply advanced their products to a point where monolithic devices cannot yet compete.

In the future, we will see many more general-purpose chips, with analogue inputs and outputs, particularly for instrumentation applications. Provided that they are fast enough, such computers could perform every imaginable instrumentation task — waveform analysis and synthesizing, amplification, sensor reading, frequency counting, voltage measurement, etc. — and all with the advantage of digital storage and flexible data processing.

Simplified ramp-type a-to-d converters. Main elements in most a-to-d converters are a d-to-a converter and comparator. Ramp types are simple and can be as accurate as any other type but conversion time is variable and relatively slow. Even with a relatively low resolution eight-bit converter, it takes 255 clock pulses before the d-to-a converter output is ramped up to the maximum analogue input voltage. Lower input voltages require fewer steps. The waveform is output from the d-to-a converter.

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DATA CONVERSION

D-to-a conversion

Nearly all digital-to-analogue converters work in the same way. A digital value, usually in the form of a parallel binary data word, is presented to a resistance network through a set of switches and a proportional current flows at the network output.

For some applications, a data latch and discrete resistor network suffice. Unless the converter is being used to turn static digital data into analogue form, as it would be if any thumbwheel switches were presenting the data, latching is essential. Many converters now include latching circuits.

Another important point is that current output from the resistor network is relatively high impedance. A buffered voltage output is more useful in most applications and again, many d-to-a converters have on-chip output buffering. Integral current-to-voltage converters increase settling time of the converter though.

Accurate converters need an accurate reference voltage. Often, the converter has an independent built-in reference with its own output, and a separate reference input is not available. Normally, the output is connected directly to the converter reference input, but in some cases the multiplying converter, the internal reference output can be disconnected and an external varying reference can be connected to the reference input instead.

Multiplying converters allow for a value to be proportional to the product of the reference and the fractional equivalent of the input digital value, acting as a sort of digital potentiometer. If a number of converters are used together, reference output from one converter may be used to feed others to give good tracking. Enhancements to the basic d-to-a converter take many forms. Adding sample-and-hold circuits to the output of an accurate d-to-a converter gives multiple channels. There are converters with gated outputs for frequency and time-division multiplexing and there are logarithmic output and multiplexed data input devices for high resolution using narrow data bases. Some converters even include a shift register so that data may be fed in serially. Precisely matched multiplying converters on a single chip can also be found.

A-d converters

Many analogue-to-digital converters include a digital-to-analogue converter and comparator. The unknown analogue input is compared with the output of the comparator and analogue output from the d-to-a converter switches. With an eight bit converter, the number of values sent can be as high as 256 for maximum input voltage. Some a-to-d converters include a counter and are very useful for generating ramp outputs. For faster applications, a

Successful approximation used in a-d to-conversion speeds up conversion time. Elements of this type of converter are similar to those of a ramp type but the counter is replaced with a successive approximation register. The number of conversion steps required is equal to the number of bits in the data word as this example for six-bit conversion shows.

Converter networks

In a weighted-resistor network, current is halved in each bit step toward the l.o.b. by doubling the value of resistance R. Current from each stage is summed to give an analogue output. This method is simple but not often used because many different resistance values are needed and values become very high as the number of conversion bits increases. With a value of R = 16Ω in a 12bit converter, the l.o.b. resistance value is over 2 MΩ. In a converter using discrete resistors, finding the required values is also a problem. Only two resistance values are required in the R-2R ladder network, regardless of the number of conversion bits. Current from each stage of change, the state of the digital value at the d-to-a converter output represents the analogue input value.

Where speed is not important, sequentially incrementing digital values starting from zero are sent to the d-to-a converter. If the input voltage is high enough, the number of values may be needed to be sent to the d-to-a converter for a specific output range. Switches with an eight bit converter, the number of values sent can be as high as 256 for maximum input voltage. Some a-to-d converters include a counter and are very useful for generating ramp outputs.

For faster applications, a

little logic is used. The first value sent to the d-to-a converter is l.o.b. and the first MSB of the d-to-a converter is switched on. Conversion is checked for a higher or lower indication; if higher, the bit is left on. The next bit is now switched and the check done, and so on down to the L.M.S.

This technique, successive approximation, reduces the number of steps required to the number of bits in the word. Again, many converters include successive approximation registers and accurate clock signal. Alternatively the successive approximation can be done in software under computer control.

Tracking converters use comparator output to control whether the counter driving the d-to-a converter counts up or down. As the name implies, output from the d-to-a converter tracks the analogue input so that after an initial count up at switch on, digital output is always true.

Voltage-to-time type a-to-d converters are used for slower applications. With this type of converter, the number of bits an alternation is not dependent on accuracy of a resistor network but on charging of a capacitor. Noise rejection is also inherent provided that sample and hold results are not used at the input.

Its simplest form, this type of converter consists of a resistor and capacitor connected to a comparator input, and a counter driven by an accurate frequency clock. A reference voltage is applied to the comparator and for each bit step the comparator output switches and clock is incremented. The counter now holds a value representing the time it took to charge the capacitor.

With this crude form of voltage to time converter, the voltage representation on the counter is not linearly proportional to input because of the capacitor charging curve so interpretation is necessary. Voltage input must also be higher than the reference.

Practical voltage-to-time converters use an op amp integrator at the input and semi-conductor switches. In a dual-slope integrating converter, current proportional to the input voltage charges the integrator capacitor for a fixed number of clock periods. The counter is then set back to zero and used to count the number of clock periods taken to discharge the capacitor to the starting point using an opposite polarity current proportional to the reference. Discharge time is thus directly proportional to the average input signal value.

Sometimes a third operation is included to compensate for errors in the integrating amplifier input. Charging the capacitor with zero input gives a drift error which can be inverted and used as a compensation value to be introduced when integration of the input signal occurs. Such integrating converters are called triple or quad-slope converters.

Fastest a-to-d conversion is obtained by using a resistor network and many comparators. Such converters, referred to as parallel or flash types, are used in video, radar and instrumentation applications.

They are fast because there is only one step in determining the input voltage. But to do so they need 2^n-1 comparators and divider taps, where n is the number of bits in the digital word, and a proportionately large amount of priority-encoding logic. A compromise is the subranging converter which processes the digital word in two parts.

Parallel or flash a-to-d conversion is fast but requires many components and complex encoding - as this example for only 8-bit conversion shows. As a result, high resolution flash converters become expensive. Most are 6-bit devices.

Subranging converters use two lower resolution parallel a-to-d converters and a d-to-a converter to combine high resolution with speed.

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Sales and Innovation

Customer demands for data conversion are to some extent initiated by the innovation of converter manufacturers. In other words, converter sales areas are being created by the supplier anticipating rather than reacting to customer demands. It is the rapid development of appreciated technology that has led to new product concepts and lower prices.

An ever increasing number of functions in the converter circuit is demonstrated by the fact that the first 10bit d-to-a converter occupied a chip area of four feet that of a current 16bit d-to-a converter with two-layer metallization. Ability to manufacture substantially larger die on progressively larger wafers (flip to fin) together with integration of the hitherto external chip functions gives the customer what is wanted — many functions, low cost, low power, small size and high speed.

An important factor of having solved the problem of manufacturing functionally complete data conversion devices with no user trimming at 10 and 12bit levels is the affect that it is beginning to have on 8bit devices. These traditionally low-cost devices are far more significant in that they are sold in large numbers. Users of 8bit devices are finding that much of the cost of using these cheap devices is in trimming and setting up. Consequently the need for devices that can be used without setting up is increasing. Surface mounting techniques are making similar demands on converter manufacture. Reduction in the size of the overall system board makes it practically difficult to use set-up trimmers.

Will converter sales decline?

There is an unwritten assumption that the need for data conversion devices will decline as microprocessor manufacturers incorporate on-chip signal-processing circuits and the use of digital data and automobile electronics increases.

The fact remains that by incorporating a d-to-a converter in a microprocessor, potential applications for such a product become limited by dynamic and resolution considerations of the converter.

Digital audio has indeed caused the production of 14bit d-to-a converters with appropriate thd specifications but these cannot cope with the monotonity that might be required in a closed loop control system. Digital tv manufacturers have pushed forward flash-conversion but only for a specific signal bandwidth. Converter design-to-manufacture time is now down to nine months from the original 2-3 years through advances like computer-aided design and it is possible to configure a wide range of signal-conditioning functions on the same chip. With this in mind, conversion products will feature strongly in areas of advanced semicon and linear l.c.

The next few years

Current technologies are capable of serving most of the identified needs. Immediate challenges are to continue to increase the number of functions offered in an i.c. to suit the endless number of analogue switching functions.

Such products as gain-ranging, differential-input and multiplexed a-to-d converters, perhaps with on-chip sample-and-hold amplifiers, and all capable of 12-bit operation are already scheduled.

Complete monolithic data-acquisition systems are now a reality. Multiple functions such as quad d-to-a converters and combined d-to-a and a-to-d conversion will continue to evolve and p.c.b. area will be reduced by a factor of five to eight through the application of small-outline packages. Faster single-supply devices will be possible when fabrication geometry allows 1.5um widths.

The need for even wider bandwidth product will be met by the development of bipolar flash and GaAs technologies which by the end of the decade will be provided on products to once again generate a whole new sales area.

Information on specific conversion devices will appear in next month's issue.
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CIRCLE 25 FOR FURTHER DETAILS.

