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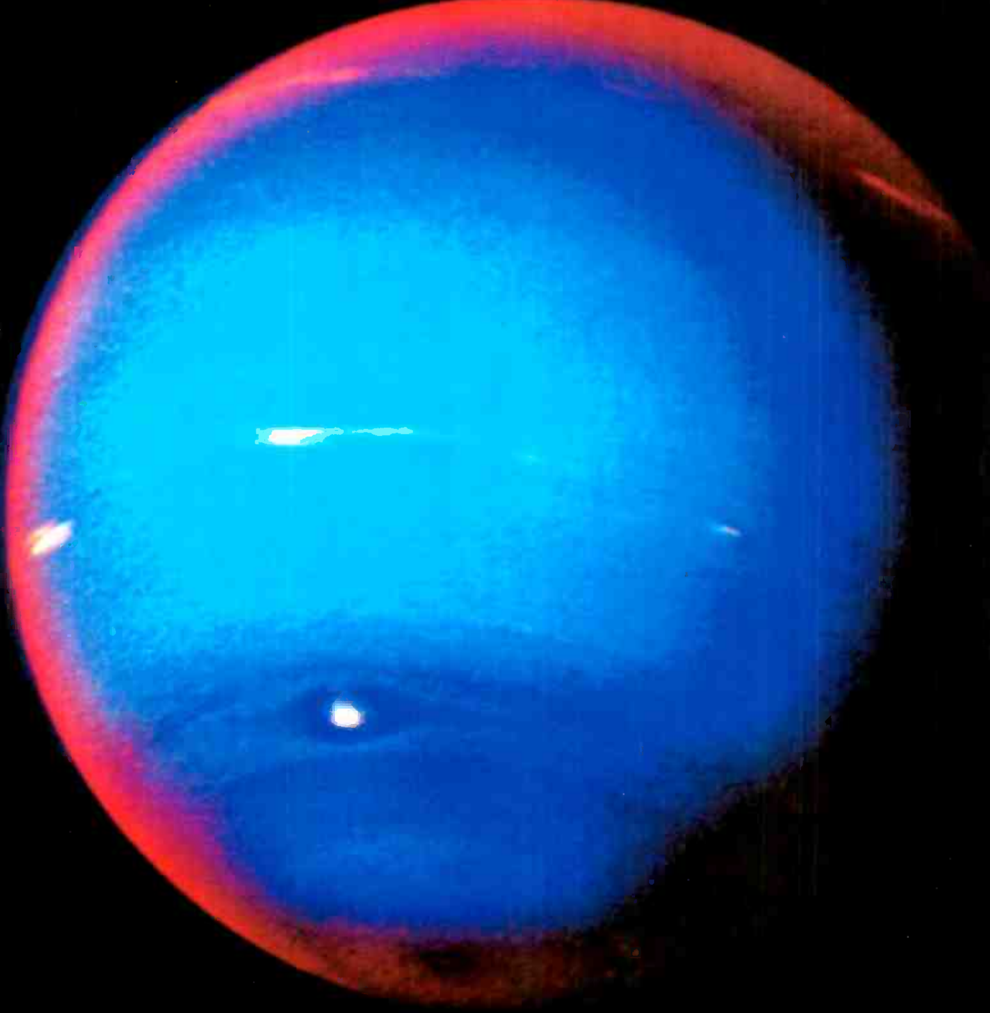

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Plus automotive electronics, consumer electronics in Japan, S-VHS vs Hi8 and the latest in Surround Sound.

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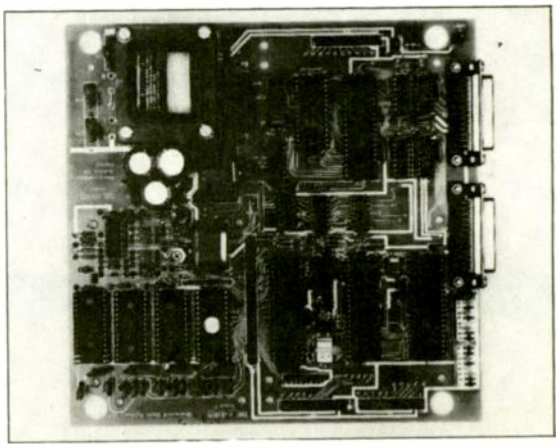

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Undervalued?

What price electronic engineers? The latest survey conducted by the Engineering council states that chartered engineers earn around £22 600 and incorporated engineers receive £17 000 on average. This puts both groups nearer the top of the earning league than colleagues working in other disciplines, but a long way below the levels enjoyed by other professions.

This survey doesn't tell the whole story. A further study conducted by our sister publication *Electronics Weekly* suggests that electronics engineers working in R&D receive a substantially inferior remuneration package to that of their managerial and marketing counterparts. Very few get company cars and not many more receive other fringe benefits such as health insurance or bonus payments. In short, the R&D function is undervalued.

Perhaps this reflects the disturbing contraction in primary electronics manufacturing, or it could be that UK industry doesn't see research as part of the product marketing process. Either way, it reduces the attraction of a career in electronics design for bright, ambitious people.

One suspects that the managerial classes who set salaries regard their R&D cousins as single minded, dull and driven by job satisfaction alone. Perhaps they would do well to remind themselves that Silicon Valley, Silicon Glen and the M4 corridor were created by ambitious, lateral-thinking engineers, not accountants.

Overvalued?

When will they learn? When will they understand the massive devaluation which has taken place in the public mind about all forms of consumer electronics?

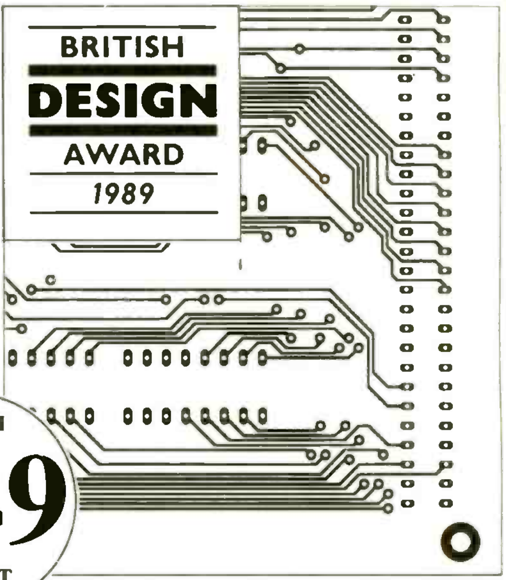
Reasonably powerful computers cost less than £500. You can buy a CD player for under £100. More significantly, air-time retailers will give you a full-feature mobile 'phone for nothing provided that you are willing to pay their outrageous installation, call and connection charges.

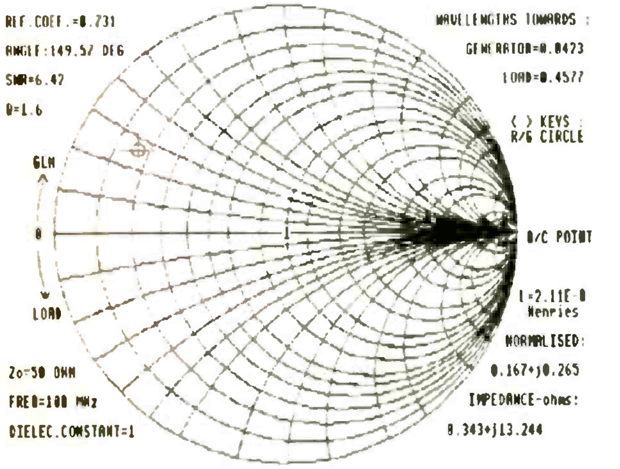
Telepoint provides a very cut down version of the cellular network for a user with a personal handset. For instance, you have to be within a few hundred metres of a base station; these connection points are unlikely to be widely available; they won't be available in country areas; the user can't roam between base station connection points. Worst of all, there is no facility to receive incoming calls.

Zonephone, sponsored by Ferranti, is a Telepoint system. Ferranti intends to charge £200 for each handset and its associated charger. Calls will be priced at normal call-box rates with an additional 5p flat rate charge for each call connection. The subscriber will also be expected to pay £25 per quarter on top of everything else. Although cheaper than the true cellular network, Telepoint looks expensive for what it offers.

We confidently predict that Zonephone won't be able to give their handsets away, this time next year.

Frank Ogden





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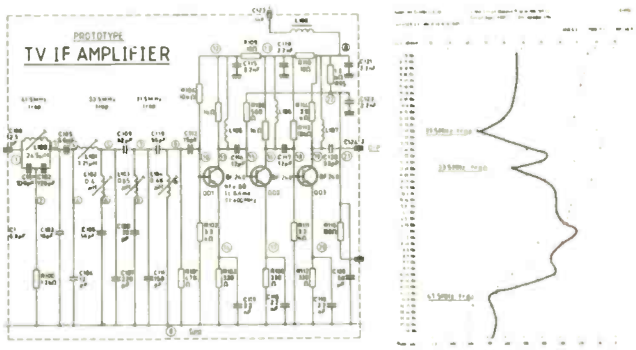

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INSIDE VOYAGER

John Wilson looks into the daunting business of running an old spacecraft five light hours away, boldly going where no robot has gone before

"A truly remarkable spacecraft" is the somewhat understated description by one scientist of the 825kg of hardware that has recently sent us some of the most dazzling pictures we're ever likely to see of our own solar system. It would be a fitting description of 1980s technology, let alone a machine designed in the early 1970s and which has wandered, unserviced, for 12 years through the inhospitable vacuum radiation and wildly fluctuating temperatures of space.

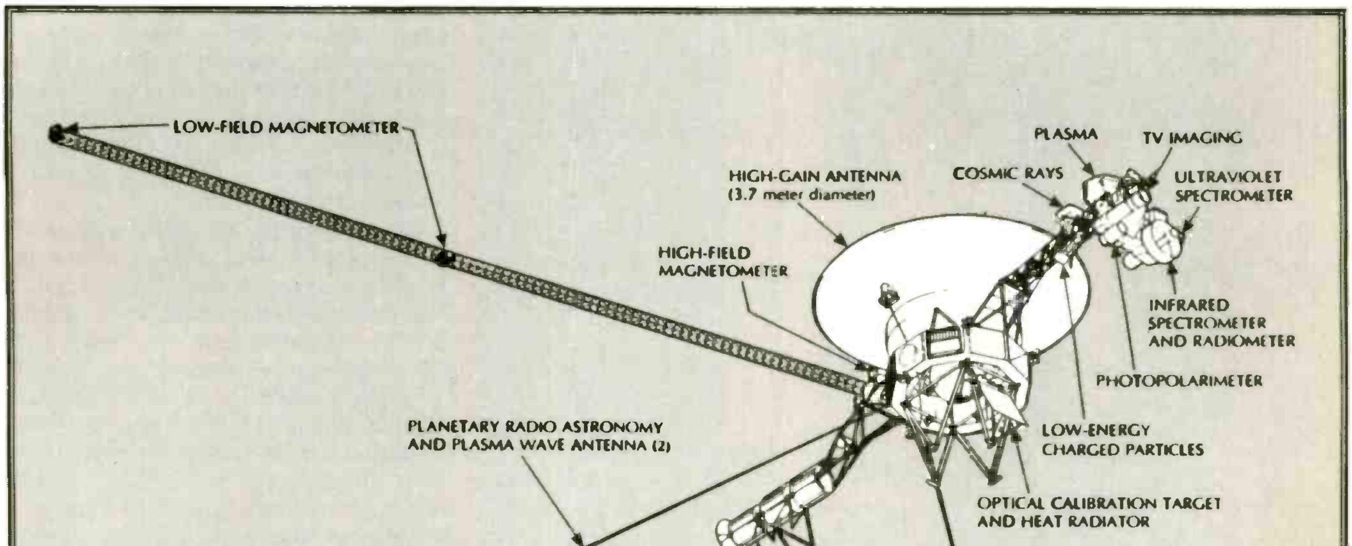
Although Voyager will mainly be remembered for its pictures, it's worth noting that it carries eleven different experiments, each of which undertook hundreds and sometimes thousands of observations each time the craft passed a planet or moon. Designing and positioning these instruments and their power supplies and housekeeping equipment to work without manual interference was therefore as much an achievement as any of the pictures or data that were transmitted the 4.4 billion kilometres back to Earth.

Structure and configuration

The basic structure of Voyager-2, shown in **Fig. 1**, (and its identical, equally successful sister craft Voyager-1 now also heading off into deep space) is a 29.5kg 10-sided aluminium framework with ten compartments to house electronics packages. These packages also form structural elements of the framework which, overall, measures 1.8m in diameter.

Occupying the centre of this decagon below the attached high-gain antenna are 16 small thruster rockets for delicate attitude control manoeuvres as well as for major corrections to the flight trajectory. Also mounted on this main frame are the Sun sensors (which poke through a hole in the dish antenna) and the Canopus star tracker units which together provide input data for the onboard navigational computer.

Fig. 1. Sketch of the Voyager spacecraft, showing its main experiments.



Power supply

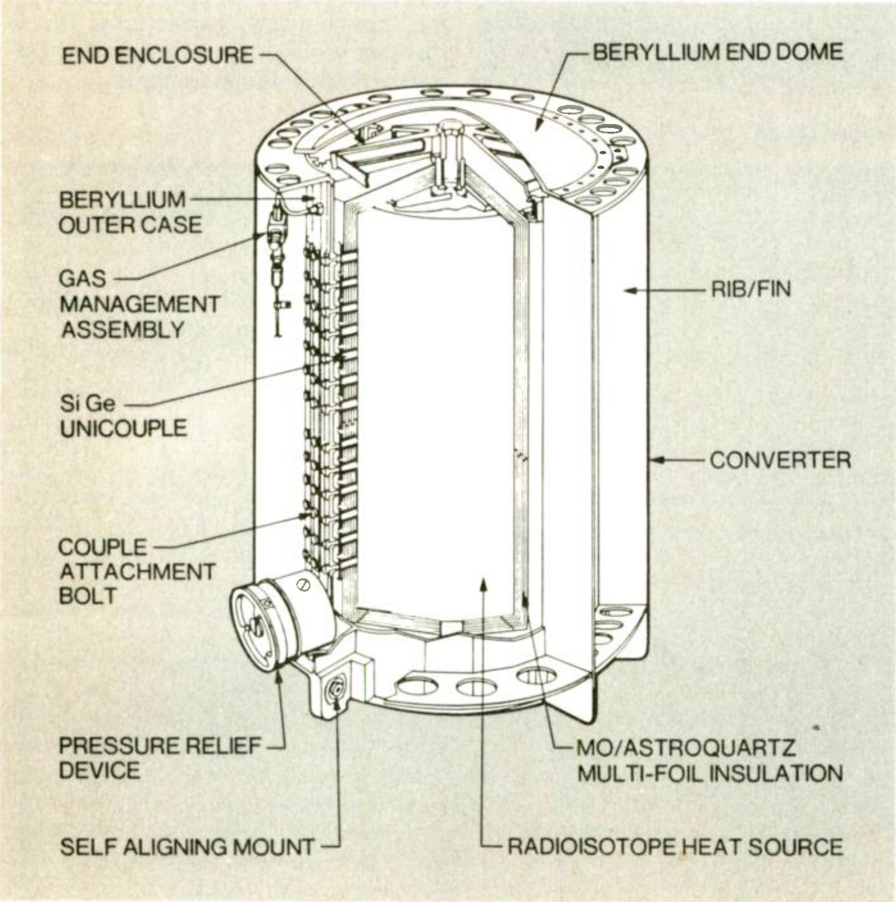
Yawning one's way through tedious descriptions of DIY AC mains PSUs makes one a little reluctant to describe this function ahead of other electronics systems. Voyager's power supply is somewhat different, however, and not just because of the absence of a plug! Operating in regions of space where the Sun's energy would scarcely melt solid nitrogen, every watt of electricity has to be generated by an entirely self-contained system. Three thermoelectric generators, each weighing 39kg and producing 160W, are assembled on a boom well away from the spacecraft proper, to ensure efficient cooling and avoid problems caused by spurious gamma radiation. Isotopic decay of plutonium 238 provides the heat energy which, when converted into electricity, is expected to provide usable power well into the next century!

Current from the thermoelectric generators is controlled to a constant 30V DC by a shunt regulator and fed directly to some of the spacecraft's subsystems. The reason for the shunt regulator is to provide a constant load on the generators which would overheat if operated open-circuit. A fat resistor dissipates the surplus energy into space. Among the users of the 30V rail are the radio subsystem, the gyros, the control valves, the temperature control system and the antenna deployment motors.

Most of the spacecraft's systems make use, however, of a 2.4kHz square-wave supply derived from the 30V by one of two inverters. A 4.8kHz timing signal derived from the flight data subsystem is used to synchronize this inverter and hence provide Voyager's master clock. Accuracy is ±0.002%.

Apart from these continuous sources of power, Voyager has some novel ways of coping with peaks of power demand. Because no batteries would work for 12 years at −200°C, the Voyager PSU incorporates oversized capacitor banks especially designed to avoid voltage dips during transient surges such as occur when a transmitter PA stage is turned on. Batteries were used during the injection phase of the mission, but jettisoned a few minutes after the craft had left Earth orbit on its trajectory towards Jupiter. Two batteries, each consisting of 22 silver oxide cells, were charged with electrolyte while in space and then used for only 12 minutes to control propellant valves before being junked!

Fig 2. Radioisotope thermoelectric generator, which provides 500W of power to the systems. Most of the power is used by the "housekeeping" operations, relatively little being taken by the experiments.



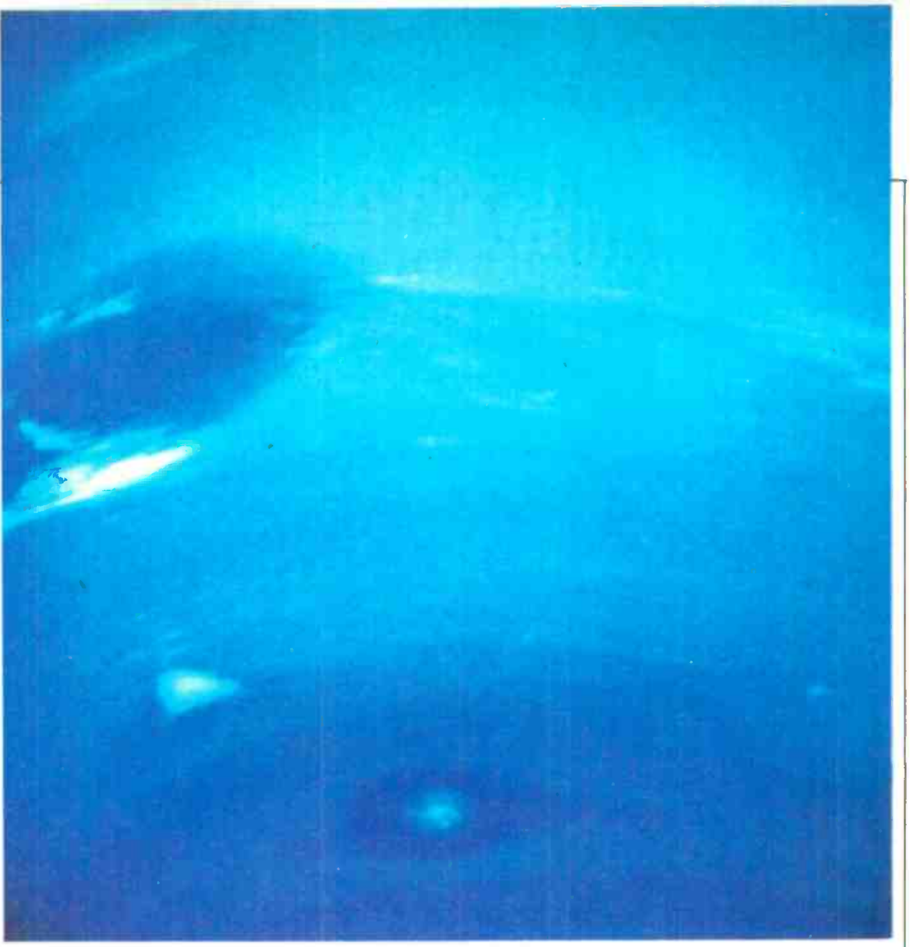
Computer control system

Apart from mid-course corrrections which require ground control to initiate, all Voyager's control systems are essentially automatic; so much so that a limited mission could have been undertaken if the uplink had failed completely. As it was, most uplink signals were used to trigger pre-programmed sequences of events emanating from the spacecraft's *computer command system* (CCS). The CCS has two independent plated-wire memories, each with a capacity of 4096 data words. Half of each memory stores re-usable fixed routines while the other halves are re-programmable by updates from the ground. These programmable sequences have proved a vital part of the mission, allowing trajectory changes in the light of new discoveries and also enabling minor technical defects to be circumvented successfully. Such updates have been transmitted from Earth at a data rate of 16bit/s.