TECHNICAL RAKE’S PROGRESS
Ivor Catt looks back on how he nearly became a maths addict

In my article of last November, I showed that Maxwell’s Equations, set in 3D, give you something to do with the heart and essence of electro-magnetism, and this week I hope to continue that thought through the essence of Maxwell’s Equations, set in 3D, and the way that we use them to understand the heart and essence of electromagnetism. The first equation, Maxwell’s Equations, states that:

\[
\mathbf{\nabla} \times \mathbf{E} = -\frac{\partial \mathbf{B}}{\partial t}
\]

This is the magnetic field, which changes in response to the electric field. The second equation is:

\[
\mathbf{\nabla} \cdot \mathbf{B} = 0
\]

This states that the magnetic field is divergence-free, meaning it has no sources or sinks. The third equation is:

\[
\mathbf{\nabla} \cdot \mathbf{E} = \frac{\rho}{\varepsilon_0}
\]

This states that the electric field is divergence-free, meaning it has no sources or sinks. The fourth equation is:

\[
\mathbf{\nabla} \times \mathbf{B} = \frac{\partial \mathbf{E}}{\partial t} + \mathbf{J}
\]

This states that the magnetic field changes in response to the electric field and currents. These equations are the fundamental laws of electromagnetism, and they describe how electric and magnetic fields are related to each other, and to charges and currents.

The fifth equation is:

\[
\mathbf{J} = \sigma \mathbf{E}
\]

This states that the current density is proportional to the electric field, with a constant of proportionality called the conductivity, \( \sigma \). This equation describes how charges move in response to an electric field.

The sixth equation is:

\[
\mathbf{\nabla} \cdot \mathbf{J} = \frac{\partial \rho}{\partial t}
\]

This states that the divergence of the current density is equal to the time derivative of the charge density. This equation describes how charges are created or destroyed.

Taken together, these six equations form a complete and consistent description of the behavior of electric and magnetic fields. They are the foundation of all of electromagnetism, and they are the basis for the development of the science of light, which is a form of electromagnetic radiation. The equations are simple, elegant, and beautiful, and they are a testament to Maxwell’s genius.

Prolonged, circular epicycles fighting back against Kepler’s less pure, more real-elliptic, Kepler, who himself loved the idea of the ‘harmony of the spheres’, saw a more pure ‘equal areas in equal time’ rather than a distinct un-earthly, heavy.

“How does a young student grow up to become part of the social group who write by mathematical nonsense like Maxwell’s Equations, and who conspire to destroy development of a scientific subject in a proper way?”

Mathematical mafia

The twisting of historical facts in the hands of the academic mafia is beautiful. I was created by the case of the discovery of the electron. Obvious-ly, a mathematician would like us to believe that the discovery of the light wave, which is a mathematical concept, was due to a mathematician. In fact, Whitas says that the pro-posal of the electromagnetic theory came from Faraday in 1851, when Maxwell was 30. Now it might be argued that the vogue suggest-ed by Faraday was confirmed and strengthened by Maxwell’s maths. However, Chalmers says that there is an error in Maxwell’s calculations, which led Pierre Duhem to accu-mulate Maxwell of any original calculation so that he could arrive at a theory of light which he for-should we say Faraday’s already had in mind.

The truth appears to be that the idea preceded the math, the math was force-fitted onto the idea, like the ugly sister’s shoe, and then the math claimed the math that generated the idea. The prince was not beheaded, and neither should we. This is the idea, of forcing mathematical literacy onto a reluctant discipline, constant-ly recurs in science, perhaps reaching its most grotesque as an called ‘computer science’ courses.


There is a similarity between the maths pushers and the drug pushers. Both entice the victim with promises of elysium. Both gradually increase the does. In both cases, there is nothing at the end of the rainbow.

Electronics and Wireless World January 1986

Circuit Ideas

8085 single stepping

I stopped using 6-tate bistable 6502s in single-step circuits because of their erratic behaviour and the problems that they give with circuit layout. This reliable 8085 single-step circuit uses very few components, yet includes a logic probe which can easily be adapted to other purposes. The probe runs from the step-circuit supply to the ready-out signal to 6800 halt pin and ALE-in to the VMA line. It might also work with 6502G processors with ALE connected to the SYNC pin and ready-out to the 6502 ready line. By injecting a negative pulse at the capacitor, slower automatic test equipment could be stepped. I have tried these possibilities.

The probe’s only disadvantage is that it cannot indicate a floating line. Using mos ic I can make the unit suitable for other logic levels, but protection in the form of zero diodes will be needed.

Deboosing is carried out by the first latch. Output of this latch feeds a capacity and pull-up resistor to give negative pulses. Normally, this method is avoided because of noise on the capacitor output, but in this case the latch is a negative input. Once the latch is set, the capacitor charges and the 8085 runs until its ALE signal resets the latch. When this happens, the ready output halts the 8085.

R. Brain
Harringay
London

Don’t waste good ideas

We prefer circuit ideas with neat drawings and widely spaced typewritten, but we rather have scribbles on “the back of an envelope” than let good ideas be wasted. Submissions are judged on originality or usefulness — not exactly imaginative modifications to existing circuits — so these points should be brought to the fore, preferably in the first sentence.

Character generator dot clocking

Because of the speed of c.r.t. dot clocks it is easy to run into problems if synchronous logic is not used, especially around the parallel-serial-out device at load time. strobe signals for data latches in the pipeline are often needed; delays in counters can drastically reduce the amount of time allowed for these memory accesses.

This circuit, based on a recurring “walking zero” principle, uses few lcs to produce a serial-parallel-out shift register circuit providing up to nine consecutive strobe signals. For a six-bit data link, A and B are not used. Link A is used for seven dots, links A and B for eight dots and links A, B, C and D for nine dots.

A character clock for c.r.t. controllers or microprocessors can be produced by connecting the set and reset inputs of a practical multiplier to appropriate outputs of the serial-parallel-out circuit.

J.R. Chalwood
Pickering
North Yorkshire
Enhancing analogue meters

Measuring instruments with pointers are still preferred for many tasks but they are normally only useful for a minimum indication of 1% whereas 0.1% is often desirable. Logarithmic scaling gets round this problem. A single diode can be used as a logarithmic converter but silicon diodes give a single-decade law, i.e. 1% of full scale corresponds to 10^X of the input required for full scale. Germanium diodes do not generally follow the logarithmic law closely, especially at higher currents. A diode-resistor network can give the required law and if several diodes are used, variations due to diode characteristics can be minimized. Using the diode network as feedback around a single op-amp as shown in the second diagram gives current output which is accurately proportional to input voltage.

The final circuit uses five cheap unselected diodes in the logarithmic network and one to protect the meter against reverse-polarity input. Low closed-loop gain at high input voltages means that the input signal must be applied to the op-amp inverting input.

Up to the point at which the first diode conducts, in this case 10% Ia, the law is linear. Results are

<table>
<thead>
<tr>
<th>Input (mV)</th>
<th>Deflection (%)</th>
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<tbody>
<tr>
<td>0.3</td>
<td>1</td>
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<tr>
<td>1</td>
<td>3</td>
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<td>10</td>
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<td>300</td>
<td>80</td>
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<tr>
<td>1000</td>
<td>100</td>
</tr>
</tbody>
</table>

Accuracy depends on temperature; if temperature compensation is needed a more complicated circuit using 'catching' diodes referenced to temperature compensated voltages may be used. This circuit was designed for the current meter of a bench power supply. Range switching is not necessary yet current drawn by low-power circuits is easily monitored.

J.M. Woolgate
J.M. Woolgate and Associates
Rayleigh

Improved coincidence circuit

The common way of registering a coincidence between two input pulses within a resolving time τ is shown in the top diagram. It has the disadvantage that output pulses vary in width, being the duration of the overlap between the two input monostable devices. If this output is used to drive t.t.l. circuits, erratic operation may occur as the result of the presence of pulses shorter than the specified minimum trigger duration. In particular 74LS123 and 74LS221 monostable l.c.s. when driven with pulses shorter than 40ns do not trigger but propagate a sharp glitch through to their outputs.

An improved coincidence circuit is shown below. The output pulse is of constant duration, τ, the resolving time. If the overlap between the two input monostables is less than 25ns the 74LS124 bistable device will fail to trigger and no output pulse occurs. This, however, happens in a controlled manner with no output glitching.

John McMillan
Dept. of Physics
University of Leeds

Comparator for capacitor sorting

Conventional methods of sorting capacitors use either analogue or digital comparison techniques. This method compares the pulse width proportional to unknown capacitor C of with that of two known limit-value capacitances.

An astable multivibrator with 50% duty cycle and 1.65s period triggers three monostable elements representing upper and lower capacitance values C1 and C2 and unknown capacitor C of.

When pulse M1 exceeds M2, the upper monostable i.e. is triggered and its led blinks at round 0.7Hz. When M2 is less than M3 similar gating triggers blending of the yellow led. When neither led blinks C of is within limits set by C1 and C2.

Gate delays are adjusted so that false triggering of the output monostable l.c.s does not occur.

V.R. Kishor
Nashik India

Simple tunes

Speed and pitch are variable on this simple tone generator. The 555 clock drives a binary counter, output of which is decoded. For each step of the clock, potentiometers set pitch by determining frequency of the astable multivibrator.

M.H.S. Bukhari
Hyderabad Pakistan

Diodes in output lines of the 74141 might stop introduction of the potentiometers.  — Ed.
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AUDIO VISUAL EQUIPMENT FOR THE PROFESSIONAL

ELECTRONICS & WIRELESS WORLD JANUARY 1986

Circle 17 for further details.

CIRCLE 29 FOR FURTHER DETAILS.

Circle 26 for further details.

Circle 28 for further details.
ELECTROLYTIC CAPACITORS IN LONG-TAILED PAIRS

In audio terms, the main shortcoming of electrolytic capacitors in their behavior when connected to the base inputs of long-tailed pairs. Fig.

When leakage is present in C1 or C2, a voltage divider is formed by R1 and R2, and it is automatically taken into account by the amplifier. When the leakage fluctuates, it is not easy to calculate, but generally, the biasing of the amplifier becomes unstable.

SATELLITE RECEIVER DESIGN

As a TVR aerial engineer who is trying to add satellite TV systems to his range in order to make a living, I must make a strong objection to the way you have allowed J.-L. Hastie Nov. 1980, to mislead your readers over the dangers connected to domestic installations.

He might personally deem that 0.9 metres is the maximum diameter required, or he might glean it from old books (two years is very short in SATV), and experience anywhere in the UK is that 1.8 metres is needed from.

NEW LOGIC SYMBOLS

At my school here, I offered a reward to anyone who could point out the working of the CD ROM-selector (published in WW October 1983, p.59) straight from those guys, given the phone numbers in them and spaghetti interfacing themselves.

That offer has stood since 1983, and nobody has collected yet. . . . Are continental students so dumb?

Peter R. Clark
Clark Arnersd

Stereos

From Pat Hawker's report (ERW September 1985, p.69) one can learn that the first ones to try to improve the stereo performance are: Anabyl Holf

In my opinion these efforts, which already have the face of the incomprehensible mass of futurology, must be stopped. The fallacy lies in the new understanding that any improvement must be compared with all previous systems and equipment.

The present availability of these components is such that it is possible to build expensive audio equipment and powerful transmissions. Today's L. A. pigeons object to the objective assessment of the situation; apparently nothing seems to be in the way of the Ayton-Jones gadget.

The preceding was stated on August 1985, ERW, p. 8, top of column 3 in the 'Step by step' series of notes. Someone once noted that a neutrino is as good a medium as anything else for conveying electronic device, or even better. They write: Here is the way to explain the hope that the neutrino may be an (in wave guise, I presume) electric charge is playing hide and seek at distances of 10^-16m. As easy measurements, in other words. They can carry out measurements with an accuracy of 1 in 100,000,000 only when the device with the two proportions of sin and ratio is different. This format could conceivably also be used on the television sound source.

P. Heymedium

Satellite Receiver Design

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as fast as present day electronic stores. Because they will be small and manufactured by the proposed subscription stores, and machines, they will be inherently cheap.

In the paper by Conrad Schnier (which has a long list of references), it is argued that the development of simple and inexpensive

replicating microtechnology devices may be possible. The most of ideas used are still not new, but draw from many different scientific disciplines. It is interesting to note that there wasn't anything by that time. The components in the future computer of the near future that is already available for 10 to 15 years. Again, the construction of the acoustic photograph did not rely on any technologies that wasn't available for another century earlier.

J. de Rivera, Tum, Cornwall

WHAT'S IN A THEORY?

Our four Cat always makes cheerful light reading, especially when he points out the limitations of some physical statements which are usually mentioned only with

bated breath. Typically, in E+ H for November 1985 he reminded us that only one electromagnetic information contained in the two Maxwell equations relating E and H in vacuum lies in the three energy

and not in the four. So don't even consider to "derive" the "impedance of free space" as Z_0 = \mu_0 / \epsilon_0 and the "universal velocity of light" as c = \lambda / \nu_0.

The phenomenon is in no way confined to electromagnetism. Some of your readers might care to try the following unorthodox derivation in the wave theory of matter:

A completely general expression for 3-dimensional waves in any medium is provided by

\[ \nabla \cdot E = \frac{\partial B}{\partial t} \]

\[ \nabla \cdot H = -\mu_0 \epsilon_0 \frac{\partial E}{\partial t} \]

\[ \nabla \times B = \mu_0 \epsilon_0 \frac{\partial E}{\partial t} \]

\[ \nabla \times H = \frac{\partial E}{\partial t} \]

(1) where E is "what it is that oscillates" in the theory, so we will simply eliminate them by means of the wave

equation (self-evident truth \( E = 0 \)).

Directly related to the particle's kinetic energy \( K = \frac{1}{2}mv^2 \) by the form \( p^2 = 2mK \)

we have derived

\[ p^2 = \frac{2mK}{\epsilon} \]

Finally, since the total energy is \( E = K + \frac{1}{2}mv^2 \), evidently \( K = \epsilon^2 - \frac{1}{2}mv^2 \)

\[ \epsilon = \frac{p^2}{2m} + \frac{1}{2}mv^2 \]

HALL AND HOLES

To reply to R Pazarov Nov, the "standard explanation" of a "free moving back electron" is not a realistic if one imagines a current as a result, circled and probably rather than a doctor's waiting-room. The "hole" is now in a distinct minority; and I see a further analogy with the bubble in Bunker's Accelerometer— if the acceleration is to the right, the bubble moves to the right — this is probably the delight of teachers who are not anything by way of following the tape — and everyone knows it is only liquid which has a good to the left.

"Opposite" behaviour, depending on whether the charge carrier is in a minority or on roughly equal terms with the mob, also helps to explain the opposite effects of temperature on the resistivity of semiconductors. Consider a person trying to clean the town square, when it is densely packed. If the crowd is large, it becomes more difficult to clean. But if the square contains just a few folk, and the charge carrier knows he (she must touch a different person) tells him that the "heating" makes the journey easier.

May I suggest Dr J W Warren at Brunel University as being well qualified to say which of your many recent correspondents are breathing.

"The most worthy attempt to prevent errors in the literature" — he has a long record of nailing fallacies perpetuated by text writers.

MA, CYHO, MHPST

Relativity

The idea that classical physics cannot account for the constancy of light velocity needs correction. The velocity will be constant in the fields of observers A and B, whose coordinates are in terms of the

Galinon correspondences, both infinity equations of Maxwell's

To express the fields B in terms of those of A, it's charge variables tensorially with Lorentz correspondences. Chosen that his new equations are different from the functionally identical to B's equations. The functionally identical to A's new equations and thus

known, and B's fields are obtained by inserting his coordinates in the functions. The basis of relativists' beliefs in the Principle of

Covariance which asserts that if any observer can change his variables then the resulting equations will be unchanged and given to another observer. Relativists should look here classical physics avoids their assuming Principle but still gets their well-stated formulation.

The difference between the two sets of fields at any point of "absolute space" are the motional fields due to the relative motion of the observers. Conversely, such motional fields ensure the form invariance of Maxwell's equations and may be presented as a measure of the constancy of light velocity. A consequence in that relativists must seek justification outside the electromagnetic form since any valid relativistic calculation made in relation to an electromagnetic experiment can be described (usually by using motional fields in lieu of "spatial" space-time).

The falsity of claims that electromagnetic experiments dispel classical physics should be remembered when assessing the credibility of other claims that relativists will universally make.

1987 is the 300th anniversary of the publication of Principia and it would be nice to have the means of being tidied up by then. The procedure is obvious — renounce the Principles of Covariance and thereafter respect the principles of mathematics. It will be found that all valid relativistic formulations will carry over into classical physics since the renunciation of the Principle of Covariance does not imply that tensor methods cannot be used.

R. Berriman

Palmerston North

New Zealand

ENERGY TRANSFER

The reversed polarity of the Hall effect, referred to by T. Leopold in the November issue, is not confirmed to be the presence of semiconductor. The same reason is found in certain materials, such as zinc and cadmium. The reason is lack of appreciation of this until the late 1990s, when it was accounted for in quantum mechanics.

As regards Catt's explanation of electrical conductivity, he seems to have confused two alternative fields. In the February issue to electrons entering and leaving the conducton band from and to the conduction band by the metal strip or "hops" its trinity. This electron transport, the physical realities, except for the electron interaction, is in the classical electromagnetic, that participates in the physical processes in conductions, such as photons and waves. My main point was, and remains, that the velocity of electron does not form a strong enough fog to advance, on which to make the sound "the death of electric current" and "electricity does not exist" (December 1889).

G Berinn

London

ELECTRONICS & WIRELESS WORLD JANUARY 1986

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**Electronics & Wireless World January 1986**

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**Naiad training robot**

Third installment completes the description of the robot arm's various drives. Design by Dick Becker and John Wells

Axis 5, the gripper, also has a 10mm cylinder and this too uses a rubber seal. Fig. 16. Power may be either pneumatic or hydraulic. The two systems may be simply compared by minor re-plumbing. When operating hydraulically the whole system is self-contained. Pneumatic operation however is faster and the difficulties of servo-controlling a pneumatic system do not apply to a gripper which requires only to be fully opened or firmly clamped onto the component being handled. There is a connector on the end panel of the robot which permits fitting to either an airline or to a cylinder of carbon dioxide when no air is available. With a cylinder, as used for fizzy drink dispensers, there is sufficient capacity for over 1000 operations of the gripper. This cylinder together with a pressure regulator is mounted on the side of the robot.

The hydraulic and pneumatic systems of the Naiad arm are controlled by solenoid-operated valves in which there is a small less planner with rubber ends for closing off whichever orifice they are in contact with. Fig. 17. A spring normally holds the plunger in the down position and water can then flow from port 2 to port 3. When 24 volts is applied to the solenoid, the current causes magnetic flux to lift the ferromagnetic plunger, closing off port 2 and opening port 3. Each valve can thus be visualised as a 1-2 way switch. Two ports are required in the hydraulic circuit, port 3 is omitted from the valve. Fig. 18. Hydraulic power comes from a small vibrating-piston pump inside the robot base. It draws water from a bottle, acting as the pump, and pumps it into an accumulator. A hydraulic accumulator is a pressure reservoir and consists of a chamber into which the fluid is pumped, and a spring wall that is displaced by the pressure. When demand exceeds the capacity of the pump, the wall returns providing additional fluid power. An accumulator may consist of a cylinder in which a piston compresses the fluid, either by a helical spring or air pressure, but more frequently a rubber bladder or diaphragm with compressed air behind it is used.

Naiad uses a diaphragm-type accumulator consisting of a hemispherical dome with a sheet of rubber sandwiched between it and the top plate of the robot. Fig. 19. The cavity on the underside of the diaphragm is pumped up with air to 4 bar. Water is then pumped into the cavity between the diaphragm and the dome. A dome is made of cellulose acetate butyrate, which is transparent, and the action of the diaphragm raising and falling, depending on demand, the storage is the hydraulic cylinders, can be observed.

To have the robot under servos control, its position is sensed by a potentiometer fitted to each rotary joint. A stable 10 volt supply goes to each potentiometer, the wiper of which is connected to a high

---

**RUGBY TIME?**

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LOW PRICE: Includes parts, 5 x 8 x 15 case, post, by return postage etc and list of further kits. Our TIME WILL TELL.