Attitude and articulation control system (AACS)

Like the CCS, the AACS includes a re-programmable computer with two independent 4096-word memories. This is fed with data from two redundant Sun sensors, the two Canopus star trackers, three two-axis gyros and, if necessary, ground control. Outputs go to the various onboard rocket motors to maintain overall spacecraft orientation in three axes and to the actuators driving the science platforms, which carry two tv cameras, a UV spectrometer, a photopolarimeter, an infrared spectrometer and a radiometer.

Maintaining the spacecraft's orientation is vital for three reasons: to ensure it follows the proper trajectory, to maintain communications with Earth and to provide a stable base for visual and other planetary observations. With Voyager (unlike the ill-fated Russian Phobos missions) this works even when communications from Earth are garbled. The Sun sensors stabilize the craft in two dimensions while the Canopus trackers add the third dimension. Canopus is one of the brightest stars in the galaxy and brightness measurements are telemetered to the ground to verify that the trackers have locked on to the correct star! If not (or when Voyager is occulted or deliberately put out of celestial lock), stabilization on three axes can



Neptune seen from Voyager. The Great Dark Spot moves round the planet in 18.3 hours.

be achieved using just the three gyros. Each gyro has associated electronics to provide positional information about two orthogonal axes.

The science platform referred to above can be rotated about two axes independently of the spacecraft as a whole. This allows panning and precise pointing to within 2.5 milliradians as Voyager whizzes past its target objects at 60 000km/h or more. The platform actuators are fed from driver circuits within the AACS and can be slewed on one axis at a time in response to computer commands. Maximum slew rate is one degree per second.

In 1987 Voyager-2's science platform jammed in one axis just after the encounter with Saturn, though it freed itself after two days. Three years of subsequent analysis and testing showed that the problem was due to a loss of lubricant from over-use at the maximum slew rate. This resulted in damage to a bearing in a high-speed gear train. Fortunately the lubricant apparently migrated back into the gears after a period of rest, allowing the platform to operate successfully (albeit at lower speeds) during the Uranus and Neptune encounters.

Communications

The communications system consists essentially of a pair of S-band receivers operating at 2113MHz, a pair of S-band transmitters operating at 2295MHz and a pair of X-band transmitters on 8418MHz. In actual fact various combinations of exciters and TWT power amplifiers can be 'bolted together' as directed by the onboard logic within the CCS. In addition to these, the Voyager communications system carries a modulation/demodulation subystem (MDS), a data storage subsystem (DSS), the low and high-gain antennas and a programmable flight data subsystem (FDS) that controls the scientific instruments and formats all science and engineering data for transmission to Earth on a maximum of 28.3W!

The justification for the extensive redundancy built into Voyager's design was nowhere better demonstrated than in the events of April 5th, 1978. On that almost fateful day the spacecraft's CCS automatically switched to the back-up receiver. The back-up at that point had concealed a problem of its own – a faulty tracking loop capacitor – meaning that the receiver could not lock onto the perceived changes in uplink transmission frequency. This required the ground transmitter to be varied from its nominal 2113MHz to take into account several factors including receiver temperature fluctuations and the Doppler shift caused by the relative motion between the spacecraft and Earth. Voyager engineers have now developed techniques to predict the frequency they need to use, though in desperation they sometimes pepper the sky with commands on a rapid succession of different frequencies!

A full account of the whole communications exercise would be a subject on its own; suffice to say that numerous data rates for each type of telemetered information were required to cope with the changing path lengths, the type of data and various other factors. The flight data subsystem (FDS) handles imaging data from the two vidicon cameras at six different rates varying from 115.2 to 19.2 kbit/s, while the data storage subsystem on Voyager consists of a belt-driven, half-inch, eight-track magnetic tape recorder capable of recording at two speeds and playing back at four. Total recyclable storage capacity is about 536Mbit.

Science investigations

Imaging devices and infrared and UV spectroscopy have already been referred to. Also on board are non-steerable experiments that divide into two basic categories: magnetic and particle detectors and radio and plasma wave investigators.

The first of these senses fluxes and particle fields, not just from the planets but on Sun/planet and planet/satellite interactions. Also, as Voyager heads out of the solar system, these instruments will be taking on increasing interest in cosmic rays and the outer reaches of the solar plasma.

A second family of non-steerable experiments includes radio astronomy and plasma wave investigations. The planetary radio astronomy investigation consists of a stepped-frequency radio receiver that covers 20kHz to 40.5MHz and two 10m whip antennas to study a variety of signals emitted by the planets, notably Jupiter.

Other radio science investigations make use of Voyager's primary communications system to study the effects of the Earth's atmosphere and also of planetary and satellite atmospheres and ionosphere, especially the scattering due to Saturn's rings.

This look at Voyager's housekeeping, communications and experimental equipment has been necessarily brief and omits whole areas of interest such as thermal management, data processing and operating and experimental procedures. It is hoped, though, that this information – all culled from NASA sources – has given some insight into the complex problems of designing and managing a 12-year-old robot in a freezing alien world nearly five light hours from planet Earth.

Research Notes, July 1989, p.648 described the communications package of Voyager in greater detail.

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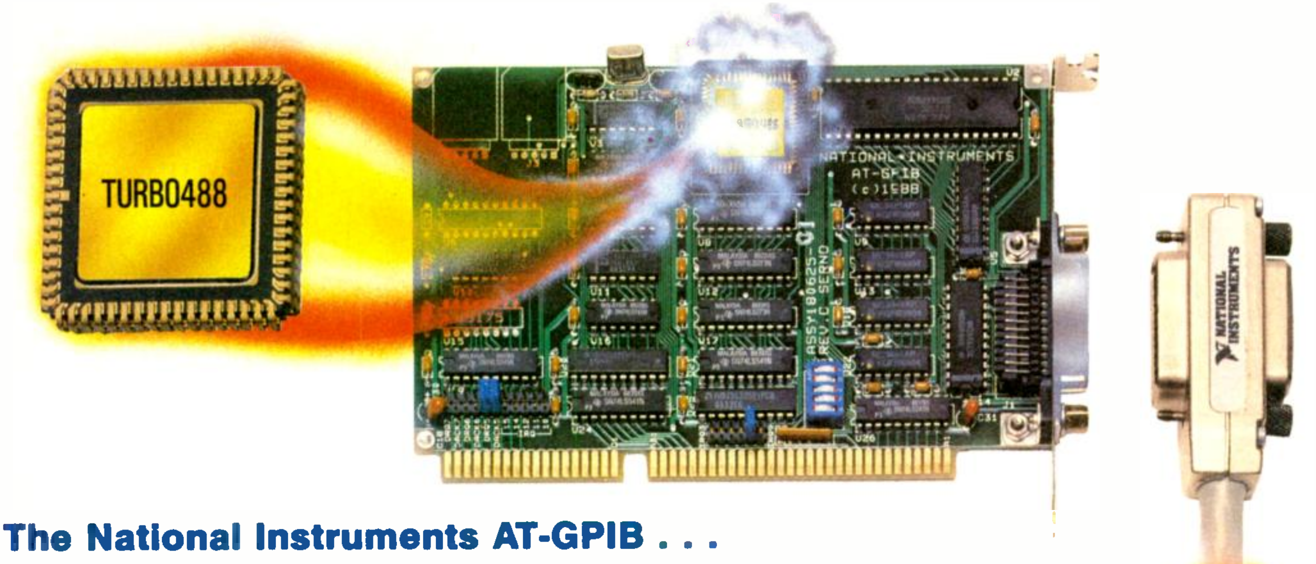

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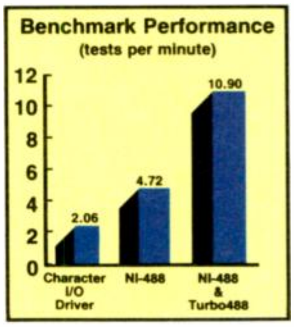

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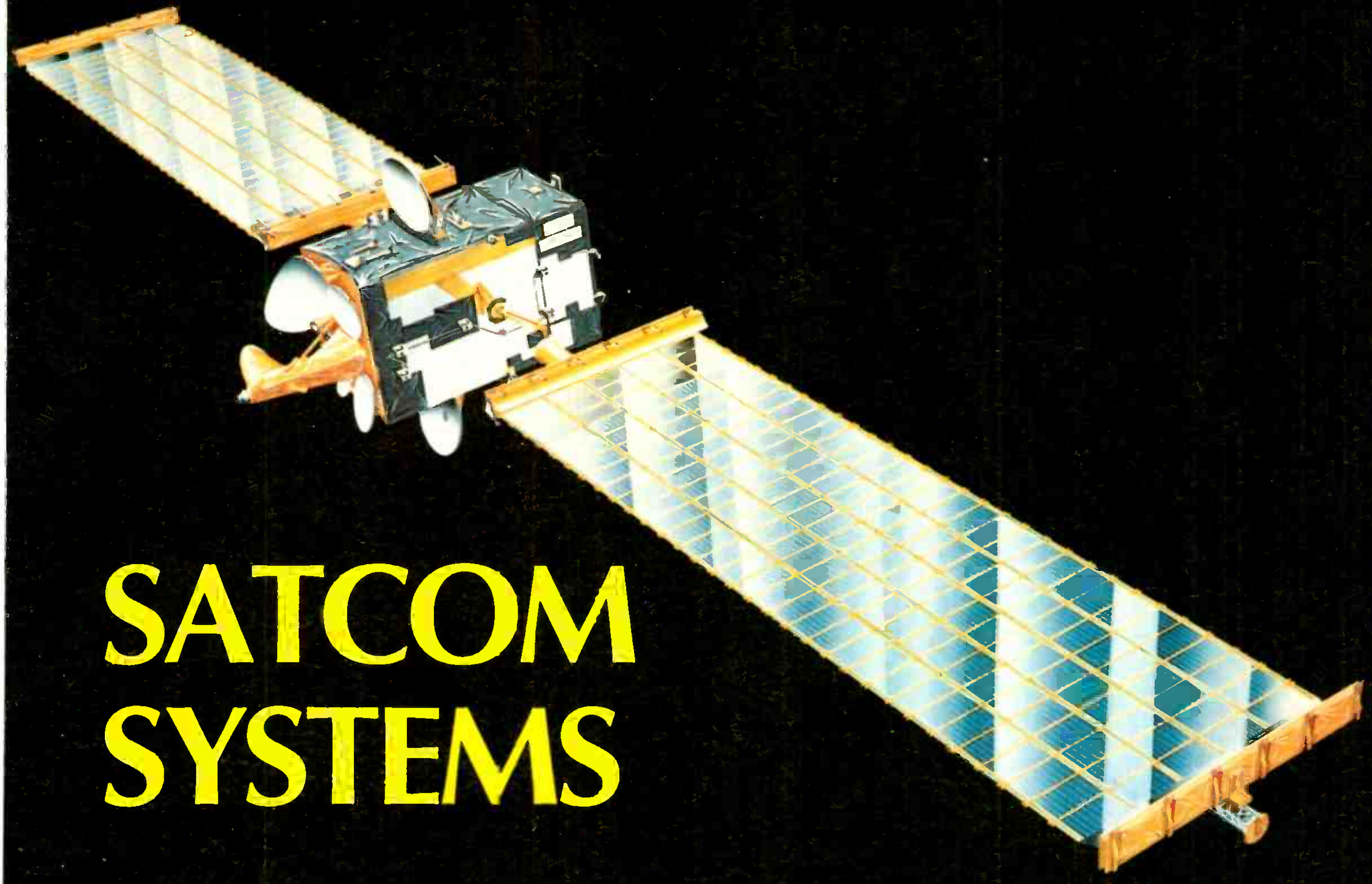


SATCOM SYSTEMS

Roger Dewell describes communications payloads of the type used in current-generation satellites.

Artist's impression of Olympus satellite in orbit. Picture ESA.

It has often been said that optical-fibre and other cable technologies will put an end to the need for satellite communications; however, recently published market surveys of fixed cable and satellite services[1] have shown that both have their advantages and disadvantages. These surveys indicate that, far from replacing satellites, terrestrial links will live side-by-side with communication satellites for many years to come.

Satellites provide enormous capacity. Business services are increasing the demand for satellite services dramatically, growing from some tens of channels at 64 Kbit/s in 1984 to many thousands of such channels in use today. With television broadcast by satellite, mobile communications to and from ships and aircraft, and other services such as position determination and data relay, the place of the satellite within the communications sphere seems assured.

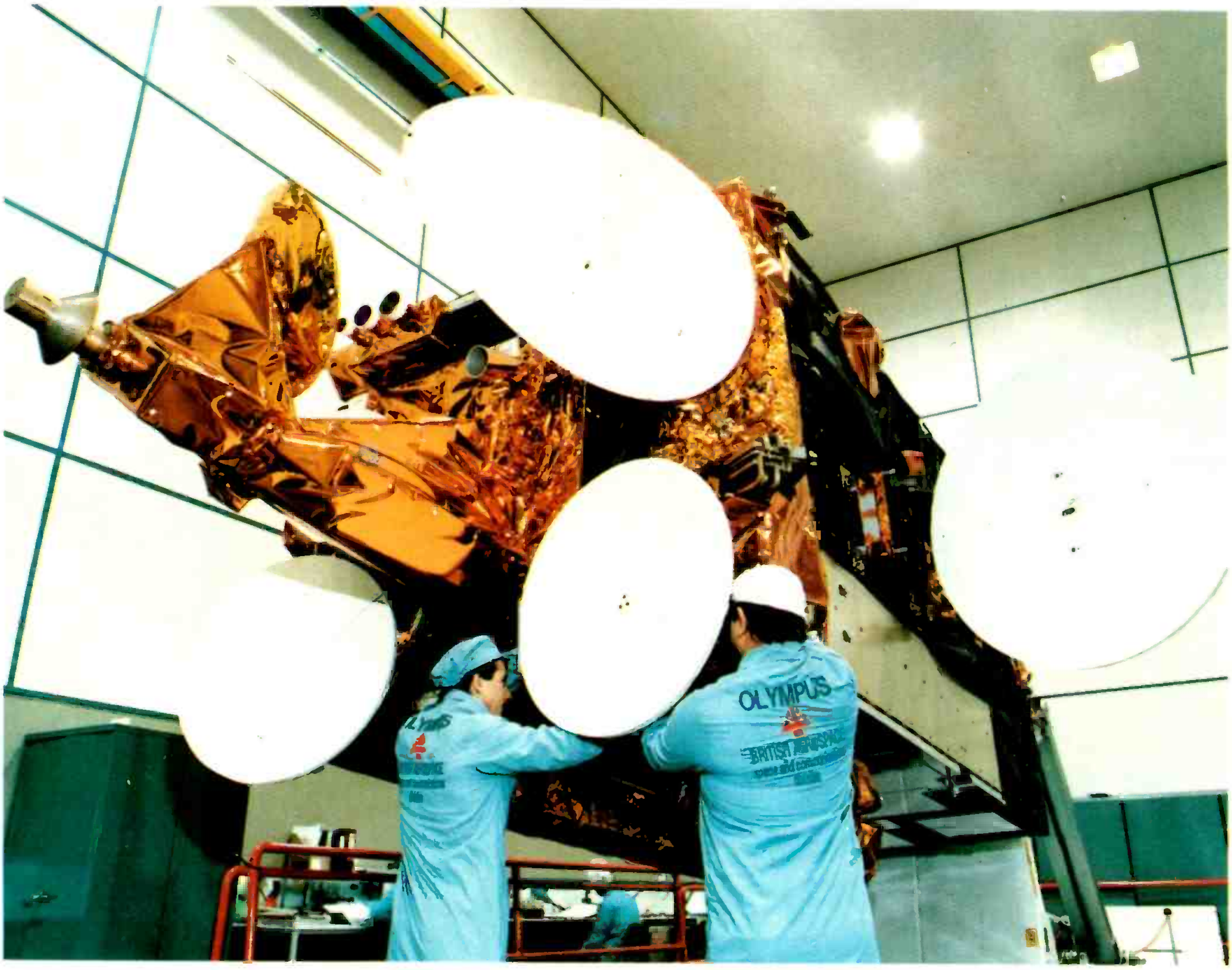
Hardware continues to expand in complexity: new techniques and technologies are being used within the communications payload; more on-board functions are now self-monitoring and correcting; precise methods of attitude control are being implemented to maintain satellite pointing accuracy; high-efficiency equipment is making even better use of the limited power available; and so on.

In developing these new equipment designs, critical performance and environmental parameters must be taken into account. Only a limited amount of power is available from batteries and solar arrays, for example. Heat needs to be removed from sensitive areas of the equipment, other areas being kept warm and the structure must withstand launch vibrations, mechanical shock and constant hot/cold cycling over many years.

Satellite configurations

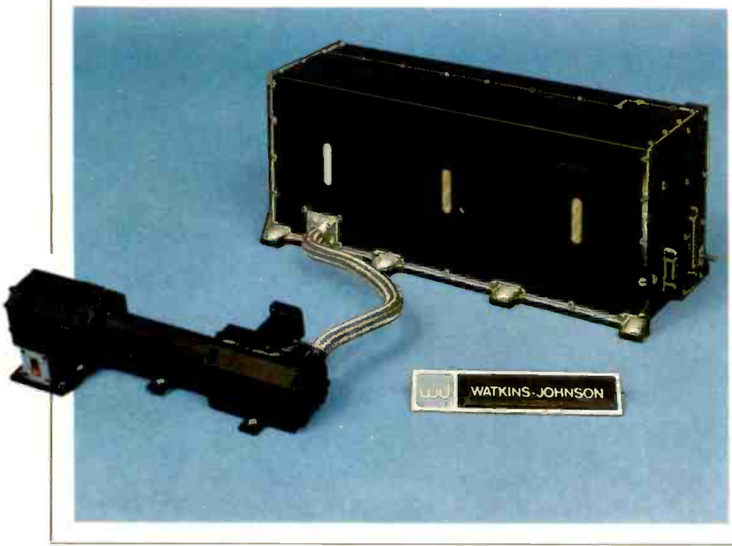
There are two types of communications satellite: the spin-stabilized type, or 'spinner', where attitude stability is achieved by the satellite spinning at around 60rev/min; and the three-axis

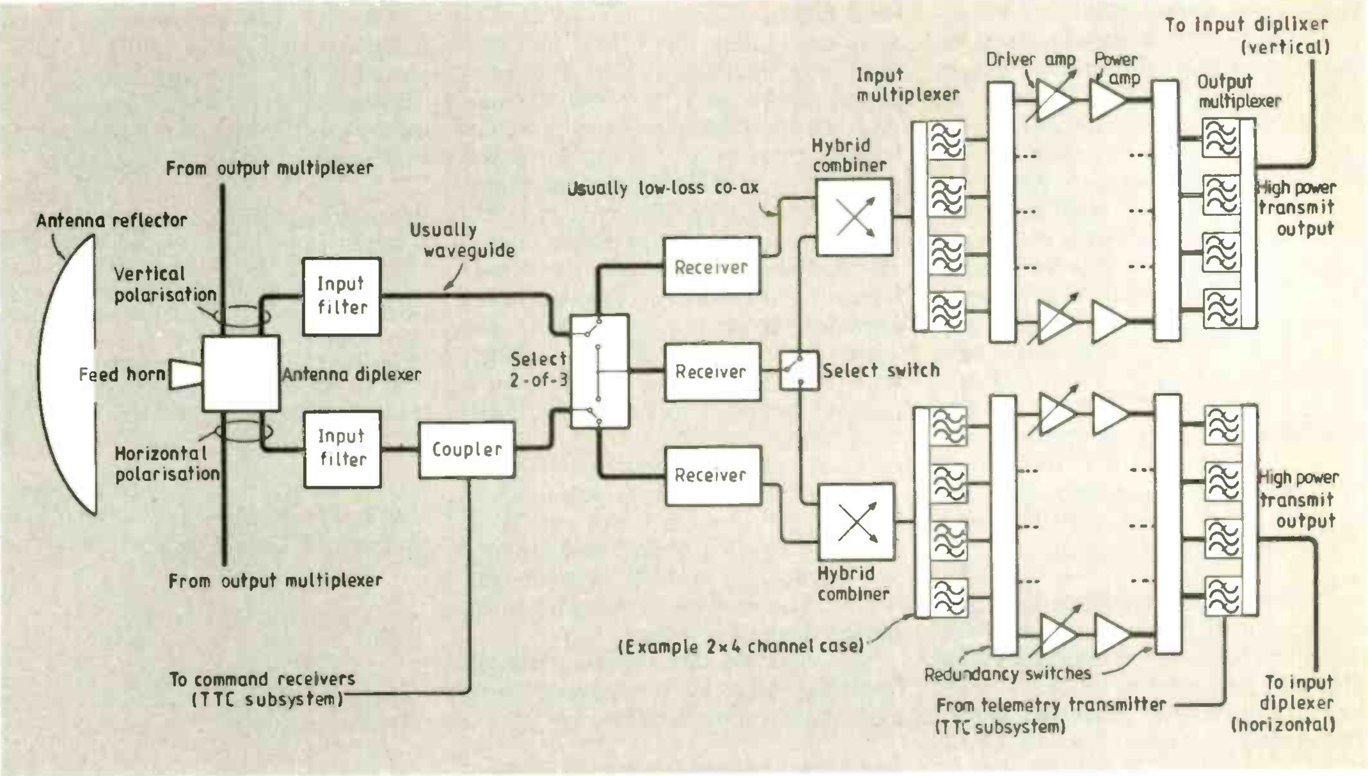
"A true broadcast service, giving constant field strength at all times over the whole globe would be invaluable, not to say indispensable, in a world society." –Arthur C. Clarke, Wireless World, October 1945.