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**Fig. 16. Gripper is a Perspex cylindrical block with an axial cylinder. A spring returning pin passes through the Perspex at the mounting bush and a similar pin through a hole in the piston and through slots on opposite sides of the cylinder. Two longitudinal holes down the side of the cylinder act as spring guides and the springs are located on the pins. When air or water pressure is applied the input port the piston is forced down the cylinder closing the jaws.**

---

**Fig. 17. In the solenoid valve shown, valve is held onto its seating by spring pressure thus shutting of inlet port. In this condition there is free passage of fluid between ports 2 and 3. When a voltage is applied to the coil, plunger is pushed towards the seating of the pressure port and seats into port 3. Flow is then directed from port 1 to port 2.**
impedance amplifier so that the voltage measured is linearly dependent upon the angular position of the axis. If linear
potentiometers or l.v.d.s had been fitted to the cylinders then there would be a complicated relationship between their output and the angle of the axis. Also with those methods the voltagex-angle relationship is strongly dependent on offset errors, making computation of positions in world coordinates more difficult than it already is on a robot of this versatility.

Whilst the operation of a robot is much easier when there is a built-in servo system, Naial uses software-controlling the hydraulics to increase its versatility as an educational tool. With software serving the solenoids are directly controlled by the computer in response to the instantaneous measured position, whereas with hardware servoing a robot requires only to have data defining its next position, and this is well illustrated by axis 3, which is the motor driven wrist elevation axis. The servo amplifier for this axis has software-selectable gain so the effect on accuracy and stability on hand manipulated and over-damped servos systems can be observed.

With the hardware servoing a single line in Basic sends an axis to its next position; software servoing Basic is not fast enough and a machine code routine running in the background is necessary. It’s possible to use Basic to give tolerable results if only a single axis is being controlled and this provides another valuable comparison of techniques used in robotics.

To be continued.

**Naial specification**

<table>
<thead>
<tr>
<th>Axis 0 (waist) Angular movement 180° - Axle centre 101mm above tp of base</th>
</tr>
</thead>
<tbody>
<tr>
<td>Axis 1 (shoulder) Angular movement 90° - Arm length between axle centres 170mm</td>
</tr>
<tr>
<td>Axis 2 (elbow) Angular movement 90° - Arm length between axle centres 190mm</td>
</tr>
<tr>
<td>Axis 3 (wrist elevation) Angular movement 250°</td>
</tr>
<tr>
<td>Axis 4 (wrist rotation) Angular movement 320° - Axis 5 (gripper) Jaw opening 60mm, Jaw pressure 20 newtons, Distance from end of jaws and axis 3 axle 140mm</td>
</tr>
<tr>
<td>Repeatability 2mm</td>
</tr>
<tr>
<td>Lifting Capacity 500g</td>
</tr>
<tr>
<td>Reach (from axis 1 axle centres) 500mm</td>
</tr>
<tr>
<td>Base dimensions width 480mm depth 220mm Height 161mm</td>
</tr>
</tbody>
</table>

161mm Control System Axes 0.4 under closed-loop servo-control

Position defined by 8 data bits giving angular resolution of 0.1°

Computer Interface: Serial Parallel. Robot addressed as if part of computer memory. Connects to 1MHz bus of BBC, expansion port of C64, slot of Apple or IBM PC.

Software: Accepts commands in Basic or machine language.

Software provided:

Extended package of Basic programs including direct control from computer keyboard, control by simulation, sequence storing, replay, sequence editing, sequence storage on disc and graphical display of robot dynamics, on disc for BBC, C64, Apple IIe, IBM PC computers.
Synchronous demodulator design gives low distortion, variable selectivity and freedom from whistles

In the days when the large broadcast transmitters could almost invariably mean a system for receiving amplitude-modulated signals, a large number of good quality a.m. sets were available. Their major limitations were mainly those imposed by external considerations, such as reception conditions or overcrowding of the broadcast bands.

This has led to the widespread adoption of v.h.f. broadcast transmitters, but many of the old design changes have occurred——not all of them at the benefit of the users. Because of the very high quality signal available from this type of device, a very great deal of work has been done on these systems, largely as a result of the interest of the hi-fi fraternity, in exploiting the low line, wide and very flat bandwidth of the transmitted signal.

Fortunately, all this useful and beneficial development work is not completely passed by the users of audio broadcasts on the long and medium wavebands, presumably because it is assumed that the quality of signal normally available on these bands is so poor that it does not warrant any transmission device used to receive it.

This has led to the serious situation that the owner of good quality audio equipment is likely to have no available facility for an a.m. reception; or if his circuits are used, to that by an l.f.m. receiver. This encourages the search for something better than the conventional low cost transistor circuit.

An almost complete satisfaction of the requirements listed above is offered by a system based on synchronous demodulators, such as the A.R.H. demodulator and the BBCcho o choose to transmit significant parts of their program output on a.m. only.

Basic receiver requirements

Some worthwhile improvements to the conventional a.m. receiver would be:

- a low distortion demodulator system
- a wide range of whistles often found with superhet-type receivers as a result of the inherent bandwidth and local oscillator harmonics

For variety of selectivity, to reject adjacent-channel signals

Sensitivity and resistance to fading are also highly important but they are normally quite well met by existing superhet design.

Any alternative system should be at least as good as these in respect.

Given a good receiver system the signal quality available from many a.m. radio transmitters and medium wavebands, presumably because it is assumed that the quality of signal normally available on these bands is so poor that it does not warrant any transmission device used to receive it.

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having a zero beat frequency, leaving just the carrier modulation — the sidebands — as the residual signal. Since the process is simply one of transformation of the carrier frequency down to zero, the system is, in principle, quite linear and the harmonic distortion inherent in any rectifier-based envelope detector can be avoided. I have illustrated the comparative performance, in the case of a high modulation depth, in Fig. 1. However, there are snags which are sufficiently daunting to prevent this otherwise excellent system from being widely adopted.

**Snags**

In the case of the synchrony, the major problem is the piercing whistle which occurs as the station is tuned in, or detuned, because of the a.f. beat note between the local oscillator and the incoming carrier. Since this has an amplitude equivalent to 100% modulation, it is substantially louder than the modulation on the signal itself when correctly tuned.

This problem is avoided in the homodyne, since the reference oscillator signal is derived from the incoming carrier itself. However, the principal advantage of the synchrony, as conceived by Tucker, is its inventiveness, or that since an adjacent carrier signal will produce beat frequencies which are higher than that of the wanted one by the difference in the carrier frequencies, the required selectivity can be obtained by post-demodulator a.f. filtering.

The conventional heterodyne, in which the carrier of the incoming signal is demodulated singly by amplitude limiting, cannot offer this advantage of post-detector selectivity, since any incoming carrier will be treated equally. If pre-detector selectivity has not given adequate carrier-gate discrimination, post-detector a.f. bandwidth cannot do so either.

If the circuit is a superhet, in which the i.f. frequency is fixed and predetermined, the required carrier isolation can be achieved by a narrow band-pass circuit, such as a simple crystal filter. But this has the snag that small adjustments in tuning will lead to large changes in the relative phase of the countermodulated carrier, with consequent large changes in demodulator sensitivity.

This effect arises for the reasons which I have shown graphically in Fig. 2, with reference to the simple synchronous switch demodulator of Fig. 1c. If the relative phase of the incoming carrier and the switching waveforms are at quadrature, the averaged d.c. output in any one limb of the demodulator (illustrated by the cross-hatched portion in the drawing) will be zero. Since this will be true for a carrier of any amplitude, provided that it is symmetrical, it follows that changes in the amplitude of the carrier (for example, produced by amplitude modulation) will have no effect on the output. Therefore the modulation will not be recoverable.

For full recovery of the modulation envelope, it is essential that the switching waveform shall be accurately synchronised in phase with the incoming carrier. This is in addition to the requirement, for whistle avoidance, that it should be in frequency synchronisation, which presents additional difficulties.

In the case of single-sideband, suppressed carrier a.m. radio reception, neither frequency nor phase synchronisation are so crucially important, and synchrony systems with stable, free-running local oscillators have been very widely adopted. They are usually referred to as directconversion systems.

**Synchodyne receivers**

The simplest functional synchrony system of the type proposed by Tucker is as shown in Fig. 2a. In this, no specific a.f. tuning is employed, and the signal which is selected is simply that which is in synchrony with the oscillator. Frequency and phase synchrony are achieved by injecting a small amount of the incoming aerial signal into the oscillator circuit, to induce pull-in lock.

While such a system can work, especially when there is a strong local station, it is difficult to get the local oscillator frequency sufficiently stable. A much better system is that shown in Fig. 3b, in which two mixers are employed: one to demodulate the incoming signal and one to operate a separate phase-locked loop system controlling the frequency and phase of the reference oscillator. This is a well-known technique, and practical examples have been described by Lepkoff and Warschaw.

Since the operation of the phase-locked closed loop (p.l.l.), for reasons which will become apparent later, is such as to force the control oscillator into synchronism at quadrature to the phase of the incoming carrier, a 90° phase-shift network or its equivalent must be interposed between the output of the local oscillator and the control input to the mixing circuit.

With this amplification, this kind of system will form the basis for a practical synchodyne receiver, which could be used domestically without any undue difficulty in operation. Such a system is shown in outline in Fig. 3c.

**A practical synchodyne**

As I mentioned, there are a number of practical problems inherent in the synchodyne system which must be remedied before such a receiver can be considered a usable alternative to the conventional superhet. Of these, the two most intractable (in the case of a simple direct-conversion system without tuned r.f. stages) are those associated with the cross-modulation of the mixer system, and those associated with spurious signal reception due to oscillator harmonics or the inevitable nonlinearities in the mixer.

A pre-tuned r.f. stage is of great benefit in both of these cases. Firstly, it allows some form of automatic gain control, to prevent the signal level reaching the mixer from exceeding the level at which excessive cross-modulation occurs (typically in the range 30 mV to several volts, depending on mixer type). Secondly, it will provide enough selectivity to avoid spurious signals due to signal or oscillator harmonics.

Also, because some degree of r.f. gain reduces the need for a proper post-demodulator a.f. gain, the problems of aerial-sourced earth-loop mains hum and tuned-circuit microphony are greatly reduced.

Since the output of the signal demodulator will contain a d.c. component, this can, with suitable amplification, be used as a highly specific source of automatic gain control (a.g.c.) voltage, and also as a control voltage for a signal-matching circuit to suppress a.f. output when the receiver is not on tune. This will remove the unpleasant whistle characteristic of a synchodyne receiver when it approaches or leaves the point of synchronisation with the incoming signal.

The practical benefits of such a receiver are considerable. They include, in addition to freedom from whistles and easy adjustment of the adjacent channel selectivity to suit listening conditions, a very low distortion demodulated a.f. signal and a very clean low noise background. This arises, because, in contrast to the diode envelope-demodulator which will demodulate the signal presented to it (including wide band noise), the synchrony detector will demodulate into the a.f. band only those signals which are within the chosen a.f. bandwidth of the synchronous oscillator frequency.

Also, the combination of a synchronous demodulator with an a.f. tuning circuit gives a situation whereby when the receiver is tuned through the receiving band, there is complete silence between stations. The only signals received are those from properly tuned stations having a signal strength above some predetermined and presettable level. At first acquaintance, this is an interesting and novel experience.

---

John Linsley Hood's phase-locked synchrony a.m. receiver covers both long and medium wave bands, giving low distortion, low noise, adjustable selectivity and whistle-free tuning. A kit of parts will be available from Hart Electronics.
The phase-locked loop

There are certain types of circuit arrangement in which the output depends on the relative phase of two inputs. The synchronous switch of Fig. 1 is a simple and primitive example. A rather more elegant one is the balanced modulator-demodulator arrangement shown in Fig. 4, using the LMC6140 family of integrated circuits. These can be described as phase-sensitive detectors (p.s.d.s).

If such a p.s.d. is used as a component element in the circuit layout shown in Fig. 5, where a voltage-controlled oscillator (v.c.o.) is used to generate the second input (f2) to the p.s.d., then the output of the p.s.d. will be a square wave (f1 + f2), containing the sum and difference frequencies of the input signal (f1) and the signal from the v.c.o. (f2). The output from the low-pass filter will contain simply the difference frequency (f2 - f1). In this case, the frequency of the square signal is determined by the instantaneous value of the difference between the two signals, and this will vary from a positive potential, through zero, to a negative potential. In this arrangement, the signal frequency can change from one to another in steps, through quadratic, at f2, and a phase-locked loop organización is shown in Fig. 6, with its frequency of operation of the input of the v.c.o. Two approaches can be employed to minimize this snag: to use the lowest amplifier gain practicable; and to make the pass band of the low-pass filter as narrow as possible.

Both have the snag that they limit the capture range of the loop. Ideally, should be able to jump into synchronization with an input signal which is moderately large, otherwise it will be difficult to capture the required signal.

Fig. 5. Basic phase-locked loop arrangement.

when tuning through the wave- band, inevitably some compromise is required on this point.

The reason why phase modulation in the v.c.o. is so undesirable is that it introduces a measure of second-harmonic distortion into the audio output of the demodulator p.s.d. (Phase det. 1 in Fig. 3c), thereby diminishing the practical advantage in linearity which such a system offers in comparison with the simple envelope detector.

It is nevertheless possible to achieve a reasonably satisfactory compromise, and in the following, we will discuss the schematic of the circuit design shown in Fig. 3c. This gives a sound quality noticeably better than that of the conventional type of m.s.e. receiver.

References


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CIRCLE 17 FOR FURTHER DETAILS.
## Integrated Circuits

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<td>Octal D-type synchronous counter</td>
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<td>74HC164</td>
<td>8-bit parallel-in, parallel-out shift register</td>
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<td>74HC4010</td>
<td>1-of-4 encoder</td>
<td></td>
<td>0.95</td>
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### Video Heads

- Sony, JVC, Sanyo, Panasonic
- Price: £50 - £150

### Sanyo Original Video Parts

- Sony, JVC, Sanyo, Panasonic
- Price: £20 - £50

### Video Alignment Tool

- Automatic video alignment
- Price: £29.99

### Line Output Transformers

<table>
<thead>
<tr>
<th>Type</th>
<th>Frequency</th>
<th>Gain</th>
</tr>
</thead>
<tbody>
<tr>
<td>75</td>
<td>1 MHz</td>
<td>30</td>
</tr>
<tr>
<td>180</td>
<td>2 MHz</td>
<td>35</td>
</tr>
<tr>
<td>300</td>
<td>3 MHz</td>
<td>40</td>
</tr>
</tbody>
</table>

### Varicap TUNERS

- Price: £5 - £10

### Push Button Units

<table>
<thead>
<tr>
<th>Type</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>ON/OFF</td>
<td>Power Control</td>
</tr>
<tr>
<td>VOLUME</td>
<td>Audio Adjust</td>
</tr>
<tr>
<td>MUTE</td>
<td>Volume Mute</td>
</tr>
</tbody>
</table>

### Replacement Electrolytic Capacitors

- Price: £0.50 - £1.50

### Thermistors

- Price: £0.25 - £0.50

### 2mm Quick Blow Fuses

- Price: £0.05 - £0.10

### 3mm Anti Surge Fuses

- Price: £0.10 - £0.20

### Spares & Assos

- Price: £0.10 - £1.00
The TTL processor is...
Polyphonic keyboard

Microcode for the high-speed t.t.l. processor is contained in a 63x6-series programmable rom (Monolithic Memories, Farmborough). This circuit, published on page 39 in the April 1985 issue of Electronic Engineering is for programming such roms. There are one or two minor errors in the previously published circuit.

The 6349 prom may be programmed manually by addressing a byte then using this circuit to program all bits that must be zero. The program pointer is the chip-enable input, pin 15, and the bit pulse to the output pin.

Table 1. Memory use in the t.t.l. processor

<table>
<thead>
<tr>
<th>Address</th>
<th>Array</th>
</tr>
</thead>
<tbody>
<tr>
<td>000-0279</td>
<td>low-order set, program</td>
</tr>
<tr>
<td>028-047</td>
<td>high-order set, program</td>
</tr>
<tr>
<td>048-065</td>
<td>low-order frequency values</td>
</tr>
<tr>
<td>066-073</td>
<td>high-order frequency values</td>
</tr>
<tr>
<td>200-227</td>
<td>volume values</td>
</tr>
<tr>
<td>228-229</td>
<td>table of references</td>
</tr>
<tr>
<td>224-225</td>
<td>waveform table</td>
</tr>
<tr>
<td>230-231</td>
<td>register</td>
</tr>
<tr>
<td>232-233</td>
<td>register</td>
</tr>
<tr>
<td>234-235</td>
<td>register</td>
</tr>
</tbody>
</table>

Digipoly back panel provides an illuminated on/off power switch and access to the mains fuse. A BS441 connector is provided for 240V a.c. input and 6mm jacks connect the sustain-pedal switch and the audio output.

Table 2. Port data latches

<table>
<thead>
<tr>
<th>Port</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-55</td>
<td>select type of memory to be modified</td>
</tr>
<tr>
<td>56-57</td>
<td>memory offset of type defined above</td>
</tr>
<tr>
<td>58-59</td>
<td>data to be stored</td>
</tr>
</tbody>
</table>

Output is constant d.c.

Sampling noise can be heard quite clearly if Digipoly is connected into a high-quality amplifier and loudspeakers. This means that a further low-pass filter, for example on a mixing desk, has to be added before the sinewave voice can be used for quiet solo work. For all other voices there is no problem with output signal-to-noise ratio.

Owing to the note-generating technique, synthesis of high-frequency complex waveforms such as those used for upper 1/4th octave is not good. Using higher frequencies, non-consecutive samples from the waveform table are taken with gaps of several samples. This causes small features in the waveform to become aliased, thus introducing the characteristic quasi-periodic sinusoidal frequencies into the sound. Remember, though, that the true harmonics that are these small features are supposed to add to the sound would be out of the audio spectrum and the desired sound can be achieved by using a simpler waveform.

Figure 6a in the September issue shows the Digipoly output spectrum when synthesizing a single 1/4th octave sine wave. The noise floor is at -65dB relative to the single note. This is virtually noise which disappears when all notes are pressed since d-t-a converter holding down two keys at once. This product is presumably created in the 741-based active filter used in Digipoly's output circuit since the digital circuit behaves totally linearly. Figure 6c shows harmonic spectrum from a single squarewave.

Performance

Figure 6a in the September issue shows the Digipoly output spectrum when synthesizing a single 1/4th octave sine wave. The noise floor is at -65dB relative to the single note. This is virtually noise which disappears when all notes are pressed since d-t-a converter

Electronics & Wireless World January 1986

Midi standard calls for three connections; Midi-in receives data which is automatically echoed on Midi-through. Midi-out leads to other devices under Digipoly control.
The microcomputer has now become a basic tool of modern life. The original 16K and 32K models were limited to use in homes, offices, and schools. However, the microcomputer is now also being used in homes and offices as well. It is becoming more and more popular among people who are interested in computers. The future looks very promising for the microcomputer. The microcomputer is no longer a toy for the rich or a luxury for the few. It is now becoming a necessity for everyone. The microcomputer is becoming more and more affordable, and more and more people are starting to use it. The microcomputer is becoming a way of life for many people.
Amateur Radio

Sloower growth

The decline in the number of youngsters becoming interested in the hobby of amateur radio, other than as a means of linking personal traffic, is reflected in the R.S.G.B. review of the year to June 30, 1985.

This shows that while membership has risen from 35,960 to 37,096 during the year, the number of new members has declined sharply since the peak of 57,377 in 1981 to 5,804 in 1983-4 and 4,310 in 1985-8, with just over 3,000 members dropping out this year.

The Society has managed to reduce its financial revenue deficit for the year from £50,242 to £30,720.