Olympus is to be used mainly for television broadcasting. Weight at launch was 2617kg, the power available at the beginning of life 3600W, and the solar arrays 26m end-to-end. This satellite is claimed to be the largest civil communications satellite ever launched. Photo ESA.

Examples of space-qualified equipment. On the left, a 5W travelling-wave-tube amplifier working at 20GHz and a 100W 2.2GHz TWT amplifier previously flown in Shuttle Orbiter. Photos from Watkins-Johnson of California.





Functional block diagram of communications payload. Same antenna is used for reception and re-transmission.

stabilized' type, where the attitude is controlled by momentum wheels and magnetic torquers—coils which, by coupling with the earth's magnetic field, exert a turning moment on the satellite body. The first kind of configuration has solar arrays around the side of the cylindrical body, while the second has solar panels on each side of the box-shaped structure, which turn once a day to maintain the solar cells pointing towards the sun. Since we cannot cover both types in sufficient detail, we will concentrate here on the second, three-axis-stabilized type of configuration.

A typical three-axis satellite structure is composed of a box made up of separate panels built around a supporting cage, which is attached to a central cone that houses a (normally) solid-propellant motor, referred to as the apogee kick motor. The panels are extremely strong composite structures, made from a lightweight honeycomb material with two 'face sheets' of thin aluminium bonded to each side. The equipment, whether communications, telemetry, attitude control or other subsystem equipment, is bolted to each of the various panels.

Design Stage

Units are disposed on the panels to distribute the weight, to position the final centre of gravity of the satellite and to define other important mechanical characteristics. Other factors affecting the placement of equipment on the panels include the heating or cooling effect of any equipment on its neighbouring units, the electrical compatibility of any unit with surrounding equipment, the possibilities for heat removal to the external radiators on the satellite body or directly out into space, and so on. This is a very involved process with many parameters to consider, done these days at computer-aided design workstations. Such design facilities can show three-dimensional views of the completed spacecraft before any construction work has been started, and can allow equipment placement to be optimized at a very early stage.

Testing

A great deal of assembly work is done before the equipment panels are assembled to form the familiar box shape. Testing is also started at the panel level, building on the testing that has already been done on the individual units. In this way, potential and real problems can be identified before assembly has gone too far to be easily correctable. All performance testing, right up to the fully-assembled satellite level, refers to earlier test results in constantly checking that the latest performance data are consistent. This holds true for all tests on the spacecraft, whether for communications payload, attitude control, power subsystem, structure, or any other major subsystem.

Communications payload

The payload of a satellite consists of the communications antennas, both receive-from-the-ground and retransmit-to-the-ground, together with everything 'in between'. A transponder consists of equipment limited to *one* communication channel within the payload, as will be seen below. The equipment typically provides low-noise reception of the communications signal from the receive antenna; frequency conversion; demultiplexing of distinct communications bands— this is the dividing point into the various transponders; individual amplification to transmit levels; and multiplexing and feed to the transmit antenna.

Antennas. Modern satellites often carry more than one transmit antenna, or a single antenna reflector with multiple feeds; in this way, several service coverage areas can be provided at the same time. By using larger antenna reflectors, higher gain can be achieved by the antenna over the coverage area (most important if one can trade this off against larger, more expensive receiving ground stations). Most satellite antennas work simultaneously in two polarization directions, so that the same frequencies can be used twice within the same area, without producing interference. Intelsat VII, for example, is expected to carry six communications antennas, two of which may well have 150 feed elements each! A more usual number would be two to four antennas.

Low-noise receivers. The received signals (after having been wide-band filtered to exclude out-of-band signals that might overload or damage the receiver) are amplified in a low-noise receiver. This raises the power level of the signal from, typically, −90dBm (or one picowatt!) to some 50dB above this level, still much less that a microwatt. This can be done these days with a noise figure of around 2dB at 14GHz, some receivers employing electric cooling of their active devices to improve their low-noise performance. Frequency conversion is generally, but not always, accomplished within the receiver using a local oscillator in a one-step conversion between uplink and downlink frequencies. More complex payloads now employ signal processing at IF.

Input demultiplexing. Once the communication signal levels have been raised to a suitable level, the individual channels, perhaps 24, 36 or 72 MHz wide, are separated from each other. This means that unassociated signals do not have to go through the same amplifier, since this can cause cross-coupling between them.

Amplification. This leaves the way open for amplification of the communication signals. Driver amplifiers, sometimes employing automatic gain control automatically to adjust their output power level despite uplink fading conditions, and usually having a ground-commandable fixed-step gain-change facility, amplify the signals to a level suitable for the high-power amplifier that follows. This high-power amplifier is generally a solid-state power amplifier (SSPA), or travelling-wave tube amplifier. The SSPA is a more recent inovation, and is inherently more linear in operation, although the recent introduction of predistortion linearizers is redressing the balance.

Multiplexing/retransmission. The individual high-power signals are then re-multiplexed before being taken to the same, or another, antenna for retransmission. At higher power levels, particular design attention has to be paid to potential failures through arcing, due to the high field levels involved, or to other high field-intensity problems.

Typical operating values

Size, weight and power requirements of spacecraft vary, from the small, limited-capacity spacecraft at 40 to 50kg and the larger, domestic communications satellites at 1200 to 1800kg, to the very large, multi-payload satellites which can exceed 2600kg. The satellite body dimensions can exceed 2 by 2.5 by 4m (with antennas included). The deployed arrays can be more than 25m, end-to-end. Power consumption also varies widely, from tens of watts for small satellites up to 4kW for the same range of satellite configurations. Very small communication satellites may not carry any fuel at all for attitude correction. Larger, geostationary communication satellites, however, are normally designed for a ten-year-plus service lifetime, carrying perhaps 200kg of liquid fuel for periodic orbital and attitude corrections.

When one remembers that the first communication satellites, such as Sputnik I in 1957, had a launch weight of 85kg and the first United States satellite, Explorer I in 1958 weighed just 8.3kg, the modern communications satellite is a veritable giant.

The following table shows principal operating values for some examples of current generation satellites:

Satellite	Application	Launch weight (kg)	Power (W)	Life (yrs)
TV-SAT 2	Tv direct broadcast	2145	3200	9
DFS KOPERNIKUS	telecomms, tv distribution to cable networks (within Germany)	1400	1500	10
TELECOM 2	internat. telecomms, business comms or tv, and military	2180	3500	10.25
TELE-X	tv direct broadcast, business comms. (within Scandinavia)	2130	3200	5-7

Olympus

Olympus was constructed for the European Space Agency in the Netherlands by British Aerospace, and recently launched from the Arianespace launch facility in Kourou, French Guiana. The satellite will provide advanced communications services, direct broadcast television and high-frequency payloads for propagation and communications experiments. This is a particularly good example, since it not only carries advanced communications hardware, but also indicates the direction of future space communications and broadcasting systems by operating two of the four payloads in the 20/30GHz frequency bands – not yet widely used.

One aspect of particular interest in the business or 'specialized services' communications payload is the use of an advanced time-division technique called satellite switched TDMA – a technique for automatically routeing TDMA bursts received by the satellite to different downlink coverage areas. These coverage areas (of which there are five for this payload) can be steered over the whole visible earth by telecommand.

References

A comparison of Transatlantic Digital Services Via IBS, TAT-8, PAS-1 and PTAT-1: How users Select Wideband Transmission Services Dr K.J. Hansell, ISCSD Conference Proceedings, April 1989, pp 439-443.

Comparative Economics of Advanced Satellites And Cables: B.L. Crockett, S.S. Skjei, ISCSD Conference Proceedings, April 1989, pp 435-438. ■

Roger Dewell is director of Communications and Technology Consultants Ltd of Shillingford, Oxfordshire.

Correction note

In Adrian Espin's article "Who needs electronic circuit analysis?" in the September issue, a couple of errors appeared, which might have caused a little head scratching.

On p.852, first column, 12 lines down, the expression read $2k\Omega/1k\Omega=2$.

21 lines from the bottom of the same column, the expression should be $(R_L/R_E+r_e))$.

At the bottom of the middle column, the penultimate sentence should read "In the circuit shown, at low frequencies, the input resistance of the transistor is approximately $r_3\times H_{fe}$. which appears in parallel with the combined resistance of the base bias chain.

We apologize for these errors.

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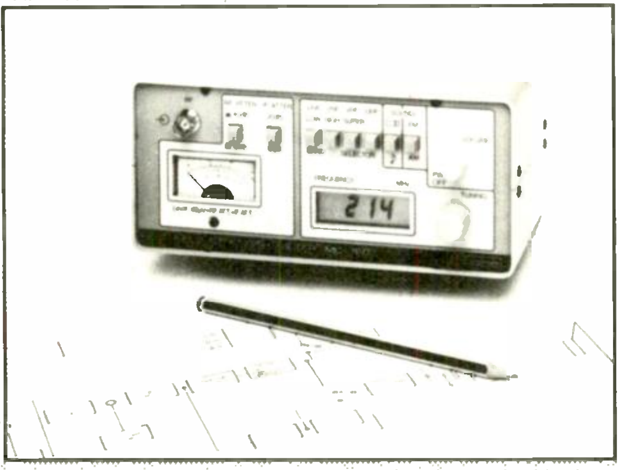

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Power stations in space

As I've frequently observed in these pages, Soviet scientists and engineers are an imaginative lot, unfettered it seems by the pressures that keep much of Western research within conservative bounds. Physicists in search of element 110, officially approved ufologists and armies of Yeti hunters . . . none of them seem to raise a glimmer of a smile. Yet even if some ideas (including perhaps the laser tv tube) are a little ahead of practical reality, you still have to hand it to the Russians for their originality.

According to a paper by physicist and mathematician Leonid Leskov (APN) it was a Russian, Valentin Glushko, who first proposed the idea of solar power stations in space to beam microwave energy down to Earth for conversion into electricity. The date of this proposal, 1929, seems extraordinary in view of the fact that magnetrons were a decade away and the first Sputnik nearly 30 years off.

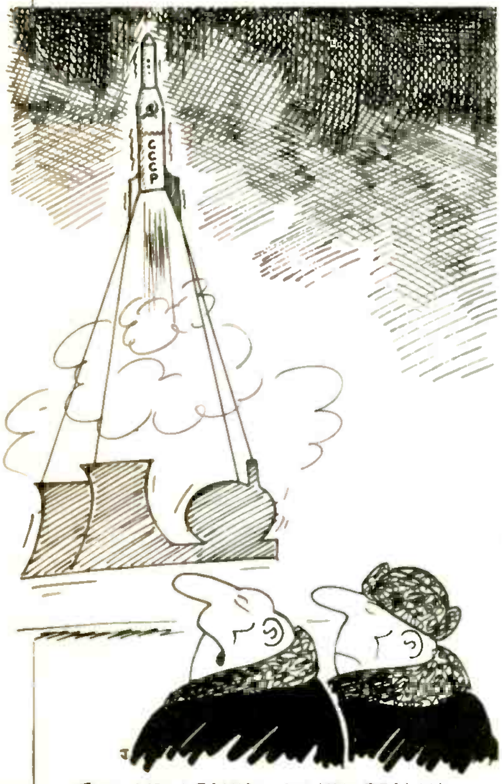
Today, now that an extraterrestrial power station could in theory be built, many researchers have re-examined the economics, especially in the light of dwindling fossil fuel reserves, 'green' influences and nuclear safety. Optimists like Professor J. O'Neill of Princeton University (USA) believe that it would be possible to put into orbit a pilot solar station by 1990, based on existing technology. Others, like Leskov, think the cost in environmental terms would be much too great.

Leskov calculates that if space-borne solar power were to meet even 20 per cent of global energy demand by the year 2020, then the amount of hardware needed would imply launching a big rocket every 20 minutes over a period of 20 years. The resulting pollution from spent rocket fuel would, on this basis, exceed the total airborne pollution from all other sources. Leskov doesn't believe, though, that the prospect of orbiting solar power stations is a non-starter; in fact quite the reverse. Each day, with the arrival of new environmental issues to blight conventional power generation and with the steady progress of space technology, the balance is tipping in favour of solar microwave generators.

Leskov argues that the real breakthrough will come with the development of a new generation of ion motors – electric rockets – powered by integral solar collectors. These would allow a solar power station to be assembled in near-Earth orbit and then self-propelled to geostationary orbit. As for getting the components into orbit in the first place, Leskov believes that it may eventually be possible to use laser heat-exchange engines instead of today's polluting rockets.

What then of the power station, once completed? Leonid Leskov points out that considerable progress has already been made, both in the efficiency of solar cells and in devices to convert the resulting electrical power into a microwave beam. Efficiencies of up to 90 per cent and power ratings of 1kW/kg are not beyond the bounds of possibility. Leskov's dream station would be a massive construction, generating 5GW from 50km^2 of solar panels. The resulting downward-pointing microwave beam, at a frequency of 10-12cm, would then be collected by a receiving antenna some 10km in diameter. Leskov claims this would create no hazard outside the protected zone of the antenna itself.

Reading this futuristic paper may, as I hinted earlier, lead one to dismiss this as yet another fanciful Soviet dream. Yet, as Leskov himself points out, large amounts of money are already being poured into equally unproven technologies such as thermonuclear fusion . . . and, we might add, cold fusion . . .



TELL ME LEONID – DO YOU REALLY THINK THIS IS GOING TO WORK?

Secretive algebra

As someone who struggled with mathematics at university, I've always taken for granted the assumption that algebra is something of a black art, the symbolic equivalent of officialese. Endless test questions beginning: 'Simplify . . .' served only to emphasize my sneaking suspicion that someone was making a deliberate attempt to upstage the Official Secrets Act. After all, why should anyone in real life ever need to simplify an expression like:

$$\sqrt[3]{\sqrt[3]{\sqrt{5}+2} - \sqrt[3]{\sqrt{5}-2}} \quad *$$

Well, according to research at a variety of U.S. universities (*Science* vol. 245:1190), it's not just luckless students who have to try and discover the simple quantities lurking deep within grotesquely nested expressions like the above. Mathematical gobbledygook, it seems, often arises accidentally from the routine application of general-purpose formulae for finding the roots of polynomials. The results – a whole collection of nested radicals – may, like

*equals 1

Stars in a spin

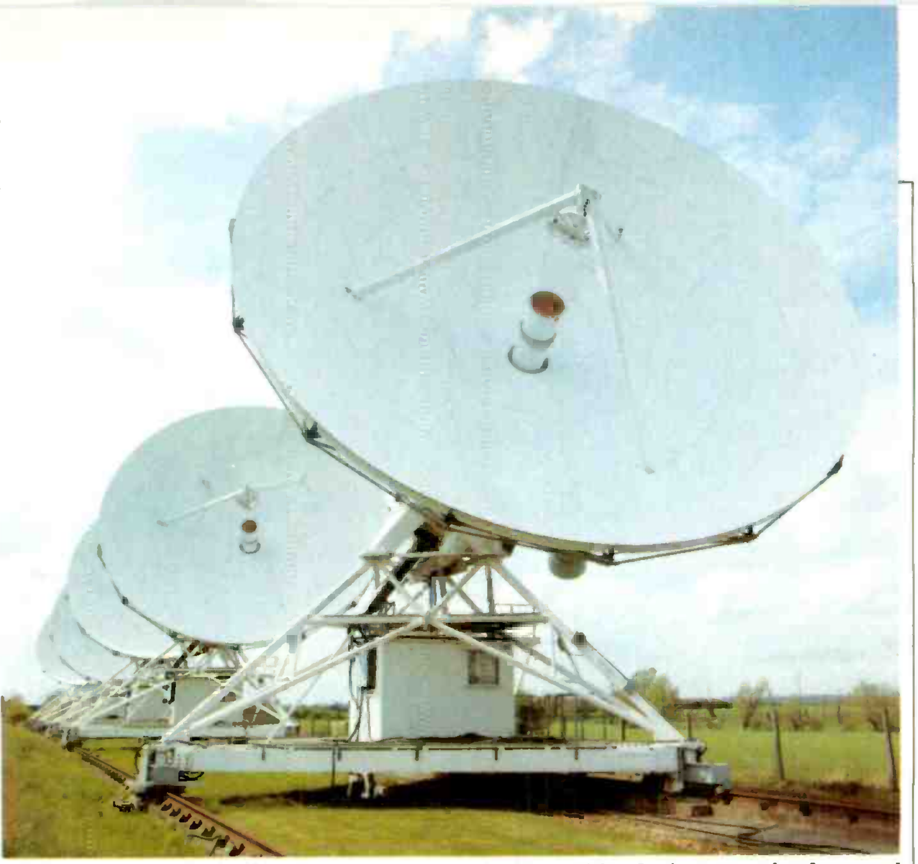
Pulsars must rank among the most intriguing of all astronomical bodies. When they were first discovered at Cambridge, their regular bursts of radio emission led many serious researchers to speculate about the possibility of extra-terrestrial intelligence. The absolute precision of pulsar bursts is comparable with that of any atomic clock and quite unlike the randomly irregular emission of most radio stars.

Eventually, of course, these 'ticking stars' were seen to have a perfectly rational physical explanation, though nonetheless bizarre. Pulsars are formed when unstable stars explode as supernovae. After large amounts of matter have been flung out into space, what's left contracts under the force of gravity to form a so-called neutron star. So powerful is the inward force that the electrons and protons of normal matter are squeezed together to form a soup of neutrons so dense that, on Earth, a teaspoonful of it would weigh a thousand million tons.

The effect of all this compression is that a star, once bigger than our Sun, is now only a few kilometres in diameter. And just as a ballerina spins faster as she draws her arms to her body, so a the above, be relatively easy to unscramble, or they may prove hideously impenetrable.

Surprisingly, the de-nesting of complex expressions is no easier for computers than it is for most ordinary mortals. It appears that until recently no algorithms have existed to do other than unravel simple expressions involving a few square roots. Among those who have now advanced the art of simplifying algegraic gobbledygook, perhaps the most successful is Susan Landau, a computer scientist formerly at the University of Massachusetts at Amherst. Landau has come up with a theorem which in turn has led to a general-purpose algorithm capable of de-nesting most highly nested radicals. It guarantees the simplest version in the end but still has one minor disadvantage: it requires huge amounts of computing power if the initial expression is at all complex. But again, how much grey matter does it need to convert the Official Secrets Act into plain English? Perhaps algebra wasn't such a bad invention after all.

Research Notes are by John Wilson of the BBC World Service science unit.



Major upgrades to the Ryle telescope now make it capable of microwave background astronomy. The telescope – an interferometer consisting of eight antennae over a 5km base line – will be used to plot the temperature of space so that astronomers can study the early universe and the origin of structure itself. As researcher Stafford Withington puts it, it will allow us to "look at where space itself came from".