The IFT have more clearly defined the conditions under which Class B (h.v.) licenses may work "cross-band" to amateurs using h.f. bands, including satellite transponders on the 28MHz band. The RSGB is also pressing that 50MHz, when this band is generally released, should be available to Class B licensees. The Society is also urging that the Radio Investigation Service should take more active steps to stamp out "spectrum abuse", labelling the service as grossly inadequate.

It is noted in the report that many television stations which meet the requirements of BS800 and experience no problems from local h.f. transmissions, nevertheless suffer severe breakdown when near 144MHz s.s.b. transmitters of more than about 10 watts (p.e.p. output). The number of QSL cards passing through the Society's QSL Bureau is put at 2.4 million, about the same as last year.

The 55 national societies of the I.A.R.U. Region 1 Division had some 117,000 licensed members in the 1985 rally, an increase of about 4,000 over 1984. West Germany (DARC) has the largest number, 39,378, followed by RSGB 28,882, Spain (URE) 12,495, and USSR (RSF) 11,429. Several societies, however, have reported a decrease in licensed members including France (REF), Holland (VERON) and Belgium (U.BA). For example, of 3,551 licensed amateurs in Norway, 3,691 were members of NRR, a reduction of 200 in the year to April 1985.

From all quarters


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Morse and the deal

Neil Neame, formerly G2AUB, became interested in radio as a young schoolboy at a time when it was possible to buy or devise components and build receivers and transmitters within the budgetary limitations of "pocket money" earned by the weekly technical radio magazines that sold for a few pence. He became aware of Morse code and began to learn to spell and use the alphabet, and entering the hobby today has become altogether too expensive and too dependent on factory-made equipment. Schoolboy enthusiasts of the 1940s often found a career in radio.

But his main plea is made with his own handicap of deafness. He believes that communication by Morse code is one of the few ways in which the deaf can communicate with other people "on equal terms". He has proved that even the severely deaf can read Morse signals with the aid of audio filters ("stereo" headphones or sensors) and that every effort should be made to teach them more, perhaps by changing the construction of simple transmitters and to provide low-cost cw-only licences etc.

Pat Hawker, G3VA

Here and there

Misprints, unhappily, we all have to live with. But an undoubtedly misleading error crept into my November item on "Friendly f.t.". This gave the success rate of QSL LF waves employed to heal difficult bone fractures as "close to 90%", even though, as the Americans pointed out, "the bone fractures of patients selected for this treatment had generally failed to heal over months or even years - often despite repeated surgery." In one trial at Columbia Presbyterian Hospital a success rate of 90% was achieved, raising the 86% after a second round of treatments with no known adverse effects. Many of these patients had been disabled for several years and seemed destined for permanent disability.

The BBC 200W long wave station at Imbriwin is now using its new 500W transmitter with two new 700W amplifiers. The frequency will be changed at 1984Hz during 1988, a paint to be fed into production and to eliminate the software bugs, while repeatedly testing on later bits of new technology. We still have not learned the aims of the "simple, stupid" and "pioneering don't pay". It's better to come second with a simple, bug-free product, and forget the "not-invented-here" syndrome.

It may also be time for the N.E.C. to decide in what direction the annual Mountbatten Lecture should go. The eighth so far have had no common central theme or discernible purpose. A few brilliant, some pedestrian and some overly political. As major occasions, chaired by the Duke of Kent, they seem to lack something.

FORTH computer

Remember that -

* FORTH is fast
* It is interactive like BASIC
* It combines the power of an assembler
* Can mix high-level and assembler code
* You can communicate perfectly without penalty
* It can be left running or rewritten
* TSS900 series computers have a full-screen editor and the TSS900 series has both X- and C- Morris versions
* TSS902 consumes 25mA and has 62K bytes memory
* Address space data bases take 500/2000 computers
* Many systems are just one TSS900 in a box
* Others may have one extra cop for special needs
* All cards have mounting holes, or use a rack or stand
* Offer RS232 and EIA-XE-488 expansion
* TS8972c adds RS232, A to D and parallel ports
* TSS73TA gives up to 6 K memory on 32 input/output
connect with quality

The Oryx name means a range of soldering tools and accessories designed to meet any modern requirement. Our comprehensive range includes lightweight, cordless soldering models, as well as practical packages for the famous "Super" and "Viking" standard designs and large, high temperature - controlled models. All with a wide selection of tip designs and sizes. The unique PortaSol butane gas soldering iron completes the range. Oryx also supply the largest range of SMT desoldering tools, including the new anti-static pump, power supply units, safety stands and solder pots.

www.americanradiohistory.com

68000 board 4

With the board now working and talking to the terminal Bob Coates turns to his Kaybug monitor software.

The monitor has been made as friendly as possible. It prompts the user for the next entry line where necessary and gives a 'help' listing which shows all the commands with a brief description of each. Even the occasional user should not need to refer to the full description having once studied it.

A total of 39 different commands is available, each one invoked by a simple two-letter code. Any further information required is prompted for. The commands allow listing of memory blocks, altering memory, loading code from host, setting breakpoints, altering register contents, running programs, single-step tracing through programs and so on.

The monitor accepts either upper or lower-case letters. Printing on the terminal screen is formatted to suit 80-column terminals but a command allows an alternative 40-column format.

There is a collection of system calls (sub-routines) which a user's program may call at any time. Most are invoked while reading the keyboard and writing to the terminal screen, but others include: b.c.d. to binary conversions and a 32-bit divide.

Unless otherwise stated, addresses and values entered are eight-digit hex numbers. The last eight are taken if more than eight are entered, and zeroes are inserted if there are fewer then eight. Addresses must not exceed word boundaries (even addresses).

The command set

An examination of this code reveals the simplicity of the tasks which are performed by this monitor. The simple code and its simplicity are the result of constant, careful refinement over a long period of time.

Each assembler source line should be terminated by a carriage return, e.g. movq $10,d3

By R. Coates

Kayspecifcation

Processor
Motorola MC68000 or MC68010

Data bus
16 bits

Clock speed
Up to 10MHz

Eprom
Up to 128K-bytes

RAM
Up to 128K-bytes

Serial i/o
Two Rs232 ports, 75 to 19200 bits/s

Parallel i/o
26 i/o; six input; six output

External bus
G64-bus (peripherals)

Dimensions
233 x 160mm (double Eurocard)

Power
+5V at 0.7A, +12V and -12V at 360mA

Firmware
Comprehensive monitor

Line-by-line assembler

Bare board: £18.90; with eproms and monitor, £34.40; with assembler, £48.40; from Magenta Electronics, 135 Hunter Street, Burton-on-Trent, Staffordshire DE14 2ST. All prices include v.a.t. Postage costs 60p extra.
address mode details

indexed

The size subscript for the indexing register is optional, "word" being the default. Absolute addressing
This may be entered either as an absolute address or an absolute displacement from the current address. It must be
fixed with either .w or .l to indicate absolute word or absolute
long mode. Size: 40400 cfr (40402.1) and 40400 cfr (200.1)
are equivalent instructions ("means current program
counter contents). P.c. relative, indexed
The format of these is similar to "register indirect with displacement" and "indexed", but with "p.c." replacing the
register. The interpretation of the displacement is differ-
ent though:

move r(p.c),r

means the displacement will be the relative offset be-

tween address 10 and the current address.

move p(p.c),r

means the displacement will be the relative offset be-

tween the current address + 10 and the current address

in other words, 10.

In the case of the "p.c. relative, indexed"

lea string, r

(which loads as with the relative address of label "string"

at assembled address of 40043ca, the line would be entered as

lea 40043ca, r)

Trapped instruction with vector
number 15 to 12 for B1 to B4 respectively.

When this instruction is ex-

cuted the processor jumps

to the address pointed to by

the current program counter.

If it is now the current

address of the processor then the

command will re-start the pro-

gram by re-entering the original in-

struction at the break-

point address and running that instruc-

tion. Thus the breakpoint is

automatically cancelled by this

command.

CV - convert between hex and
decimal: this useful programming

aid will convert numbers from hex
decimal to decimal and vice-versa.

To enter a number in hex-
decimal form, prefix it with the

letter X. The largest number

that may be converted is

99999999 or its hexadecimal
counterpart.

On - examine/alter data regis-
ters: this is exactly the same as
Av, but works on data regis-
ters only.

FI - fill block of memory with
word: the start and end address of

the memory block is re-

quested first, then the value of

the desired word (three bytes in

memory). The memory block is

then filled with this word.

It has been recommended to see whether the data has been stored correctly.

If a new data word is stored, a check is made to ensure that it is stored correctly (addressed to ram and not to eprom).

If it has not been stored, "NO BREAK" is displayed and the command exited.

MV - move memory block: allows a block of memory to be moved up or down in memory by as small or large a shift as required.

It asks for the start and end address of the memory block to be moved and then the new start address it is to take. All checks are performed to see whether the bytes moved are correctly stored.

PR - print memory block: prints on the screen the contents of the specified block of memory.

It asks for the start and end addresses of the data block (which need not be at word boundaries as the start address is rounded down to the start of a 16-byte block and the end address rounded up). In asking, it displays the start address, resizes it if you hit just <cr>.

The data is formatted into word-sized groups. Eight words are displayed on a line in the 8th column of the screen. The ASCII equivalent character of each byte in the line 6 dot if there is more.

Control-S and control-Q may be used to control the output, <del> to clear the screen.

RD - display target program's registers: this command is called automatically when a breakpoint is encountered. It shows the contents of all the 68000's registers. The values displayed are those which the registers will contain if a program is stopped using GO or re-started using CN.

With the exception of the status register, all data registers (16-32bit registers and are displayed as eight-digit hex numbers. The status register is therefore displayed as 16 digit hex numbers in dig.

The status register is labelled by a legend above.

The program counter (PC) is the address where the breakpoint trap instruction was encountered.

Correction: In the December artic,
the ninth line on page 38 should begin, "If power is not derived..."
RTTY Analyst

Using a computer to analyse radio teleprinter signals, automatically scanning, searching, detecting and translating messages

Idly twiddling the tuning dial of my teleprinter receiver readily demonstrates that the airwaves are full of the human speech and a great variety of coded signals.