The important difference between this and other telescopes is that it can detect minute fluctuations in the microwave background of 20μK. Each of the eight telescopes now uses cryogenically cooled fets. It works with a new correlator consisting of 1000 custom c-mos chips and ECL devices.

neutron star spins faster than its larger progenitor. As it spins, it emits two beams of radiation that sweep around it, rather as if a torch were being whirled round on a piece of string. Each time one of these radio beams intercepts the Earth, we perceive it as a pulse, hence the regularity of what we now call pulsars.

As with many other supernovae, the famous SN1987A that blew up two years ago in the skies above the southern hemisphere left behind a pulsar. But sadly for radio astronomers, the pulsar was only briefly observable early this year because of obscuring dust clouds. This was particularly unfortunate because SN1987A appeared, from the frequency of its pulses, to be spinning at an amazing 33 revolutions per second!

Try, when you've a moment, to work out the forces operating on a body, say 10km diameter, and rotating at 2000 RPM and you'll become instantly aware of why this observation was queried, even though it came from a highly reputable source. Other astronomers suggested that instead of rotating, SN1987A might be shaking with some sort of radial vibration.

From then on the arguments became complex, though the latest contribution from Shapiro, Teukolsky and Wasserman of the Center for Radiophysics at Cornell University [*Nature* vol. 340 No 6233] argues that the pulsar really is rotating. But to spin at 2000 RPM, they say that SN1987A must be made from a special state of matter that is soft as well as dense. A sort of quark soup is one thought . . .

Unfortunately until the mists of space clear and we get another glimpse of this amazing pulsar, there's little more that astronomers can do but carry on with their sums and of course wonder at some of the incredible phenomena out there in space.

The first pulsar ever found was detected on this crop of antennae at Lords Bridge, near Cambridge. Cavendish Laboratory now uses the arrays for solar weather forecasting – plotting the movement of solar-wind clouds. More about solar effects on page 1200.

(Courtesy Withington, Cavendish Laboratory)

TI technology projection:

100Mbyte drams, 2000 mips processors

Chips sporting more than a hundred million transistors will be in mass production by the turn of the century. Memory chip capacity will exceed 100Mbit and processors will be capable of delivering a staggering 2000 million instructions per second, says TI process chief Pallab Chatterjee.

Furthermore, hundred-million-transistor monsters will be able to encapsulate entire systems on single pieces of silicon. Massive processing power will be distributed among multiple execution units and special purpose processors. These processors will be able to assess fast on-chip memory and talk to other chips using built-in communications links.

Dr Chatterjee expects the scaling down of features to continue for at least the next decade. "We believe that the transistor structures we are making now at one-micron and 0.8-micron will continue to be scalable," he said.

Dr Gordon Moore, chairman and co-founder of Intel, thinks that silicon is here to stay. "Gallium arsenide and all those other things are for special purposes.

"Silicon c-mos technology or something very like it will be around for a long time. Maybe it'll be bic-mos but it will still basically c-mos" he says.

It was Moore who predicted, back in the mid 1960s, that the power of silicon chips would grow exponentially. He speculated that the number of transistors that could be put onto a single piece of silicon would double every 18 months. This became Moore's Law.

"That trend has lasted a lot longer than I ever figured. I plotted the original version in 1965. And we're still surprisingly close to Moore's law," he said, rather modestly.

Dram memory chips will continue to be the technology drivers, according to TI's Chatterjee. He has plotted the manufacturing technologies that will be needed to make the next three generations of memory chips beyond the 4Mbit devices going into production.

A finer picture

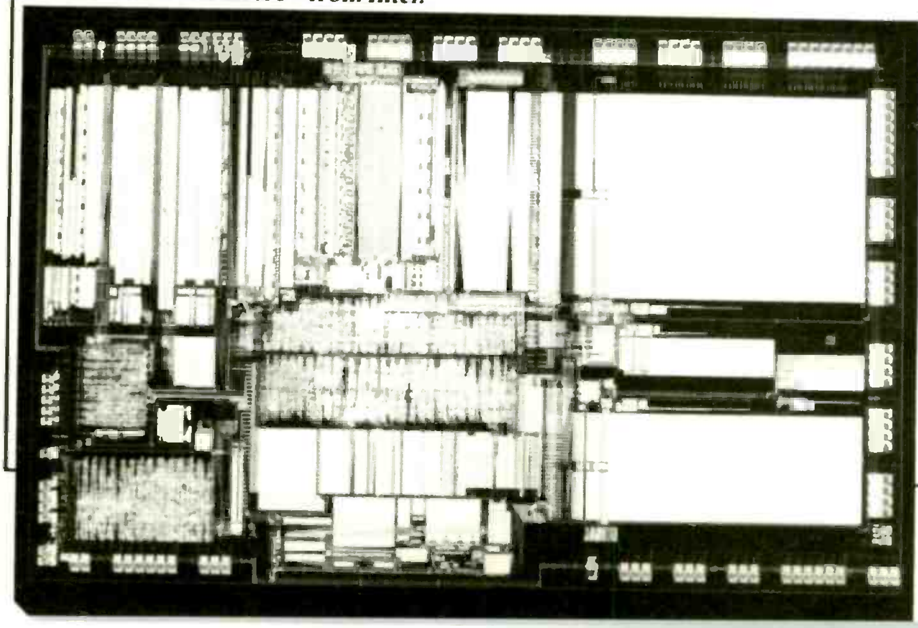
Cramming ever more transistors into chips means the semiconductor makers have to find ways of carving more and more detail onto the surface of a piece of silicon. Most chips are made using a photographic-like process where an image of the circuitry is projected onto a light-sensitive layer on the silicon. So getting finer detail means going to shorter wavelengths of light.

Visible wavelengths are used at the moment. "And we will continue to use optical lithography as we move into the 16Mbit dram production," says TI's Chatterjee. "Then we will move to 240nm Excimer laser litnography for the 64Mbit chips."

Chatterjee expects to see shorter wavelength (190nm) excimer lasers used to make later generations of 64Mbit drams which will offer faster access times. And after that chip makers will turn to X-ray lithography.

Last year, scientists working for US computer giant IBM showed that it was possible to make chips using X-rays. The trouble is that the synchrotron used to make the X-rays was too big and far too expensive to be considered for commercial chip making.

Million-transistor micro – from Intel.



So researchers at IBM and Japanese telecommunications combine NTT are developing prototypes of X-ray lithography production equipment that use smaller, more compact and cheaper synchrotrons. Indeed, a synchrotron capable of running 24 chip production lines is being built for IBM by Oxford Instruments of the UK.

A competing ultra sub-micron technique which uses beams of electrons to etch out circuitry on chips (E-beam lithography) is already in use with several chip makers. It is, however, more suited to making specially tailored application specific integrated circuits (asics) than mass produced devices.

But making the chips of the future will be the easy part, according to TI's Chatterjee. It's all very well shrinking the transistors and other circuit components down to sub-micron sizes, but they need to be able to talk to each other, so the conductive interconnections between them must also shrink; and that's not easy.

"Interconnection is a real problem. Already we are starting to use chemical vapour deposition to deposit tungsten to make better electrical contacts. And as the power density goes up as we move beyond 64Mbit drams then we will have to begin depositing copper rather than tungsten."

Testing 10^8 transistor chips is another problem. Intel's Moore thinks that self testing chips will be one solution. "If you dedicate a million transistors to a self tester then it will be a powerful test machine and you will still have a lot of transistors left to play with," he says.

And as transistors shrink, so clock rates rise. Some very clever timers and on-chip clocks will be needed to keep a 100-million transistor chip ticking over synchronously at 250MHz.

"The inductance of the leads is getting to be a problem already as we move towards 40MHz," points out Moore. As clock rates climb higher, lots of thought will have to be given to packaging; one solution is to put several chip dies in the same package as part of what's called a multi-chip module."

Leon Clifford

Workstation is a GaAs

GaAs chips have found their way on to the main processing board of a commercial workstation for the first time. Solbourne Computer's Series 5 machines use GaAs decoders and scratch pad memory devices to speed up data transfers into memory. The GaAs chips come from California start-up companies Gazelle and Vitesse.

Promising components

"The electronics industry will continue to be profitable despite a slowing down in trading since the boom year of 1988". This is one of the conclusions contained in ICC's latest reports on the component manufacturing and distribution industry.

It also states that the manufacturer's profit margin will average over six per cent. Distributors should see average margins of 10.5 per cent in their businesses.

Bootlegger Megger

The Indian company Raidant Devices is producing "lethal" pirate versions of Megger insulation and earth testers, according to Megger Instruments Ltd.

The genuine instruments are housed in extremely tough plastic cases, while the Indian copies have "poor quality" metal boxes, which would not pass a flash test between case and terminals. Construction in general is of inferior standard and the unstable test frequency renders it impossible to obtain either accurate or stable readings.

Chris Burns, Megger's managing director, says "We have uncovered a catalogue of faults that is nothing short of frightening and we intend to make every effort to see that this pirate trade is stamped out before lives are lost – and that includes a direct approach to the Indian High Commission".

So far, none of the copies has made an appearance in the UK.

Real Meggers

Fake Meggers

MacPortables, dos portables and movable objects

It has definitely been the month of the portable, with just about everybody having a go.

That everybody has included the official appearance, after years of speculation, of Apple's Macintosh portable (which for some reason is not known as the Pacamac). There is even talk of that other lot, IBM or whatever they're called, having yet another go at producing a portable. This time it will come, though has yet to appear, from the company's Japanese operation, which seems to have done its own thing well enough to impress the rest of the Big Blue empire.

The MacPortable is a snazzy, if expensive beast. At just under £4000 for a machine with only one floppy disk drive it is not likely to be a snap purchase, but for the dedicated MacFreak, it will be hard to resist.

And it has some very good points to it. Instead of having a mouse trailing about, Apple has opted for a tracker ball solution. But to cope with both left and right handed users, it can be located on either side of the keyboard.

Perhaps the best feature is the display. In a standard 'clamshell' housing it uses what is termed active matrix technology rather than an LCD approach. The effect is really rather good. The display can be easily read from a variety of angles and in a variety of lighting conditions. What is more, it gives sufficient resolution not only for Mac-standard graphics but also for the tracker-ball driven cursor to be visible no matter how fast you move it.

The problem of fitting of snazzy portable computers with clever user interfaces has been solved in a different way by Psion, the makers of the famous Organiser.

Its new Mobile Computer – laptop portable to the rest of us – comes in three varieties, one of which is a £1500+ MS-DOS compatible machine. The other two, however, are cheapo (circa £500+) machines with a similar target market to the Cambridge Computers Z88.

They have, however, a much larger screen than Uncle Sir Clive's machine. They also have a rather clever rodent-equivalent built in. This is a touch-sensitive panel just above the keyboard. Touch it and an arrow-head pointer appears on the display. Move your finger on the panel and the pointer moves to follow. Pressing hard (well, harder than a touch) on the panel is the equivalent of a click on a mouse button.

The thing works, and so long as it's reliable, it should make the Psion machine quite interesting to a lot of people.

Another portable that should attract a good bit of attention is the Stacy, from Atari. This is TOS-compatible rather than MS-DOS, making its lineage directly from the ST line, a machine with lots of fans.

Atari also wins a small prize for what sounds like a rather boring machine. This is the PC4R, a 1 Moyte-memoried, 286-powered dos machine.

Its difference, however, is the use of a Syquest 44Mbyte removable hard disk system, giving it what is, effectively, unlimited storage capacity. And what is more, at £1799 for a VGA system with colour monitor, and with additional disk platters at under £100, this looks like a good purchase for the typical PC user.

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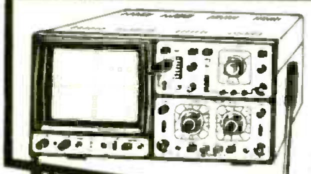

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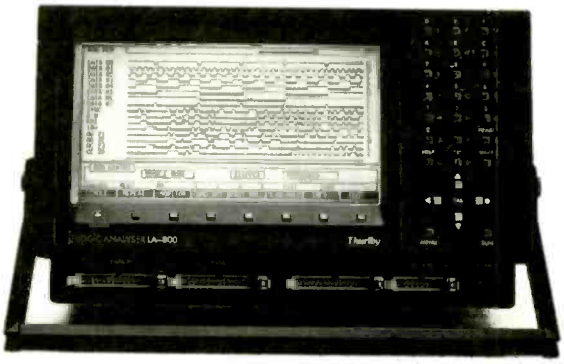

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HP goes 486/EISA

Hewlett-Packard looks like being the first company to combine Intel's 486 macho dos processor with extended industry standard architecture (EISA). The HP Vectra 486 performs three times better than previous personal computers, says the company.

Linking the 486 with the 32-bit EISA bus allows the best possible performance from chip and bus. HP has gone one step further than Intel envisaged by pushing the memory burst mode beyond its normal limits. This has been achieved by pushing 128 bits of data at a time on to the bus, which can then be used by the processor in four 32-bit sectors.

While all this sounds very wonderful in theory, it promises to be a long time before the software houses can catch up with the new hardware and make use of the system performance.

Superconducting patent

A patent has been granted to IBM for a world record high-temperature superconductor developed by scientists at the company's Almaden Research Center.

The citation covers materials containing specific proportions of the elements thallium, calcium, barium, copper and oxygen, which lose all resistance to electricity when cooled to temperatures of 120K or higher.

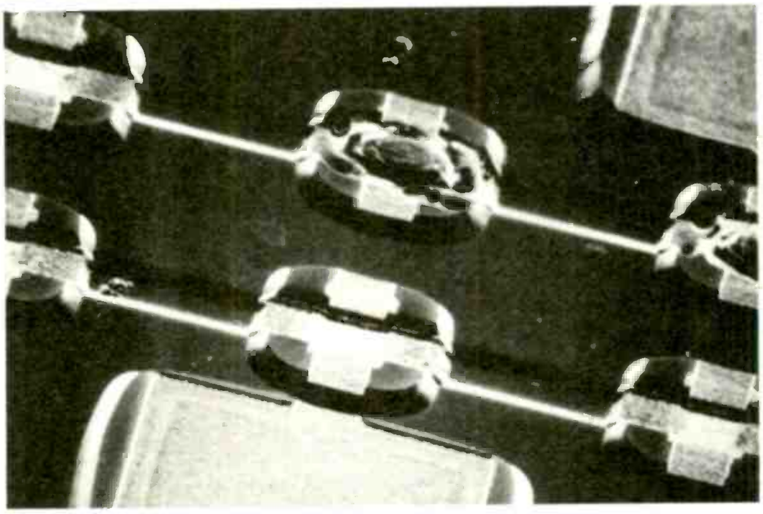
The company says that the actual record stands at 125K, the highest confirmed transition temperature reported for any stable superconductor.

Scottish supercomputer

The University of Glasgow and Motorola have joined forces in a supercomputer research project for weather forecasting, financial analysis and artificial intelligence.

COBRA (connected bus research architecture) aims to find methods of designing computers with a peak performance measured in tips – tera instructions per second or megamips – using several thousand bus-connected microprocessors.

The project organizers are hoping to design a general purpose machine for parallel implementations of established languages. It will also run the newer oops based AI derivatives. It will use Motorola's 88000 risc chip for the core devices.



With this technology – programmable hybrid substrate – you can have your hybrid device within two weeks of finalizing your circuit diagram.

Called Polystrate, the technology involves a substrate with a criss-cross of 25μm-wide conductors. Each substrate is around 2.5cm^2 and has 3600 cross overs per square centimetre.

During programming, each cross-over is either left alone, in which case a 3μm air gap isolates the two conductors, or welded using a laser or ultrasonics.

Manufacturing costs have not yet been finalized but Contraves, producer of Polystrate, says that the technology should work out cheaper than thin-film.

Psion organises computer

The British company Psion, of Organiser fame, has unveiled a range of A4 sized portable computers including a silicon based MSDOS version. This is the first ever rom implementation of the ubiquitous IBM PC operating system. It uses flash eeprom cartridges in place of the normal 3½in drives normally found on portable computers. The machine weighs just over four pounds and costs £1500. Battery life is claimed to be 60 hours.

Psion also has a pair of machines, physically similar to the dos model, which use its proprietary graphics user interface, a Windows-like environment. These do not include the MSDOS rom dos. Around half the price of the dos product, these machines can work with a speech file module which can record up to an hour of speech requiring just 300K of memory. The facility allows the storage of speech files in the same way as other computers handle text files. The GUI machines also include a touch-pad cursor driver replacing the standard mouse function.

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POSTAGE AND PACKING CHARGES: £1–£3 65p. £3–£5 85p. £5–£10 £1 07 £10–£15 £1 20, £15–£20 £1 75. Over £20 £2 30 but below 2kg Parcels over 2kg at Cost

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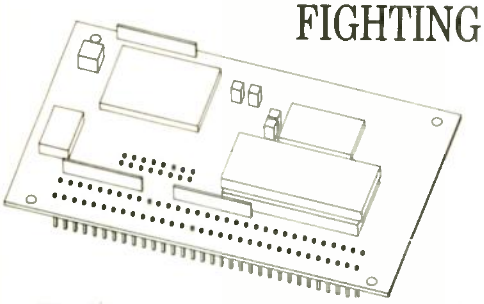
Tel: 01-743 0899 Fax: 01-749 3934. Open Monday to Friday 9 a.m. – 5.30 p.m.

CIRCLE NO. 143 ON REPLY CARD

FIGHTING TALK...



TDS 9090

Weighing in at 60g and only 100 × 72mm this card packs a punch with 2 × RS232 and 35 parallel I/O lines. Up to 16K of compiled user program and 30K of data RAM gives it a long reach. The on card Forth multitasking gives you talkback even when the Hitachi processor has something going on in background. Friendly, using +6 to +16V, the watchdog timer won't let it go crazy and the standard EEPROM means the TDS9090 need not forget those important details.

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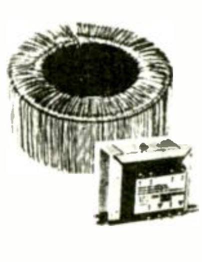
CIRCLE NO. 137 ON REPLY CARD

Toroidal Transformers



As manufacturers we are able to offer a range of quality toroidal and laminated transformers at highly competitive prices.

Toroidal Price List

Quantity prices Exclude VAT & carriage

VA	Mail Order	1-5	6+	16+	25+	50+	100+
15	9.72	8.75	6.42	6.08	5.49	5.10	4.86
30	10.3	9.27	6.80	6.44	5.82	5.41	5.15
50	10.96	9.86	7.23	6.85	6.19	5.75	5.48
60	11.28	10.15	7.44	7.05	6.37	5.92	5.64
80	11.88	10.69	7.84	7.42	6.71	6.24	5.94
100	12.88	11.59	8.50	8.05	7.28	6.76	6.44
120	13.28	11.95	8.76	8.30	7.50	6.97	6.64
150	14.88	13.39	9.82	9.30	8.41	7.81	7.44
160	15.46	13.91	10.20	9.66	8.73	8.12	7.73
225	18.22	16.40	12.03	11.39	10.29	9.57	9.11
300	20.18	18.16	13.32	12.61	11.40	10.59	10.09
400	26.52	23.87	17.50	16.57	14.98	13.92	13.26
500	26.88	24.19	17.74	16.80	15.19	14.11	13.44
625	30.06	27.05	19.84	18.79	16.98	15.78	15.03
750	38.42	34.58	25.36	24.01	21.71	20.17	19.21
800	43.96	39.56	29.01	27.48	24.84	23.08	21.98
1000	53.54	48.19	35.34	33.46	30.25	28.11	26.77
1200	59.08	53.17	38.99	36.92	33.38	31.02	29.54
1500	68.82	61.94	45.42	43.01	38.88	36.13	34.41
2000	84.12	75.71	55.52	52.58	47.53	44.16	42.06
2500	109.96	98.96	72.57	68.72	62.13	57.73	54.98

These prices are for single primary with two equal secondarie with 8" colour coded fly leads.

Available from stock in the following voltages: 6-0-6, 9-0-9, 12-0-12, 15-0-15, 18-0-18, 22-0-22, 25-0-25, 30-0-30, 35-0-35, 40-0-40, 45-0-45, 50-0-50, 110, 220, 240. Primary 240 volt.

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CIRCLE NO. 129 ON REPLY CARD

DSP design with DADiSP

Allen Brown reviews the digital signal processing package DADiSP, which adopts the spreadsheet approach to the manipulation of captured digitized signals

Digital signal processing is now finding application throughout the whole spectrum of engineering and, since the desk-top PC has evolved as an essential engineering tool, it is not surprising that several software packages have appeared to help the engineer to understand what DSP has to offer.

When using a PC, it is relatively straightforward to acquire signals though an I/O expansion card and store them in digital format on disc. From here on, applications programs like DADiSP can demonstrate the power of DSP and give the opportunity to put the formidable theory into practice. DADiSP, released by the DSP Development Corporation of Cambridge, Massachusetts, is a powerful tool in the processing and manipulation of digitized signals. Its screen layout is novel, in that it presents a spreadsheet approach to the processing of signals. A number of graphical windows can be created and the contents of any one may depend on the contents of others. When a change is made to one of the windows its effect ripples through the remaining dependent windows.

The installation of this software is straightforward, provided particular attention is paid to the instructions for the appropriate graphics board resident in the PC. Running the program for the first time, the user is confronted with a Labbook directory containing Tutor2, which is a useful exercise and generally demonstrates the overall operation of DADiSP. Each Labbook can contain a list of worksheets and data bases: a worksheet is a layout of a graphical spreadsheet and a data base will contain input data files that can be accessed and imported into a worksheet. Once the user has created and developed a worksheet, it can be stored along with its data contents in the current Labbook.

To add to its convenience, DADiSP is driven by a highlighted menu option list which is positioned at the base of the screen. Like most application programs, the standard help facility is evoked with the usual F1 key, but this offers only a rudimentary assistance. After opening a Labbook, the user is faced with the current data sets, each of which may contain several data files; the worksheets; and a number of menu options (**Fig. 1**). By choosing the Input option from the utilities menu the user can select a data file from the current directory.

Data files

One of the attractive features of DADiSP is its ability to import data files and view them graphically with a minimum amount of fuss. DADiSP uses data files which are in a binary format, but will also import ASCII, Lotus PRN, 8-bit byte, 16-bit integer or IEEE floating-point (32 or 64bit) data files. Once the required file has been selected, it may be edited before conversion into the DADiSP binary format. **Figure 2** shows the editing options available, which are particularly useful for assigning the appropriate units to the vertical and horizontal axes and for adding comments to the data files. On completion of the conversion, the file is added to a data base of the user's choice.

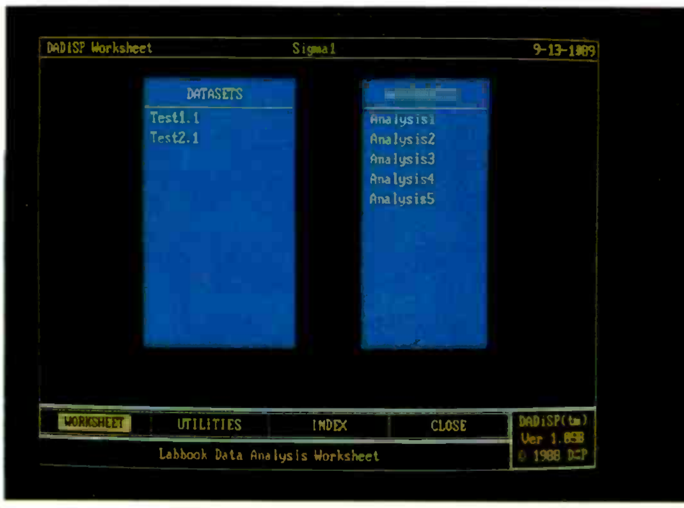
DADiSP will also accommodate multichannel data files – an obvious attraction if the PC has a multichannel acquisition I/O expansion card. The input file can have its data either interlaced or sequential, but multichannel data files must have the appropriate headers to inform DADiSP of their format. Data files are exportable to other directories in a number of formats, including Lotus PRN.

Worksheet

Once a data file has been imported into a DADiSP data base, its contents are viewed by entering the worksheet environment through the command line menu option, using an existing worksheet or a new worksheet, created by adding as many graphical windows as

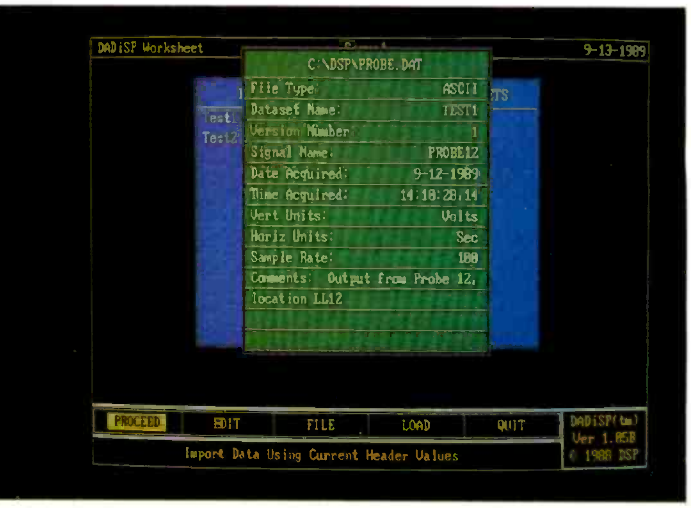
Operating enviroment

DADiSP can run on any IBM PC or compatible equipped with a suitable graphics card, Hercules, EGA or CGA and a hard-disc drive. Its initial drawback is the lack of recognition of the higher-resolution VGA graphics which would significantly improve its display. However, during this review DADiSP was run on a OPUS VII 386-PC with a VGA monitor (operating in the EGA mode) and a 80387 coprocessor. For all serious engineering applications, the coprocessor is highly recommended; for DADiSP, the presence of the coprocessor optimizes the performance of the PC. The latest version of DADiSP now recognises expanded memory of the LIM standard which allows the package to handle much larger data files.



Labbook Data Analysis Worksheet

Fig. 1. Data files and worksheets in a DADiSP Labbook.



```
C:\DSP\PROBE.DAT
File Type:                 ASCII
Dataset Name:              TEST1
Version Number:                1
Signal Name:             PROBE12
Date Acquired:         9-12-1989
Time Acquired:       14:10:28.14
Vert Units:                Volts
Horiz Units:                 Sec
Sample Rate:                 100
Comments:  Output from Probe 12,
location LL12
```

Import Data Using Current Header Values

Fig. 2. Information relating to an input data file.

required via the Add option; each is given a W index and new ones can be inserted anywhere. Moving the cursor highlights the active graphics window, which is edited from the edit line at the base of the screen. Function F8 generates the directory of the available data files in the current Labbook and the required file is then loaded into the active window.

The extensive list of worksheet functions is called on to process the input as desired. As an example, **Fig. 3** shows the number of graphics windows, where W1 is the input data: W2 performs a power spectral density (PSD) on W1, W3 performs a moving average on W1 and W4 performs a PSD on W3. Modifying W1 changes the other dependent graphic windows accordingly. DADiSP has a wealth of functions and manipulation operations for processing the data in the graphic windows and generates waveforms internally, including the complete range of trigonometric functions.

A set of graphics windows displaying the required processed signals having been constructed, the Zoom function will enlarge any one; grids and crosswires generated on the graph (**Fig. 4**) have their vertical and horizontal values displayed at the bottom of the screen. The Zoom mode will amplify the trace, reduce it or adjust it in any direction to show different degrees of detail. The number of graphics windows can be changed at any time during a working session, but the more windows that are added, the poorer the resolution of each window. One of the problems of DADiSP is that you are unable to scroll graphics windows off the screen to make room for new ones. This is surprising, since it was modelled on a spreadsheet format.

The processed data held within a graphics window may be stored and exported to other application programs if required. An appealing feature of DADiSP is the ease of loading a data file (binary or ASCII) directly into a worksheet from any directory on the PC system. This is the simplest way of importing a data file into the package, but you have no editing control. However, it is particularly useful when used in conjunction with the RUN instruction. RUN, which is part of the DADiSP DSP Pipeline, allows the user to execute an external program from within a DADiSP worksheet without having to enter the DOS shell. The program could be an operational program for an I/O expansion card reading in data from peripheral source, for example a data acquisition card or an IEEE-488 interface connected to an oscilloscope. The user therefore has instant access to freshly acquired data. For acquiring data from IEEE-488 instruments, the suppliers of DADiSP provide an extra software package to ease this task.

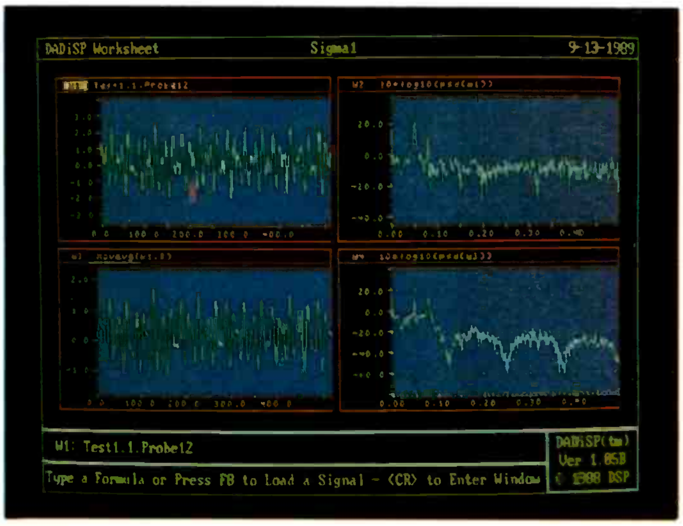
Functions

The extensive range of signal and data processing functions that are available in DADiSP can be divided into the following groups,

scalar maths
Fourier transform functions
data type conversion
statistical
trigonometric
coordinate manipulation
window control
process signal
peak analysis
signal display
DSP Pipeline
signal generation

To call appropriate functions from within these groups, one enters its name and the relevant parameters on the command line.

The options from within the Fourier



W1: Test1.1.Probe12

Type a Formula or Press F8 to Load a Signal - <CR> to Enter Window

Fig. 3. Typical display of graphics windows.

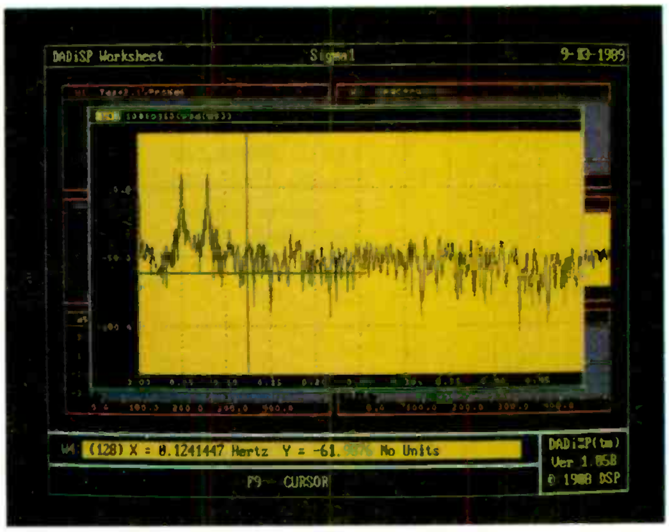


Fig. 4. Zoom facility enlarges one graphics window.

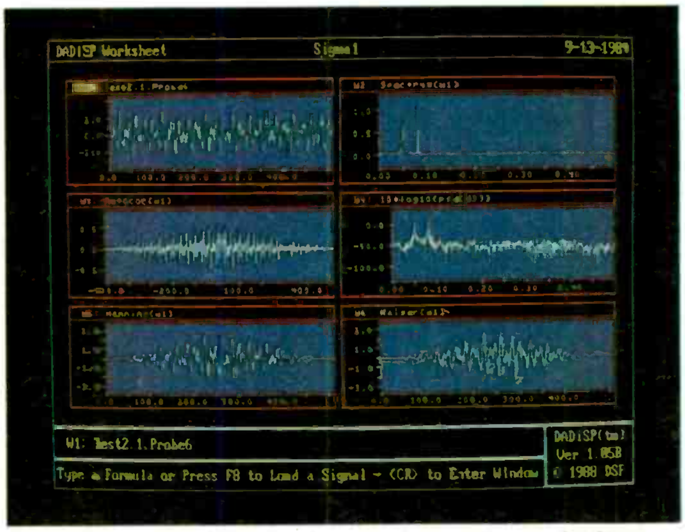


Fig. 5. Examples of the signal processing options on DADiSP.

transform function list include discrete FT, FFT, inverse FFT, windowing, convolution, spectrum and power spectral density. A selection of these functions is shown in **Fig. 5.** Other DSP functions, such as cross spectral density and the coherence function, can be created by combining the primary functions and this is among the advanced features of DADiSP. A lot of attention has been paid to the statistical processing functions in DADiSP and, since the range is quite extensive, I feel there should be more options for curve fitting. Only having linear regression is rather restrictive, especially when you have the computational power to implement quadratic, polynomial, spline and other curve-fitting methods.

Another interesting function group of DADiSP is the waveform generating options. A whole range of trigonometrical waveforms is generated and is used with great effect to synthesize complex waveforms. To add to the realism, random noise, both flat-top and normally distributed, may be added to the waveform, as shown in **Fig. 6.** The RUN function enables the synthesized data to be used as an output waveform for a I/O D-to-A expansion card. This constitutes a fast and effective means for generating real test signals for design purposes.

Advanced features

With an application program of this kind, occasionally there will be a need to perform repetitive tasks and DADiSP has a number of advanced features which are helpful in this respect. When there is a requirement to chain together several DADiSP functions, then a macro can be created, which is in effect several functions built into one. For example, if you wanted dB-scaled power spectral density, then dB could be defined as the macro

Define dB(s) 10*log10(PSD(s))

A set of macros allows a worksheet to be customized to an individual's needs.

To take it one step further, a sequence of operations can be automated by constructing a Command File, which is created with a text editor and contains a list of menu options and functions which permit the user to enter, immediately, a desired worksheet with the appropriate attached data files; screen messages and pop-up boxes are included in a command file. Command files are executable directly from a worksheet, a facility which greatly helps to automate data capture through I/O expansion cards and to load the data into a worksheet for display and further processing.

Printing and plotting

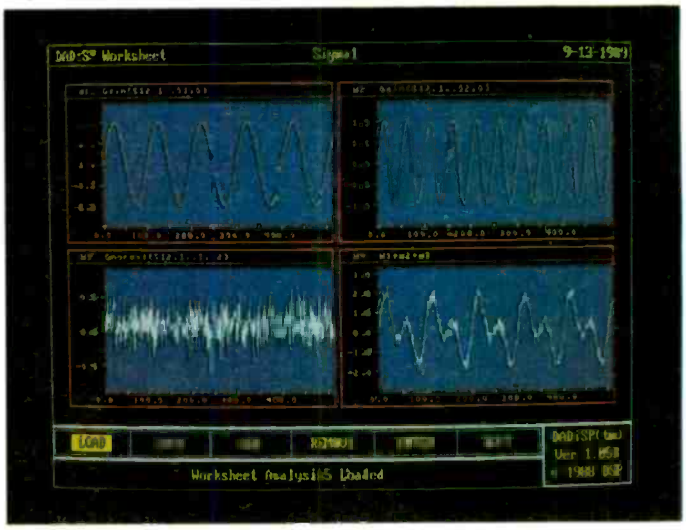
DADiSP is configurable for a number

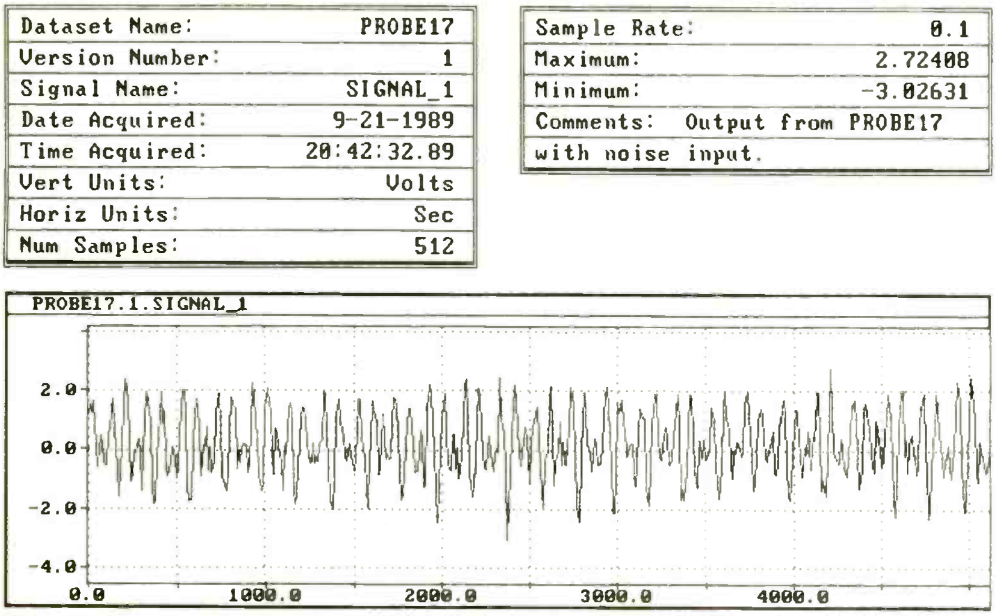
Operating enviroment

DADiSP has a secure feel about it, its operation is smooth and it is comfortable to work with. I have not experienced any system hang-ups and generally the program is very well behaved. What could appear as an annoying feature is the lack of short cuts to higher menu levels for the experienced user. To exit the program, the user is expected to plod through previous menus. Because it is a powerful package, it is very easy to make heavy demands on it by having many graphics windows; the greater the computational load of each window, the longer it takes to respond and complete a screen refresh. The coding for the FFT function is not particularly fast and the advantages offered by prime-number algorithms should be adopted for future versions of DADiSP.

DADiSP is a very effective package for processing data files and represents a product which can add to an engineer's productivity. A number of proprietary I/O expansion cards is now directly compatible with DADiSP and adds to its appeal. The user's manual is well written and is laid out in a thoughtful manner and the early guided tour of the package serves as painless introduction. The amount of learning required to get into the program is minimal and DADiSP is a no-fuss package which is well designed.

Fig. 6. Generating waveforms to synthesize a signal.





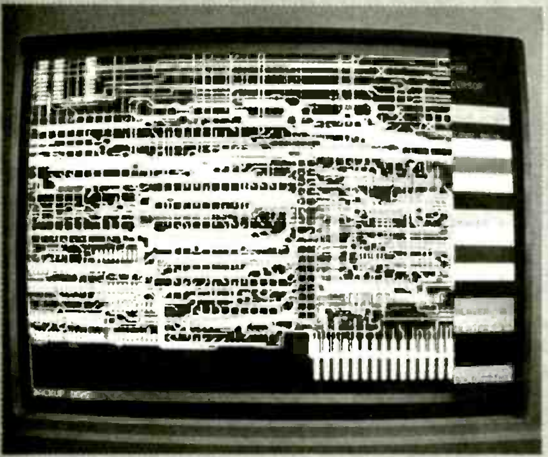
```
Dataset Name:           PROBE17        Sample Rate:              0.1
Version Number:               1        Maximum:              2.72408
Signal Name:           SIGNAL_1        Minimum:             -3.02631
Date Acquired:        9-21-1989        Comments:  Output from PROBE17
Time Acquired:      20:42:32.89        with noise input.
Vert Units:               Volts
Horiz Units:                Sec
Num Samples:                512
```

Fig. 7. Output to printer, showing waveform and information.

of matrix printers and the Hewlett Packard LaserJet printer, allowing permanent records of waveforms to be made with surprising ease. Several printer instructions allow the graphics windows to be printed in a variety of formats: PRINTALL, for example, produces a graphics dump of each window: alternatively, INFORPRINT produces a graphics dump of a specified graphics window and its corresponding information box, as shown in Fig. 7. Individual comments may be added to each plot. For plotting on HPGL plotters, the PLOT or PLOTALL instructions generate files for later processing by the supplied program – plotter. exe – which drives the plotter. Alternatively, the output from plotter. exe can be loaded into a desk-top publishing package as an image file.

DADiSP is obtainable from
Adept Scientific Ltd,
3 Letchworth Business Centre,
Avenue One,
Letchworth,
Hertfordshire SG6 2HB.
Telephone: 0462 480055.