Binary sequential codes

Apart from a single exception ("Piccolo") these signals can all be described as "binary serial codes" (b.s.c.) a pretentious phrase which is simply explained.

It means that the signals consist of two elements only which may be off (0) or on (1), high/low or short/long and that these two elements are strung together in a continuing sequence. The nature of the two elements, and the ways they are strung out are determined by coding rules: two typical examples of coding rules (for r.t.t.y and Morse) are illustrated in Figs. 1 and 2. In general, b.s.c. is such an effective means of communication that it is by no means limited to radio: telephone network messages are becoming increasingly binary, whether in the form of Prestel or many other systems.

Recent to radio, most b.s.c. encountered are some form of r.t.t.y, closely followed in popularity by high-speed Morse and the "TOR" family of codes. Indeed the prevalence of r.t.t.y has triggered a surge of amateur interest, the ready availability of r.t.t.y decoder units and computer software to translate the time-setting messages visually, but there is a snag! The very efficiency of b.s.c. has spawned, not only many types of code, but also a bewildering variety within each type - and this is especially true of r.t.t.y. Nor does the tale end there, for several r.t.t.y codes have been found even within a variety arising from the fact that transmission media and equipment, and even the strict rules of coding. Some system of classification is needed, and classifying human biological analogy can be of help.

The transmission system is the subject of the present article. Just as living creatures are classified by genus, species and varieties, so too can b.s.c.

The major groups of codes (r.t.t.y. Morse, AMTOR etc.) can be thought of as genera. Within each genus, many different species are to be found - Fig. 3 shows some of the species of r.t.t.y. Again, within each species, we can observe varieties - of which Fig 4 provides some examples.

At first hearing it can be very hard to distinguish one genus from another (let alone identify the species and variety) and, though long practice can help, there is no silver bullet.

Computer software designed to interpret r.t.t.y will often recast incoming messages, even when fed with another: messages which are, needless to say, completely spurious. It is as if one were to receive an unforeseeable telex message, and an easy way to test by resorting to the rules of Chinese grammar! The result is much time fruitlessly wasted trying to make sense of "foreign" genera, or in stepping through all possible permutations of species, until something of significance appears - which may never transpire if the message is encrypted! Not only is this a horrid waste of time, but it is a formidable obstacle to programmed search operations which the alliance between home computers and the amateur radio is making increasingly practical (see Practical Wireless, August/September, 1985).

What is clearly needed is a method of analysing any b.s.c., and supplying the user with precise information as to genus, species, variety and maybe type of message content. Though this may appear a tall order, something very close to this has been achieved by exploiting the techniques of spectral analysis. How this technique is to be applied is looked at in more detail in the next article...
Fig. 4 Variations withinspecies of r.t.t.y. mark/1, 1.5, 2.5 t.s.

Sequence-length spectra

Since a b.s.c. contains only two types of signal—strong and weak—we can plot signal-type against time as in Fig. 5(a). In practice, a demodulator or other hard-ware is interposed to differentiate between the two types of signal, and to transmit them in low or high voltage levels. The computer in turn "sees" these as 0 or 1 logic levels. Moreover, being a digital device, the computer is unable to sample signal levels continuously, but only at finite regular intervals. The result, as far as the computer is concerned, is shown in Fig. 5(b).

We define a sequence as a period of time over which the signal type is constant, and its length is simply that period. As seen by the computer, all sequence lengths are integers (related to time by the sampling rate), and there are two types of sequence co-

responding to the two types of signal.

Individual sequence lengths are determined by coding rules and the characteristic being transmitted. However, it is very interesting happens if we take a large sample, and plot frequencies of occurrences of sequences of a given length against that length. It turns out that the sequence spectrum is practically independent of the message being transmitted, but there can be bias distortion, the b.s.c. genre, species and varie-
ty. It is almost as if each b.s.c. had its uniquely identifi-
table fingerprint no matter what message was being carried (Figures 6(a) and 6(b)). It illus-

тратеs the characteristic spectra of the Morse code. The two types of sequence are distinguished by being plotted above and below the horizontal sequence-length axis respect-
vively. They were obtained by generating messages consisting of random sequences of characters, and then analyzing the resulting sequence lengths. But precisely what we are])-> (Fig. 6(a)) characterise it as an r.t.t.y. spectrum—and why?

To understand the answers, it is helpful first to define the idea of a b.s.c. type unit—t.s. for short. In the case of r.t.t.y., this is simply the length of time occupied by a single character (or mark—being of the same length). Of course, this varies according to the transmission speed. At the lowest speed of 5.5 t.s. per mark, a long sequence would be transmitted in the shortest 100 time space lengths. According to the r.t.t.y. coding rules, 1, 2, 3, 4, or 5 spaces can be strung together to create no other space lengths can legally occur. You can't have six space lengths since this would imply one start space followed by five data spaces—and five spaces is not a legal character in r.t.t.y. Thus the sequence length spectrum would only be 1.5, 4.5, 5.5, and 6.5 t.s. disappear, and those at 3.5 t.s. characteristically inverted in the mark and space frequencies.

To summarize, the sequence length spectrum provides evidence for genuine r.t.t.y. speed and polarity, whilst the heights of lines supply clues as to the nature of the message.

Real spectra

So far, we have considered only an ideal sequence length spectrum. The coding rules are strictly observ-

ед, and no transmission distortion mars the message. In the real world, alas, things are not so very far from true. What kind of distortion of the idealised spectrum (figure 6(a)) can we expect to observe in practice?

The commonest r.t.t.y. varia-
tions are due to the presence of noise in the transmission medium and to the r.t.t.y. characters and EoC (end-of-character) variation. Typical noise effects can be up to 20% longer than the space, and the EoC can vary between 1.5 and 2.5 characters. The effects of these are to shift spectral lines slightly in the frequency domain. Further, individual marks and spaces may vary slightly in length, and transmission speeds may "wax" or "wane.

This is the result in sharp spectral lines into a cluster of peaks and troughs.

The presence of noise will cause sequences up into smaller frequencies. Also, debris of pathologically short sequences will be deposited as "grass margins" on the extreme left of the spectrum. Finally, discrete sampling results in a sequence length measurement whose significance depends on the sampling rate. The ultimate is all of this is that instead of the clean lines of Fig. 6(a), we are more likely to encounter something like Fig. 7. The distortion is so severe as to produce ambiguity (e.g. inability to decide whether a received sequence is a mark or an EoC signal) then it will be difficult to interpret it correctly. However, short of this, and provided we take a sufficiently large sample, mathematical methods can usually detect underlying r.t.t.y. in even a shockingly dirty spectrum, identifying the species, and giving useful information about the variety. The latter is not without value, since r.t.t.y. ab-
nomaly is often characteristic of the type of transmitting equipment, and the care exercised in its adjustment. In some cases one can even identify stations by their tell-tale peculiarities—rather like the modus operandi of a criminal! In all his experience the author has only come across one station transmitting r.t.t.y. as perfect as his analysis could detect (from Warsaw at 13.793 MHz).

Programming methods

By exploiting the characteristics of r.t.t.y. described above, and in conjunction with computer-controlled receiver frequency tuning (see author's articles "Practical Wireless" August/September, 1985) we can set up a completely automatic system of scanning the frequency for the presence of r.t.t.y. and issuing reports on frequency, r.t.t.y. species, variation, time of day, sample rate, etc., etc.

At the end of a ses-

sion all the user need do is to glance at the printed reports, and single out interesting variations for further investigation.

Rather than listing and describing the author's program line-by-line, it may be more helpful to explain the mathematical and programm-
ing principles involved. Armed with these any reasonably com-
petent programer should have little difficulty (but much fun) in writing his own program. The computer should at least be capable of receiving the t.t.t. output signal levels from the r.t.t.y. decoder into a user

port: this will enable reports to be issued on the basis of manual tuning. In order to enable vary automatic tuning the computer should have an additional

analogue input port.

The overall flow diagram of the r.t.t.y. analyzer is shown in Fig. 8, and consists of Blocks 6

0-8, as explained in turn below.

Fig. 7 Sequence-length spectrum in practice, when signal distorted by transmission medium.

Flow diagram of r.t.t.y. analyser.
Block 0 (tuning). It is assumed that the A.I.T. terminal unit contains some sort of indication (meter or lamp) to indicate correct frequency, and that there are space-frequency, and a knob to adjust the frequency shift between the two methods. However, the method of dial tuning is to tune to the receiver which maximizes one of the two indicators, and then to tune the terminal unit to maximize the other. However, it is difficult to perform the same tuning under full computer control: fortunately in the case of most of the terminals there is no necessity. That is, good r.t.y. can be decoded by tuning the receiver only, and fine tuning for the space-frequency mark can be done by adjusting the computer's dial-choice mechanism. 

Block 1 (sounding). The terminal unit's output, low or high frequency, is stored in the computer's sound register, with the space mark being transmitted by means of a small speaker (or in some cases by means of a radio station). The signal is then transmitted to the computer, which then converts it to a digital signal and stores it in memory. The computer then performs a series of calculations on the signal, which are used to decode the signal and determine the characters being transmitted.

Block 2 (correlating). The computer then correlates the received signal with a set of known signals, which are stored in memory. The correlator compares the received signal with each of the known signals, and calculates the degree of similarity between the two. This similarity is then converted to a numerical value, which is used to determine the character that was transmitted.

Block 3 (decoding). The computer then decodes the signal, using the numerical values obtained in the previous step, to determine the characters that were transmitted. The decoding process is performed using a set of rules that are stored in memory. These rules are used to interpret the numerical values obtained in the previous step, and to determine the characters that were transmitted.

Block 4 (fit to ratios of integers). In good r.t.y., sequence lengths 1, 2, and 3 are generally used. The sequence lengths must be such that the product of the sequence lengths is not less than a certain value, which is determined by the error rate. For example, if the error rate is 0.01%, the sequence lengths must be such that the product of the sequence lengths is at least 1000. This is because the probability of a mistake in the received signal is proportional to the length of the sequence.