The price is £550 + vat + £5 delivery charge.



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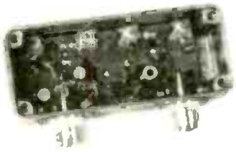
TYPE 9035. Mains power supply for above amplifiers	£43
TYPE 9010. Masthead weatherproof unit for above amplifiers	£13

TYPE 9006



TYPE 9002

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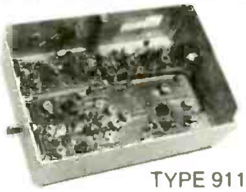
TYPE 9253. 40-860MHz. NF 6dB. Gain 30dB. Voltage output 100mV, 100dBuV, −10dBm	£94



TYPE 9113

TYPE 9252

PHASE LOCKED LOOP FREQUENCY CONVERTERS

TYPE 9113 Transmitting. Converts your specified input channels in the range 20-1000MHz to your specified output channels in the range 20-1000MHz. 1mV input, 10mW output (+10dBm). AGC controlled. Gain 60dB adjustable −30dB. Will drive transmitting amplifiers directly	£396
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TMOS WIDEBAND LINEAR POWER AMPLIFIERS

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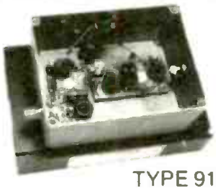
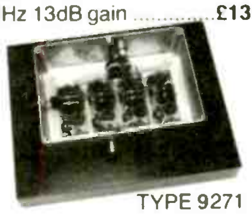


TYPE 9176



TYPE 9271

TYPE 9247. 4 watts output 1-50MHz 13dB gain	£135
TYPE 9051. 4 watts output 20-200MHz 13dB gain	£135
TYPE 9176. 4 watts output 1-50MHz 26dB gain	£285
TYPE 9177. 4 watts output 20-200MHz 26dB gain	£285
TYPE 9173. 20 watts output 1-50MHz 10dB gain	£340
TYPE 9174. 20 watts output 20-200MHz 10dB gain	£340
TYPE 9271. 40 watts output 1-50MHz 10dB gain	£680
TYPE 9172. 40 watts output 20-200MHz 10dB gain	£680
TYPE 9235. Mains power supply unit for above amplifiers	£180

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TYPE 8036. Frequency as specified in the range 250-1000MHz. Ouput 10mW	£195
TYPE 9182. FM or FSK modulation. 20-1000MHz. Output 10mW	£248

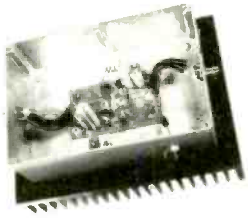
UHF LINEAR POWER AMPLIFIERS

Tuned to your specified frequency in the range of 250–470MHz. 24V.+ DC supply

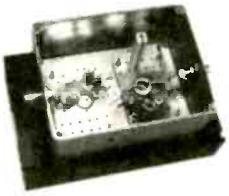
TYPE 9123 250mW input, 5 watts output	£289
TYPE 9124 2-3 watts input, 25 watts output	£335

FM TRANSMITTERS 88-108MHz. 50 watts RF output

TYPE 9086. 24V + DC supply	£1,040
TYPE 9087. Includes integral mains power supply	£1,220
TYPE 9182FM exciter ±75KHz deviation. Output 10mW	£248



TYPE 9263



TYPE 9259

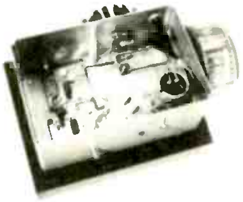
TELEVISION LINEAR POWER AMPLIFIERS

Tuned to your specified channels in bands IV or V. 24V + DC supply.

TYPE 9261. 100mV input, 10mW output	£218
TYPE 9252. 10mW input, 500mW output	£280
TYPE 9259. 500mW input, 3 watts output	£320
TYPE 9262 500mW input, 10 watts output	£580
TYPE 9263. 2-3 watts input, 15 watts output	£440
TYPE 9266 10 watts input, 50 watts output	£1,745

See below for Television Amplifiers in bands I & III.

TYPE 9105



TYPE 9158/9235

TMOS RF LINEAR POWER AMPLIFIERS

Tuned to your specified frequency in the range 20-250MHz, or your specified channels in bands I or III. 24V +DC supply.

TYPE 9105. 10mW input, 1 watt output	£250
TYPE 9106 500mW input, 10 watts output	£310
TYPE 9155. 1 watt input, 30 watts output	£360
TYPE 9158. 5 watts input, 70 watts output	£490

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CIRCLE NO. 116 ON REPLY CARD

Economical disk interface

A disk interface usually requires a floppy-disk controller, PIA (for interface signals), interface-to-microprocessor logic (occasionally DMA), data separator (cheaper FDCs) and a crystal. This can be quite expensive especially for small runs.

For a microprocessor, the main problem is getting data to and from disk quickly enough — hence the need for an FDC. The simplest way to get a pulse to drive the write-data line is to use the Z80 WRITE signal. This saves writing to an I/O port twice to toggle the write data. The clever part is to devise a signalling method using only ones and zeros to give the three required levels for reception of data from the disk.

Level 0 gives a data bit of 0 when received. This is achieved by toggling write data at 21 Z80 cycles. Level 1 gives a data bit of 1 when received. This is achieved by toggling write data at 25 Z80 cycles. Level 2 is an idle state. This gives the Z80 time to process the received data and put it into memory. This is achieved by toggling write data at 17 cycles or less continuously.

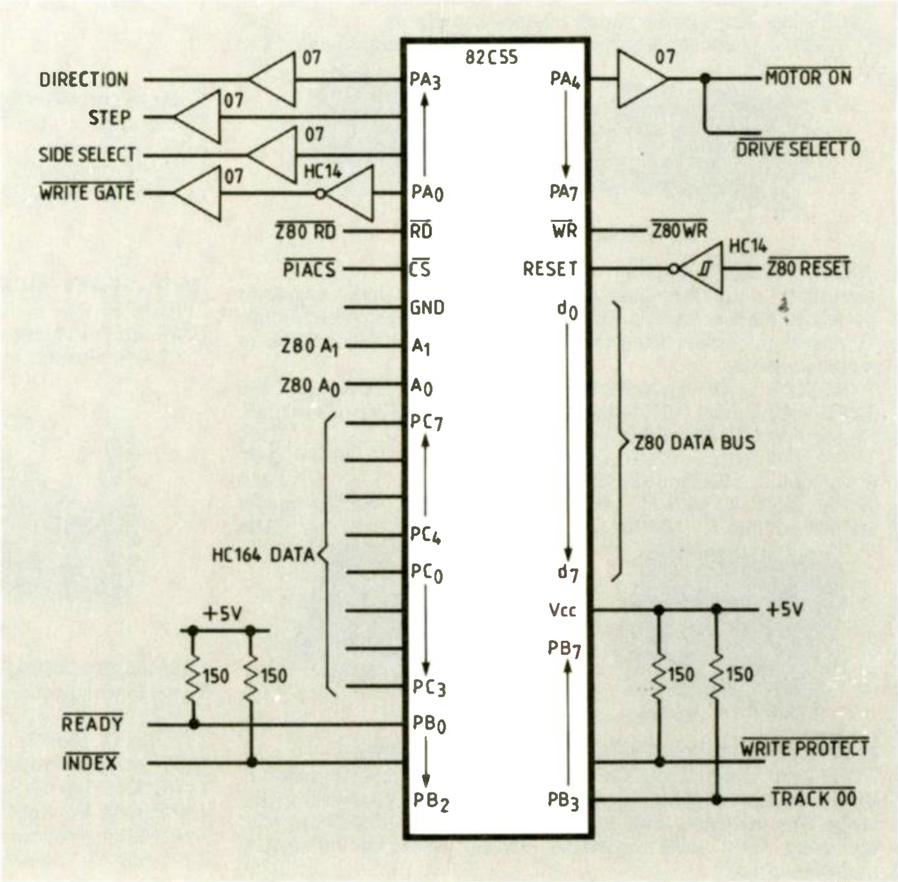
When writing data to disk, the index pulse leading edge is waited for, then a run-in period is required to get over index pulse variation which is less than 2ms. The run-in period consists of level two which stops any reception of data; we used a 4ms run-in period. Now the data is read from memory and depending on 1 or 0, a pulse is written to disk either 21 of 25 cycles then the next pulse is sent.

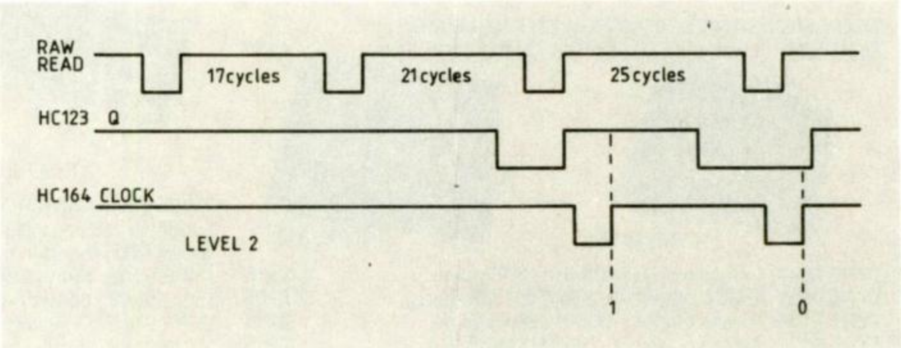
At the end of the byte, level two is sent out to allow time for storage of the received byte. As it stands the software does one sector to one track but this can be altered in software quite easily. At the end of the data a sector number and CRC are put onto disk for security.

For reading data from disk, the index leading edge is waited for then a delay of 2ms is used to synchronize with the run-in signal. The HC161 is reset and Q_3 is monitored on the 161 till it goes high then low, indicating that a byte has been received. The byte is read from the 164 via PIA port C, written into memory and the address pointer incremented, and then the software loops round until the data, sector number and CRC have been received. The CRC is calculated and compared with the received CRC. If an error has occurred the sector can be re-read.

The PIA has the usual interface to the Z80 and interfaces most of the signals to the floppy-disk drive. It receives READY, INDEX, TRACK ZERO and WRITE PROTECT and outputs WRITE GATE, SIDE SELECT, STEP, DIRECTION, MOTOR ON and DRIVE SELECT.

If more drives are to be connected, the drive selects can be separated from the MOTOR ON signal. Output WRITE DATA is the buffered Z80 write signal which is only allowed to the disk when WRITE GATE is low.





continued on page 1158.

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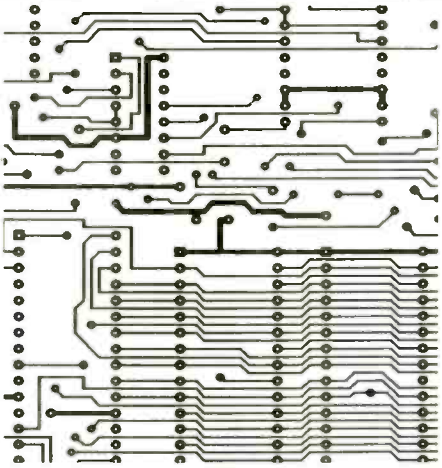

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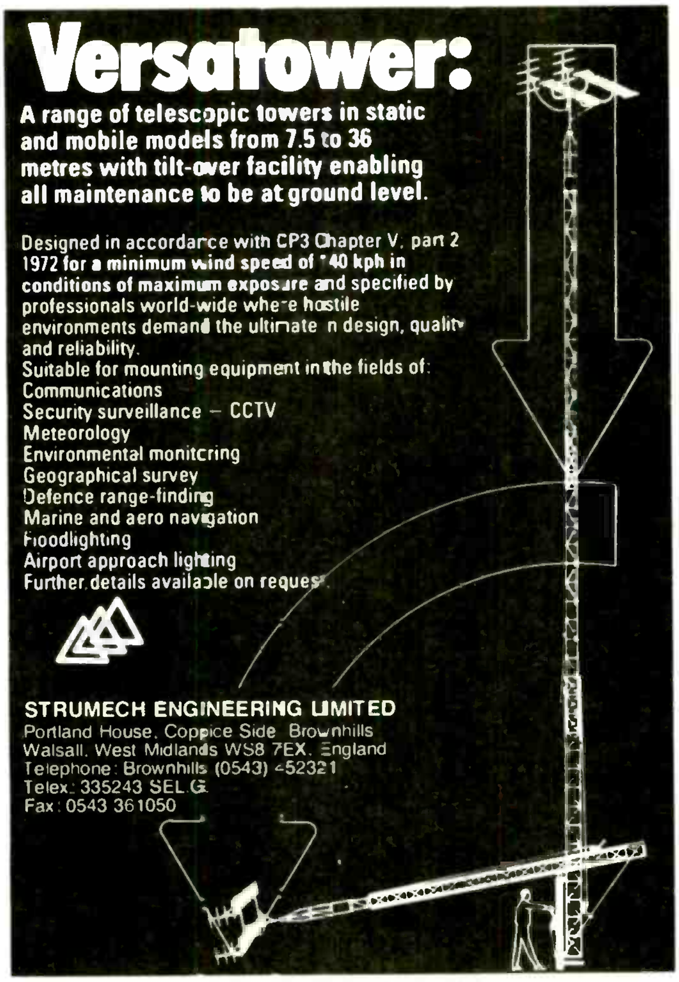

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CIRCLE NO. 120 ON REPLY CARD

continued from page 1156

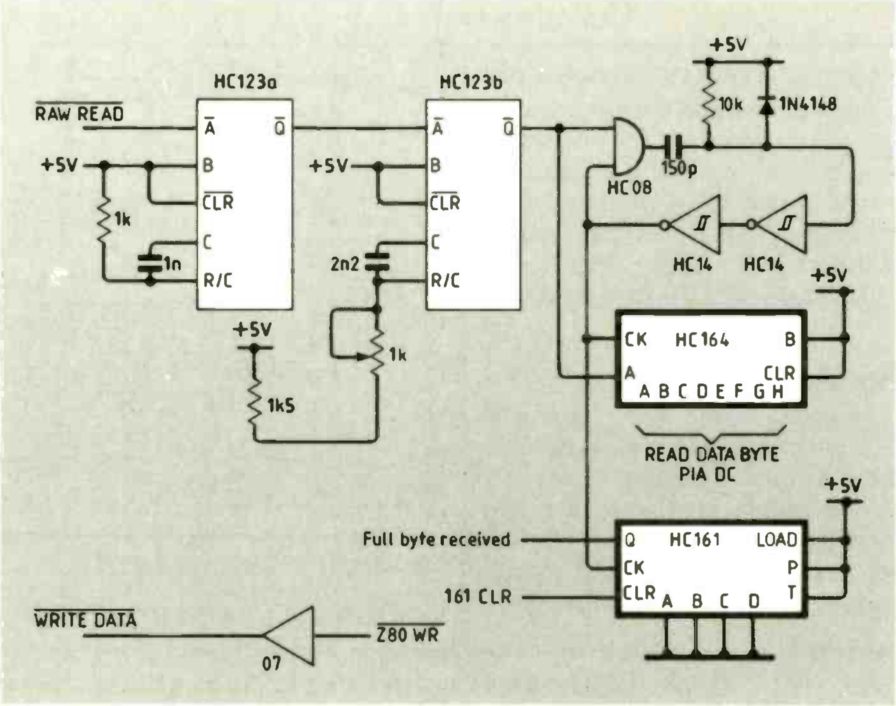
Signal, RAW READ from the disk is first stretched by the first HC123 section. Level-two signals (≤ 17 cycles) are filtered out by the second HC123 section. The HC08 and the two HC14s are a non-retriggerable monostable which separates level 0 and level 1 into data and clock for driving the HC161 and HC164. The HC164 is a shift register for clocking in the 8 bits. On counting eight bits, the 161's Q_3 goes high then low, indicating that a byte has been received.

The disk operating system has to cope with not only reading and writing to disk but with all the interface signals too. Care has to be taken with signal timing, i.e. step times, direction changing, waiting for ready to go low after motor on and seeking to the required track.

Formatting of a disk with sector numbers for seek verification and organization of a directory and sector allocation tables also need attention.

With just a few cheap gates and a PIA a reasonable floppy-disk interface can be designed. In practice we found that disk capacity depending on programmer ingenuity which varied from a few hundred bytes to more than 3000 bytes/track. The most time was taken to write the software which has a lot more to do than the normal DOS encountered on FDC systems. The circuit has been in use for many months on at least two projects with no problems at all.

N P Wright
Bandley Chipware
Appleby
Cumbria



Two-to-four-wire converter

I designed this circuit to separate transmit and receive speech components of a telephone-line signal. This allows unidirectional circuitry to operate on the bidirectional speech signal.

Two transistors form a constant-current generator which provides approximately 40mA line current to energise the telephone. Superimposed on this line current are speech signals to and from the telephone, isolated by a capacitor.

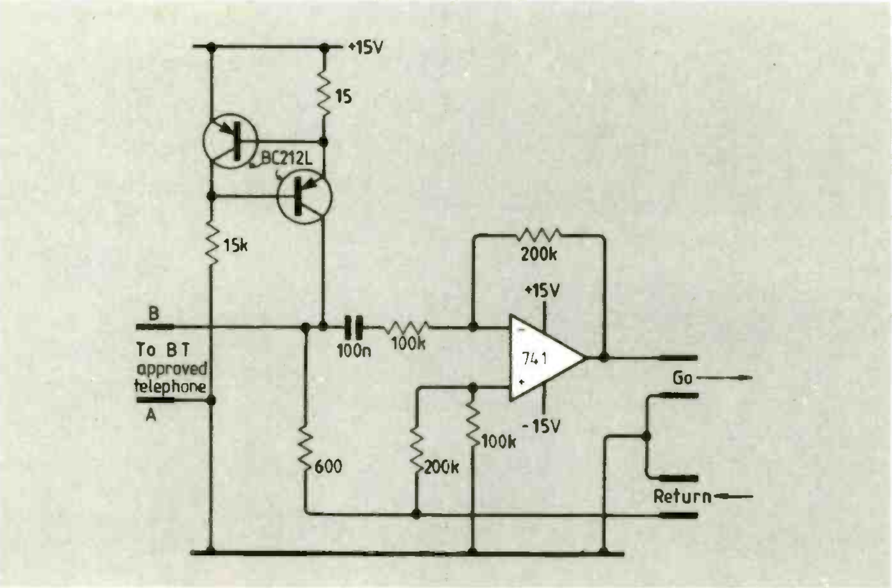
Bidirectional speech signals are applied to a subtracting amplifier arrangement which removes all the returning speech signals from the GO channel. This prevents RETURN signals from being retransmitted, which could give rise to oscillation.

In series, a 560Ω and 39Ω resistors simulate the 600Ω telephone impedance required to "balance the bridge".

Routine circuit analysis shows that the telephone-to-GO path gain is 2V/V, while the RETURN-path-to-telephone gain is 0.5V/V. Output voltage of the GO path is approximately ±0.6V for normal speech.

The circuit possesses excellent transmission quality and works well with BT 746 or 8002R (Statesman) type telephones. It is not of course approved for connection to the public telephone network.

P.S. Rose and J.M. Oakley
High Wycombe
Buckinghamshire



Binary switch encoder

In Miners' circuit on page 1101 of the November issue, the thick line at the bottom of the circuit implies ground. This is not the case; it is simply a connection between the push buttons, the resistor (47kΩ) and the Nand gate inputs. The 3705 emitter *is* grounded.