Block 5 (Calculate ip, 1, & 2). The computer then calculates the parameters needed for the encoder to perform the next step. These parameters are used to decode the signal and determine the characters that were transmitted.

Block 6 (translate sampled u, w, and e). Using the sequence lengths and marks stored in the memory, the program performs a more detailed analysis of the received signal to determine the characters that were transmitted. This is done by comparing the received signal with a set of known signals, and calculating the degree of similarity between the two. The similarity is then converted to a numerical value, which is used to determine the character that was transmitted.

The results of the two typical experiments are shown in Table 1. The (a) figures relate to an unusually good example of
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EWW 207

Disc-drive analyser
Combining the functions of a digital storage oscilloscope and a logic analyser, the Nicolet Disclocky is an instrument for testing disc drives. A number of built-in test routines may be run to give an accurate assessment of the head alignment, index pulse timing, and rotation speed. A typical inspection test takes about 30 seconds. For design and manufacturing engineers, the instrument offers the option of complete annotation of amplitudes, timing, lobe ratios, and read/write errors and can even offer a prediction as to the long-term reliability of the drive through a 'read window margin' test. A particular feature of the machine is that all the tests are carried out using a graphical display with present limits superimposed on the actual performance of the drive under test. The instrument automatically checks whether that performance is within the limits and gives a pass/fail verdict for each test. F19500 from Nicolet Instrument Ltd, Buttsbrooke Road, Warwick CV3 5XH.
EWW 214

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Zevac DR3-21 is a rework tool that is designed to desolder and rework surface-mounted devices on p.c.b. or ceramic substrates. It uses nitrogen gas for heat transfer to give maximum protection to the p.c.b. and components. The gas jets directly heated nitrogen through an interchangeable nozzle to the contact area of the selected s.m.d., positioned using a stereoscopic microscope. The station has a sliding xy table to position the component and controls for temperature, gas-flow and cycle time. Terry Chapman Electronics Ltd, Electronic House, Hamble Street, Epping, Essex CM16 4LS.
EWW 209

Automatic pattern maker
Template is a system from Digihurst which can automatically follow the outline of an object with a tv camera and display it on a screen. It is used in conjunction with AutoCad software on the IBM PC. The user "edits" the image and the software will provide a vectorized sequence so the pattern can be reproduced automatically by sewing, engraving or cutting machines. One application has been the preparation of plastic signs for hotels and the like where the artwork for the proposed sign is captured and fed into AutoCad. This can produce a cutting sequence in a very short time. Digihurst Ltd, Leadsen Hill, Yateley, Hampshire GU46 4GQ.
EWW 205

Efficient Transmitter
The latest near-letter-quality (n.l.q.) printer from Epon has a special interface cartridge which enables it to be used with Atari, Apple IIc, and IBM computers. Users of these computers have had a limited choice of compatible printers. The CX-980 is an alternative to the LX-96 n.l.q. printer. By providing the printer interface cartridge (p.c. for £50 extra), the printer may be used with a wide variety of computers with different interface standards. The printer comes with frisket, feed (like a typewriter) and can be fitted optionally with a tractor feed and a sheet fedder for multiple copies.
It is provided with a wide selection of print fonts and costs £246. Epon (UK) Ltd, Dockhead, Stone, High Road, Wemlock, Middlesex HA9 6UH.
EWW 212

Robotic controller
Up to eight stepper motors can be controlled simultaneously with the robotic controller from Sands Technology. Servo systems are being planned. The system controls speed and acceleration of multiple joints with selectable joint interpolation and full cartesian transformations. The program is contained within a 32K battery-backed ram and is based on the resident firmware of Robofirth II control language which provides named places and procedures, motion subroutines, searching, and many other routines. The language has over 200 commands but, if it is claimed, is easy to use and is being increasingly adopted by robot manufacturers. It is available separately or as a typical application would be £2,500. Sands Technology, 22 Chetters Lane, Cambridge CB5 8LD.
EWW 213

Tandara workstation
From the modeller-maker, Tandara emerges an executive workstation, to rival the much-publicized Merlin, Tonto and ICL One-Per-Desk. It is Britain-designed and built and it has some interesting technical features.
To spare the busy executive the tedium of formatting discs, loading them, interpreting the inevitable errors and putting them away again, the Tandara P.A. has no magnetic storage at all. Operating software is all in ROM — 138K expandable to 224K — and it passes effortlessly the acid test of non-friendliness by never driving you to look at the manual. Everything is menu-driven: a desk-dial, an address and telephone book, a calculator, a filling system, a text-procesor and two-way electronic mail system. Information can be switched instantly from one option into another — for example, a telephone number can be picked out of the address-book and dialled automatically by the built-in loudspeaker telephone.
For data storage, the standard model has 64K of battery-backed cmos ram, expandable to 768K. A compactness feature enables text to be compressed to half its original size. Coloured Prestel graphics pages shrink to about 60%.

Universal System
The main processor is a 16-bit 80C88, aided by a cross derivative of the 8-bit 6802 to handle the i/o. The operating system is hidden from the user, but has a multi-tasking Unix-like structure. The P.A. comes with a colour monitor suitable for 40 or 80-column use, but it also has an 16/c. screen which enables it to be operated away from the base for up to four hours on a built-in rechargeable battery. There is a full range of interfaces, including RS232, 10 expansion bus, printer, cassette, Sart and u.h.f. tv connectors. Price starts at £999. Tandara Marketing Ltd, Albert Road North, Malvern, Worcestershire WR14 2TL.
EWW 217

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**Real time graphs**

The Asyst software package enables the IBM PC XT/ AT to monitor, control and analyse data from experiments and production processes, and produce a fast graphical display as it happens. Using the full capabilities of the 8087PC/287 coprocessor, it is claimed to give the PC the speed and power of a scientific microcomputer, but at a fraction of the cost.

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From Keitley Instruments Ltd, 1 Hoosak Road, Reading, Berks RG2 0PU. EWW 224 on reply card.

**System tester for micros**

A trouble-shooting instrument for microprocessor-based systems is claimed to be easier to use than a logic analyser and, unlike microprocessors, can be used on a completely unobservable unit. Polar Electronics' B200A is connected to the unit under test in place of the processor and takes command of the address, data and control lines. It then generates the signals to test the circuit, and if a fault occurs, it can be used to trace a signal path. Tests are stored in non-volatile memory for later use.

B200A is connected to the system under test through a 'personality' pod which configures the instrument to the specific processor. Pods are available for the Z80, 80286, 68000, 68020, 68030 and one specifically for the BBC micro. It costs £950 and is available through Antes Electronics Ltd, 39 Kings Road, Haslemere. Surrey GU27 2XQ. EWW 221 on reply card.

**Microstepper motor**

A new family of two-phase stepper motors from Portescap is designed to give 800 steps per revolution. This is made possible by increasing the number of poles in the stator magnetised annular disc, and the P520 series offers 100 steps/rev. This is further increased by the phasing of the energising currents, dividing each step into eight stable microsteps each with an angular displacement of 0.45°.

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**Prototyping STE-bus**

A bus interface is already fitted to SPCI Eurocard from Dage but two-thirds of the board is left free for prototyping circuitry. The board is designed for slave I/O applications, and provides selectable address, delay and write timing. Eight chip-select lines and 16 addresses are available which can be used in various ways as required. The standard board has p.i.t which is prototyping area on a 0.3 in pitch Dage G5S Ltd, Europeo Division, Rahan Lane, Aylingbury, Bucks HP19 3RG. EWW 206

**High-voltage trimmer capacitor**

This trimmer can withstand voltages of 10kV and has a capacitance from 0.5pF with a swing of 3pF. It is manufactured from two-pole to give a diameter of 6mm and a maximum length, at lowest capacitance, of 25mm. Designed to withstand the high r.f. currents used in transceiver equipment, the trimmer is manufactured by Jackson Brothers (London) Ltd, Kingway, Waddon, Croydon CR9 4DG. EWW 220 on reply card.

**Driving circuit for laser leds**

An 8-pin integrated circuit may be used to control the output of laser diodes. It offers temperature compensation on/off control as well as light intensity, and protects the diode from poorly regulated power supplies. With a maximum output current of 170mA, the circuit is suitable for use with the Sharp range of semiconductor lasers. The diodes and the BCD01 driver circuit are available from Hero Electronics Ltd, Danestable Street, Amersham, Bucks MK45 2JS. EWW 205 on reply card.

**Circuit analysis by computer**

Jack 17 is software for use with an Apple computer that has the ability to write and solve the differential equations associated with linear circuits. It is possible to input most of the components directly from a circuit diagram. The program will give r.c.g. gain and phase response for a specified frequency in a few seconds. Typical applications include filters, amplifiers, matching circuits and attenuators.

SpaceCraft Ltd, 6 Prospect Place, Chicheley, Wymondham, Norfolk DT4 6YJ. EWW 211
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INDEX TO ADVERTISERS

Appointments Vacant Advertisements appear on pages 89-95

PAGE

ABE Electronics Ltd.
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Analog Devices, Inside Front Cover
Antron (Electronic) Ltd.
Arnos Products Ltd.
Aspen Electronics Ltd.
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Dataman Designs
Design Consultants
Dey Electronic Control
Digitronics Business Systems
Display Electronics

PAGE

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Electro Mech Industries
Electronic Brokers
Electronic & Wireless World
Electrovision
EMM Ltd.
Field Electric Ltd.
Flett Electronics Ltd.
Fulcrum (Europe) Ltd.
Greenwoods Electronics
Handy Memories
Hart Electronic Kits Ltd.
Harris Electronics
Harrisons Electronics
Hieron, R. Ltd.
Johns Radio
Langlands Supplies Ltd.
Lewis Electronics Ltd.
Map 40 Systems Ltd.
Mallory Radio
Micro Concepts
Monolith Electronics

PAGE

Number One Systems
Panasonic
Paxton Instruments
Pineapple Software
PM Components
Procom
Radioactive Clocks
RCS Microsystems
Research Communication
Richardson Electronics
Shacklock Instruments
Shield Data Systems
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