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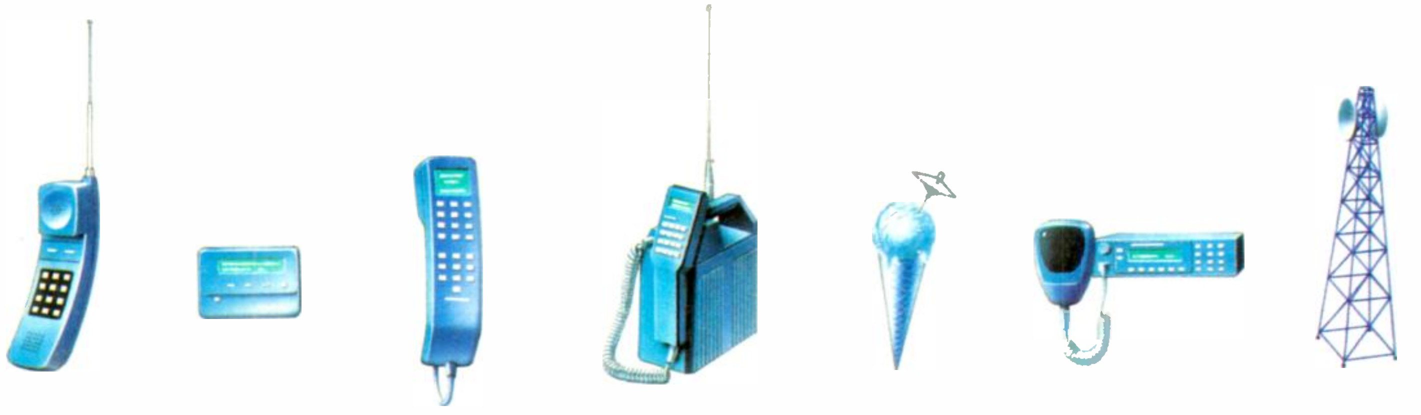

Stabilock 4031: Portable Communication Test Set
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CIRCLE NO. 128 ON REPLY CARD

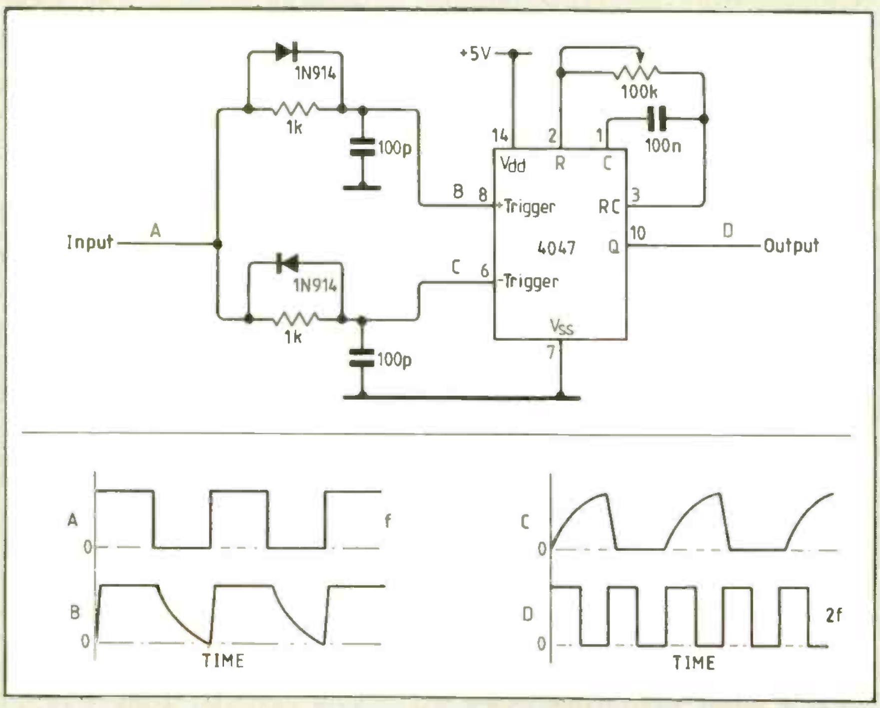
Variable duty-cycle frequency doubler

Only one IC is used in this frequency doubler. The monostable multivibrator can be triggered directly by a low-to-high or a high-to-low going signal.

Two RC integrators detect the leading and trailing edges of the digital input signal. Transition spikes of the integrators are used to trigger the monostable at both edges, effectively doubling the input signal frequency as shown in the timing diagram.

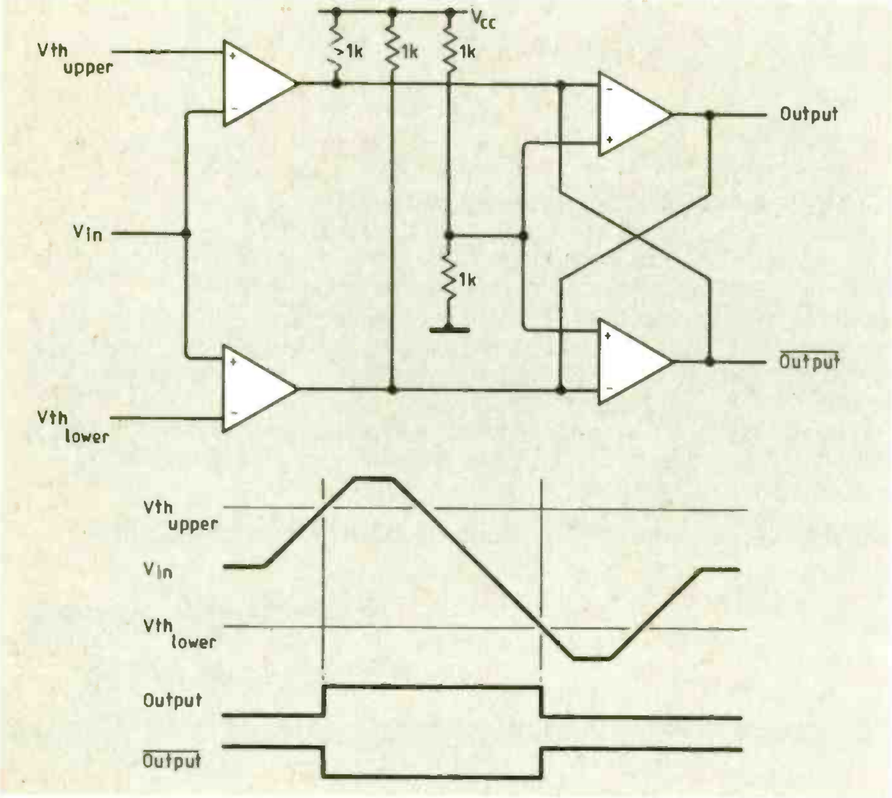
A potentiometer varies the duty-cycle of the output pulse train by up to 100%.

V Lakshminarayanan
Centre for Development of Telematics
Bangalore
India



Schmitt trigger with independently-programmable thresholds

Standard Schmitt-trigger comparators suffer from interdependency of upper and lower switching thresholds and output voltage levels. Also feedback is applied to the non-inverting input, so the source impedance of the voltage on this point (whether signal or reference voltage) needs to be kept low, or well defined, to preserve hysteresis as intended.



My circuit uses a single quad comparator such as the LM339. It features independent high-impedance inputs for upper and lower threshold references, and complementary outputs compatible with any standard logic family.

Two of the comparators detect the signal crossing the upper and lower thresholds, and the other two form an SR bistable multivibrator, using the open-collector comparator outputs for wired-AND functions. Hysteresis is unnecessary for the input comparators because of the latching action of the bistable device and consequently the threshold levels can be set accurately, the only errors being the comparator offset voltages.

Threshold voltages can be taken, for example, from op-amps or from D-to-A converters, opening up the possibilities of adaptive signal-level detection and dynamically tracking thresholds.

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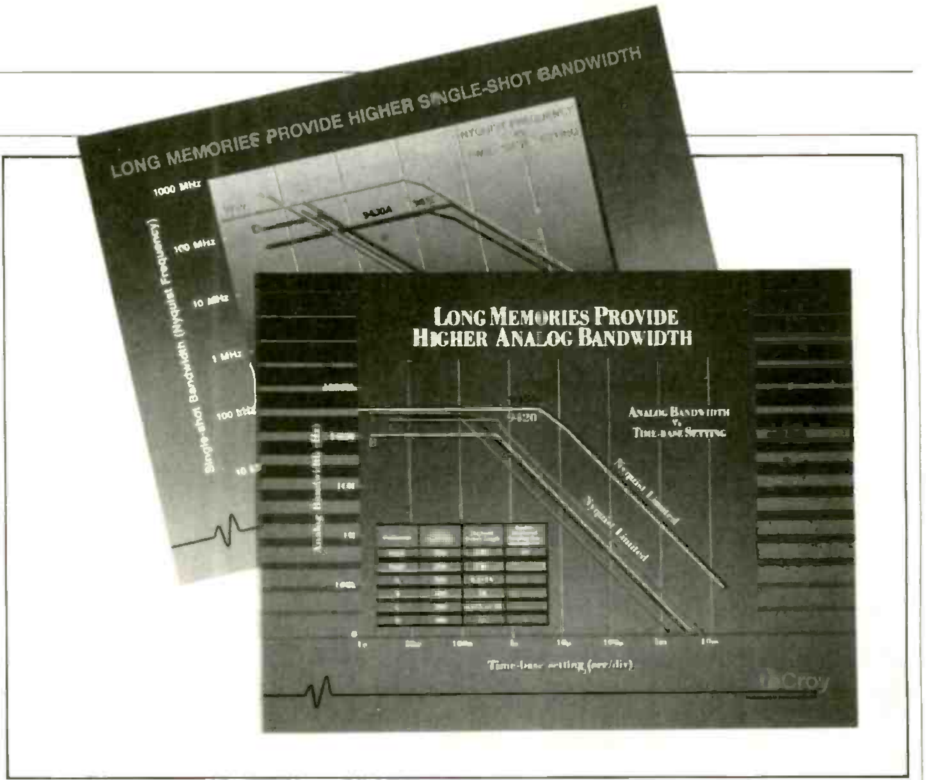
CIRCLE NO. 117 ON REPLY CARD

Oscilloscope performance charts

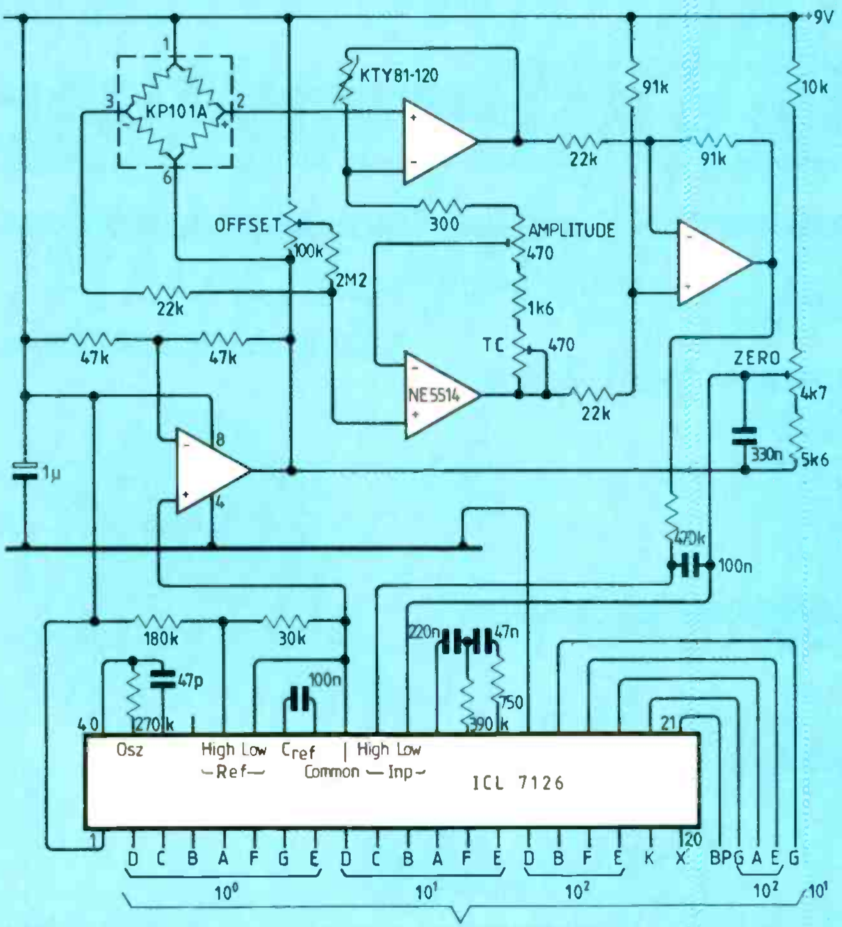
Two full-colour charts, one indicating analogue bandwidth versus time base setting and the other Nyquist frequency versus time base, are available from Le Croy. In each, two Le Croy oscilloscopes are compared with four others of unspecified origin. And both charts have applications information on the reverse. *Le Croy, 28 Blacklands Way, Abingdon Business Park, Abingdon, Oxon OX14 1DY. 0234-33114.*



Altimeter

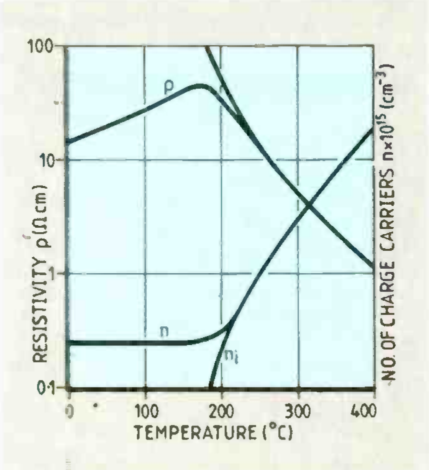
One circuit in a set of application ideas for monolithic silicon pressure sensors is this altitude meter. The KP101A measures from 0 to 0.12MPa; this circuit is suitable for 0 to 2000m altitude.

Of four monolithic pressure transducers in Philips' range, two have signal conditioning and are calibrated, and two are uncalibrated; the 101A is uncalibrated.



Temperature sensors with high linearity

Silicon intrinsically has a negative temperature coefficient but when doped with an n-type inpurity its temperature coefficient over the lower part of its range becomes positive. This change is caused by the initial fall in charge-carrier mobility with rising temperature. At higher temperature, the number of free charge carriers, n, increases because of the number of spontaneously-generated charge carriers, n_i, and the intrinsic semiconductor properties of silicon predominate.



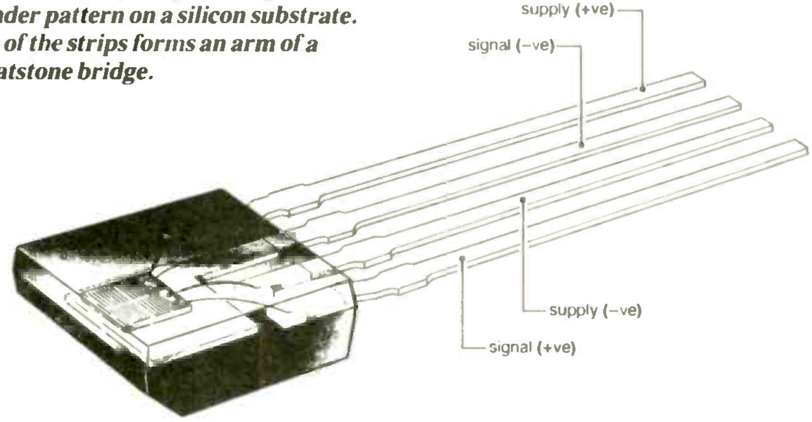
In the Philips KTY temperature sensors brochure, there are further details of the KTY sensor's structure together with specifications and applications circuits (a KTY sensor is used for temperature compensation in the magnetoresistive sensor signal conditioner on the right).

Hall-effect alternatives

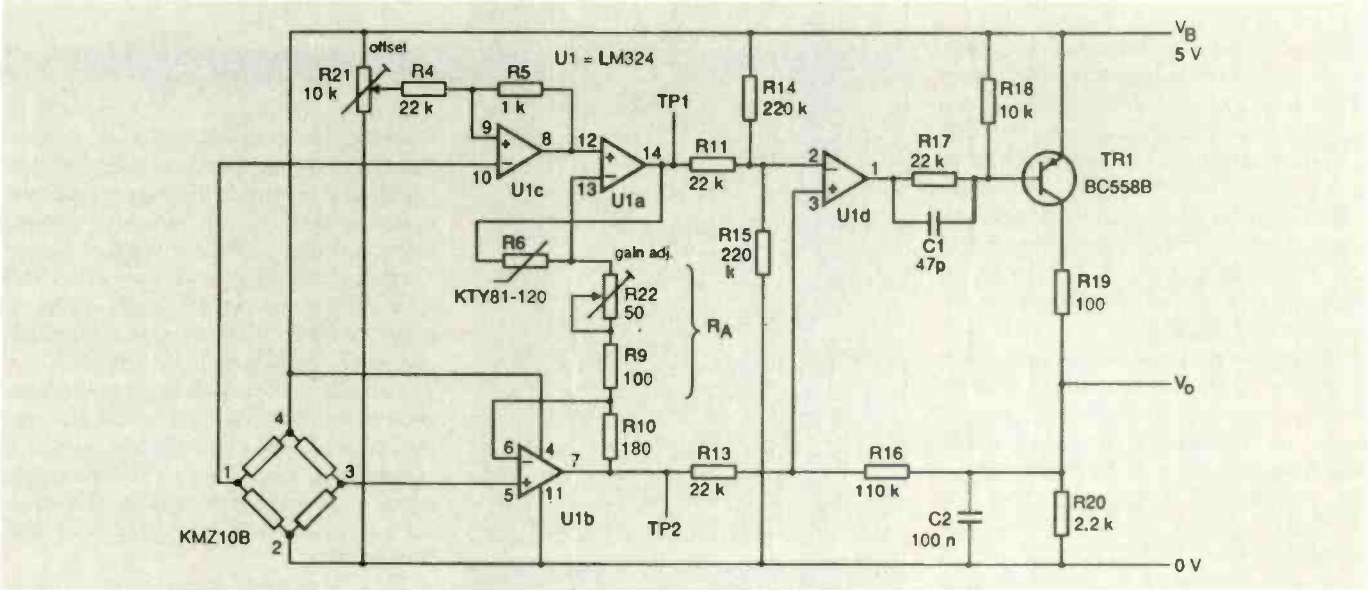
Compared with Hall-effect devices, magnetoresistive sensors are more sensitive and can operate over wider temperature and frequency ranges.

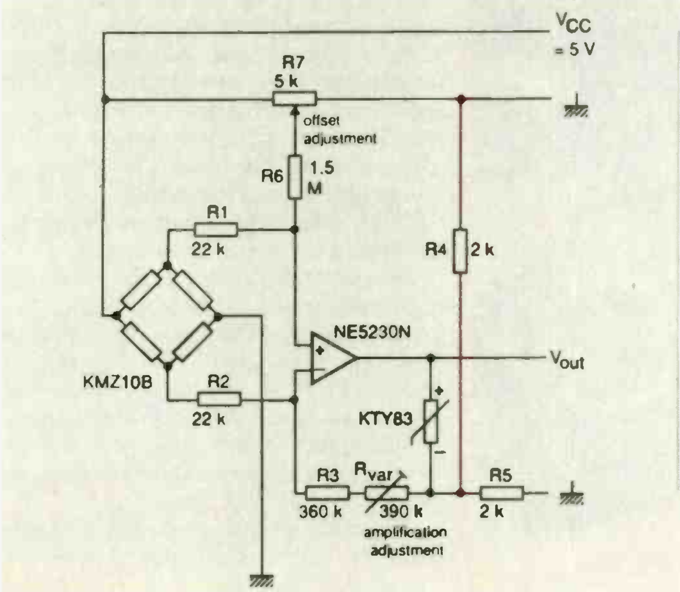
This magnetoresistive-sensor conditioner provides gain adjustment, offset-voltage compensation and temperature stabilization. Its operation is described in Philips Technical publication 268 along with further applications information and an interesting electronic compass. The brochure is free to OEM designers.

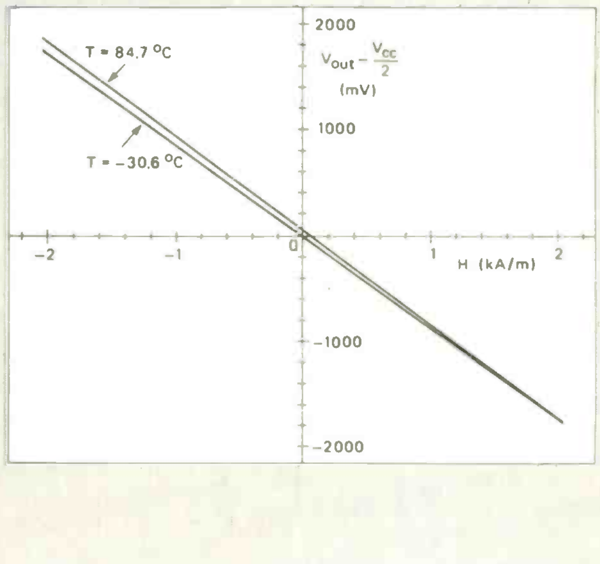
Philips Electronic Components, Mullard House, Torrington Place, London WC1E 7HE. Tel: 01-580 6633.



External magnetic fields change the resistance of a conductor. In the KMZ10 sensor shown here, the conductor sensing the magnetic field is in the form of four Permalloy strips arranged in a meander pattern on a silicon substrate. Each of the strips forms an arm of a Wheatstone bridge.







SOLID-STATE AUDIO POWER

John Linsley Hood continues his examination of the evolution of transistor audio power amplifiers with a look at methods of reducing residual defects

In the first part of this article, I covered some of the developments in the design of transistor audio power amplifiers from the commercial introduction of transistors to about 1975, by which date some competently engineered designs had been produced.

A fair proportion of the designs produced at the end of this period were capable of a performance which would, to the ear of an unprejudiced listener, at least equal most of the previous generation of valve operated equipments and were also more compact, cooler running and of substantially greater potential output power.

However, design mistakes had been made and some units having a relatively poor acoustic performance had been produced, particularly during the earlier years of this period. Although there was a better understanding of the requirements for audio power amplifiers, some relatively indifferent designs were still being offered. Even in the case of the good designs, some residual intrinsic problems remained.

There was the need to ensure that the quiescent current of the output transistors, in the typical class AB output mode, was correctly set on manufacture and remained correct during the life of the equipment. There was also the problem of time lag in the thermal compensation circuitry, which could mean that the quiescent current setting could be in error at the onset of a burst of high output power or in the period immediately following it.

In addition, the relatively high amounts of negative feedback normally employed in these designs could cause sporadic malfunction when used with loudspeakers which had awkward impedance characteristics, making the amplifiers prone to "hard" clipping on signal overload. This effect would effectively require a larger transistor amplifier to deliver the same amount of apparently undistorted output power to the speaker than would have been the case with a valve design.

Design trends

At this time, three separate design trends began to emerge, of which the most explicable, from the engineering point of view, was that of removing or lessening the residual effects of transistor designs, such as the non-linearity of the class AB push-pull output stage; the variability of, or the need to pre-set some chosen value for, the output stage quiescent current; and, in earlier designs, the need to use high levels of negative feedback to achieve acceptably low levels of harmonic distortion.

The second line of development, pursued with great vigour in Japan, was that of seeking needlessly high levels of steady/state linearity and, in the USA, equally unnecessary – in normal domestic use – levels of output power and bandwidth.

This technical development was mainly spurred on by the belief of the 'man in the street' that he needed high output powers and that large bandwidths and very low THD levels were synonymous with perceived sound quality. The same reasoning would lead to the argument that it was the difference in engine capacity which made a 220BHP Mercedes a quieter and more comfortable car than a Citroën 2CV.

Few lay enthusiasts would accept that they could not hear any difference between two units whose only dissimilarity was that between 0.005% THD and 0.05% THD at any point within the audio pass-band; or that, in the majority of cases, their needs could probably be comfortably met by 5W of peak audio output power.

The third design trend was a wholehearted, and perhaps cynical adoption of pseudo-scientific ideas offered by eccentric innovators on the fringes of the 'audiophile' fraternity, particularly when these ideas were applauded by the quasi-technical 'hi-fi' press. The hope was, one supposes, that equipment designed in accordance with these ideas might be applauded by the pundits and so become the acoustic criterion by which all other equipment would be judged.

As an engineer, I am more in sympathy with the first of these design trends because their targets are clear and their aims are explicable.

Circuit developments

Blomley. One of the first serious attempts to overcome the difficulties of defining and maintaining the correct quiescent current setting for the output transistors was that due to Blomley[1], who proposed that crossover distortion should be avoided by arranging that the output transistors were biased permanently to a point at the beginning of the linear part of their V_b/I_c characteristics. The preceding part of the circuit, of which the whole is shown in schematic form in **Fig. 1**, is then designed to present the output stage with an input signal divided into two halves by means of a preceding switching stage, so that the output devices are only required to provide an output current which increases from the pre-set quiescent level.

This is effectively a class B driver stage, but the small-signal switching stage can do this job much more accurately and cleanly than the power output devices could ever do and the small-signal switching stage is unlikely to suffer from thermal drift as a result of the total power output of the amplifier.

Although the idea is sensible and practical, no commercial unit based on this system has been offered.

Error feedforward. This method of reducing system distortion was envisaged by Black[2], the inventor of the negative-feedback technique, though at the time of its invention adequate components were not available and it was neglected.

The method was resurrected by Sandman[3] in an interesting contribution in which he showed two practical examples of amplifiers in which distortion was reduced by feeding forward an error signal to the loudspeaker; these

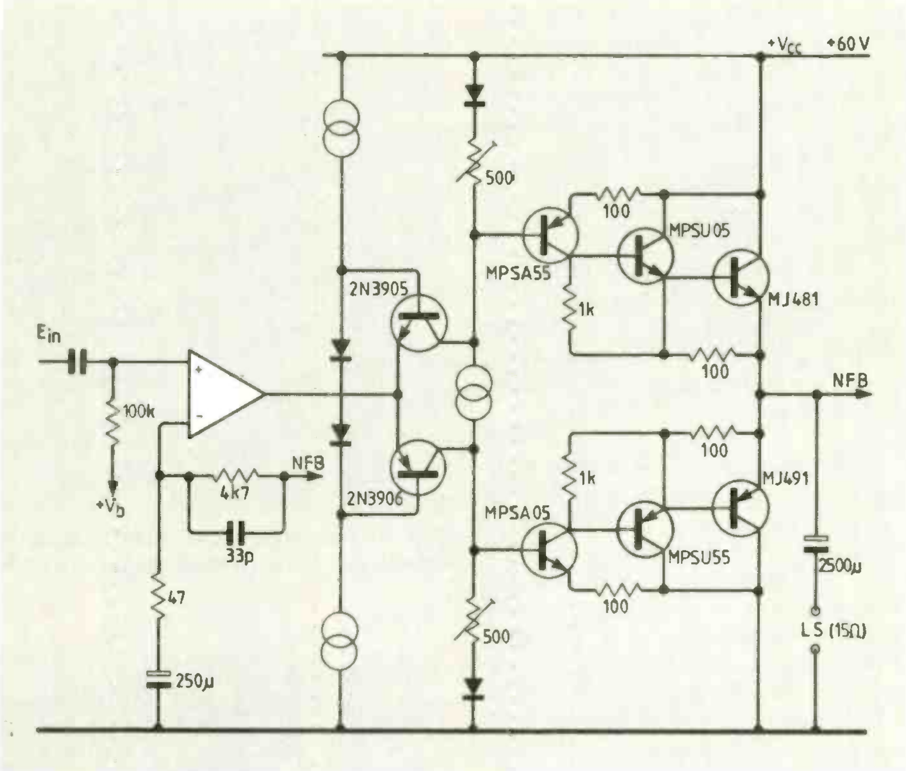


Fig. 1. Simplified Blomley 30W amplifier, with a small-signal switching stage doing the job of a class B output stage.

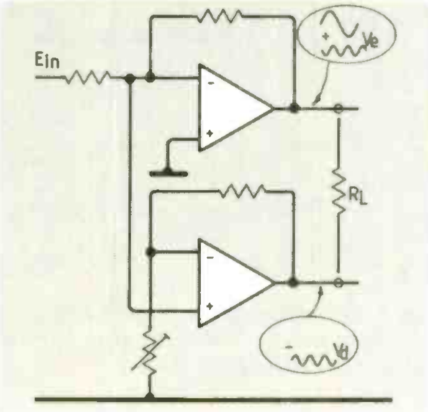


Fig. 2. Distortion correction by error take-off, due to Sandman.

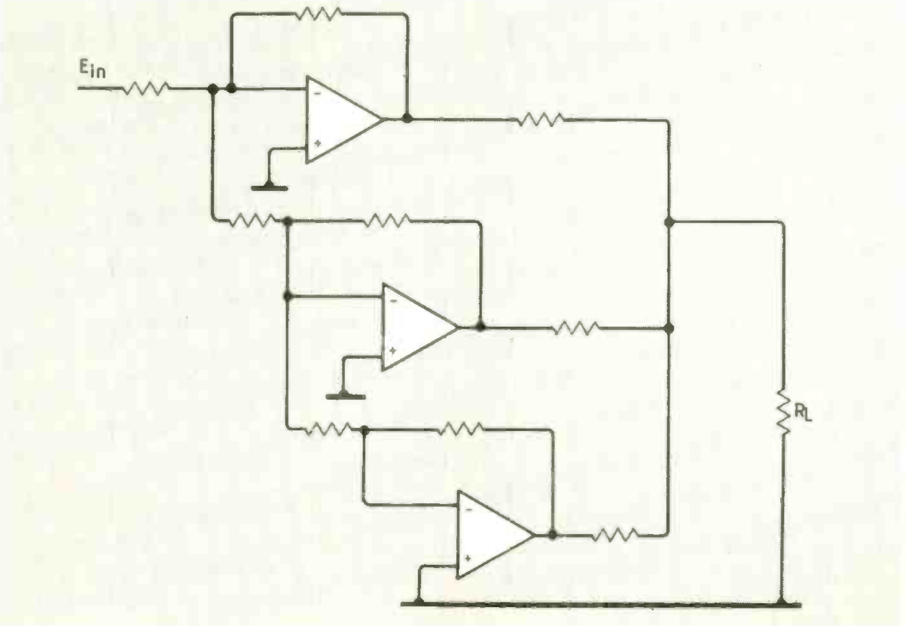


Fig. 3. Iterative feed-forward is theoretically able to reduce distortion as much as required by the use of more feed-forward stages.

are shown schematically in **Figs. 2 and 3.** In the case of the iterative feedforward system of Fig. 3, the distortion could in theory be reduced to as low a value as required by the use of extra feedforward stages.

The other approach, applying the error signal to the 'earthy' end of the load, is theoretically capable of completely removing all signal errors, including all forms of noise and waveform distortion introduced by the main amplifier, but will require some set-up adjustment as well as a floating speaker return terminal.

Current dumping. This rather inelegantly named circuit arrangement, introduced by Albinson and Walker[4] of the Acoustical Manufacturing Company and shown in outline form in **Fig. 4**, appears superficially similar to Sandman's feed-forward circuit of Fig. 2, except that it requires neither preset adjustments nor a floating 'earthy' load return point, although this similarity was disputed in a subsequent letter from Sandman[5].

Of all the circuit designs so far offered, this one seemed to come closest to the ideal transistor layout in that the power transistors could operate without any forward bias whatever and yet allow the low-distortion, low-power amplifier to fill in the residual discontinuities.

Certainly this design has excited an enormous amount of interest from other design engineers, if the number of published letters and articles seeking to explain or deny its operation is any indication. For me, the most intellectually satisfying explanation of its method of operation is that due to Baxandall[6] and is as follows.

Consider a simple amplifier arrangement of the kind shown in **Fig. 5(a)**, consisting of a high-gain linear amplifier A_1 driving an unbiased pair of power transistors Tr_1 and Tr_2 and feeding a load Z_L. Without any feedback, the input/output transfer curve of this circuit would have the shape shown by line (a) in **Fig. 6**, in which the slope would be steep from M' to N' while Tr_2 was conducting, much flatter between N' and N while only amplifier A_1 was contributing through R_3 to the load current, and then steeper again from N to M, while Tr_1 was conducting.

If overall negative feedback is applied via R_1, the kink in the transfer curve can be reduced, especially if the gain of A_1 is very high, giving a more linear characteristic of the type shown by line (b) in Fig. 6. However, it would still be unsatisfactory.

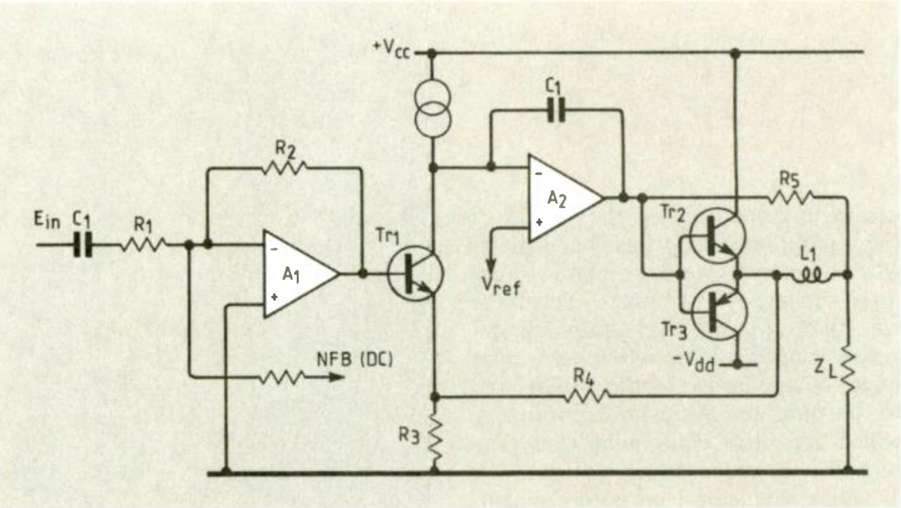


Fig. 4. Acoustical Quad current-dumping amplifier, similar to the Fig. 2 Sandman circuit except that it needs no presets or floating load.

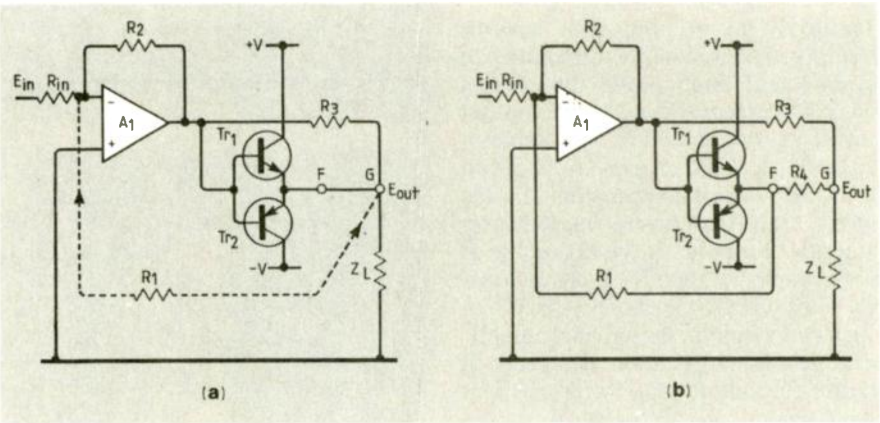


Fig. 5. Operation of the Quad circuit. Basic arrangement of unbiased transistors at (a) is improved by addition of resistor R_4, which allows almost total elimination of output transistor distortion.

What is required is some method of increasing the amount of feedback while Tr_1 and Tr_2 are conducting to reduce the overall gain so that the slope of the transfer characteristic M'–N' and N–M is identical to that N'–N.

This can be achieved, as shown in **Fig. 5(b)**, by inserting a small resistor R_4 between points F and G in the output feed from $Tr_{1,2}$ and then deriving additional feedback from point F. If the values of $R_{1,2}$ are correctly chosen in relation to the open-loop gain of A_1, and the output transistors $Tr_{1,2}$ have identical characteristics, the distortion due to the unbiased output transistors vanishes.

Unfortunately, resistor R_4 would be wasteful of power, so Walker and Albinson replace it with a small inductor and substitute a small capacitor for R_2 to compensate for the frequency-dependent impedance of the inductor.

While this substitution delivers a performance within the range expected from the component tolerances, it complicates the theoretical analysis of the circuit and has led to a lot of subsequent debate, in which the most detailed examination is that due to McLoughlin[7]. He makes a number of valid objections: that it is unlikely that the circuit will completely remove distortion, since no feedback amplifier can ever do this; that the distortion 'cancellation' depends heavily on the precision of the components in the 'bridge' network; and that it presumes that the output slope from M' to N' in Fig. 6 will be identical to that from N to M.

Nevertheless, the circuit works and gives a performance comparable to that obtainable by more conventional means, but without the need to set the

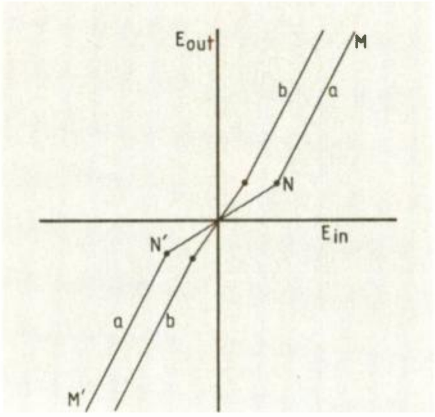


Fig. 6. Transfer characteristic of Fig. 5(a) circuit, with (b) and without (a) feedback.

output transistor quiescent currents – which was the initial objective.

Power mosfets. Junction transistors suffer from a number of inherent problems, such as hole storage and proneness to secondary breakdown and thermal runaway, which becomes more conspicious when they are used as output devices. With a view to avoiding these problems, Sony introduced high-power junction fets, suitable for use as audio amplifier output devices, in the early 1970s and an amplifier using these was marketed.

However, the parallel development of the insulated-gate power mosfet overtook that of the power fet and, by the late 1970s, there was a range of robust devices with greatly superior characteristics to that of the bipolar junction transistor. Not only are they very fast but, if good chip geometry is employed, the relationship between gate voltage and drain current within the conducting region can be very linear indeed, which facilitates low-distortion push-pull operation. Their very high operating speed allows a substantial improvement to be made in the performance of a quite straightforward audio amplifier by the mere substitution of power mosfets for bipolar power devices, as for example in two designs of my own[8].

With some exceptions, circuit designers have been slow to adopt these devices, in spite of their attractive features.

Sandman's class S system. A very interesting idea, introduced by Sandman[9] and somewhat confusingly labelled "class S" (this definition had been used before to refer to a valve grid-bias mode) is shown in schematic form in **Fig. 7.**

This employs a high-gain error amplifier A_2 to sense the difference between the output of the small-signal driver amplifier A_1 and that from the unbiased output devices $Tr_{1,2}$ to drive these so that A_1 sees a very high impedance load, under which condition its performance approaches the ideal. As in the current-dumping circuit, the input amplifier provides a drive voltage to the load when the power output devices are non-conducting.

This idea has been adopted in several Japanese power amplifiers and a simplified version of the output stage of the Technics SE-A100 power amplifier – which is representative of all their current range – is shown in **Fig. 8.**

With reference to my earlier comments on the preoccupation of some manufacturers with what appear to be needlessly high specifications, this design is a typical example, in that it offers a very low steady-state THD figure (0.0002% THD at 1kHz), a very large bandwidth (0.8Hz – 150kHz) and a high power output (240W into a 4Ω load), though with the penalty of a circuit of considerable complexity.

Pseudo class A systems. Various other circuit arrangements have been explored with the aim of avoiding the need for a pre-set, and perhaps critical value of output-stage quiescent current, without the thermal and other penalties incurred by a pure class A output stage, such as sliding bias or other non-cut-off layouts. Various names have been invented for these, such as "class AA" or "super A".

Of these, one of the more superficially appealing is the floating power supply arrangement in **Fig. 9.** In this layout, the output devices $Tr_{2,3}$ are operated in class A, with a collector current which is high enough to meet all the anticipated output current demands of the design, but with a supply voltage which is low enough that the total output stage thermal dissipation is within acceptable limits.

The output-stage low-voltage power supply is arranged to 'float', with its

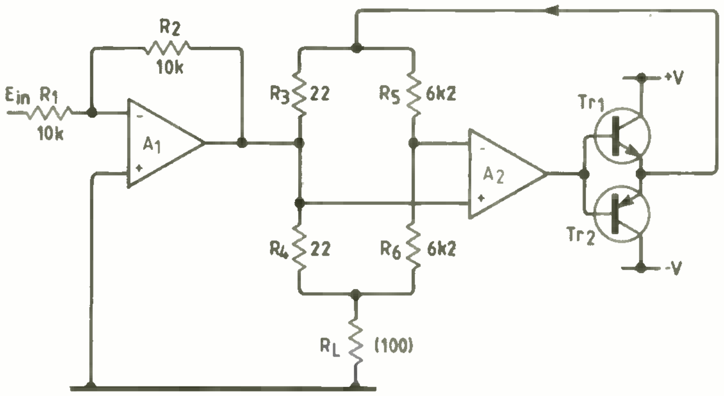


Fig. 7. Sandman's class S amplifier.

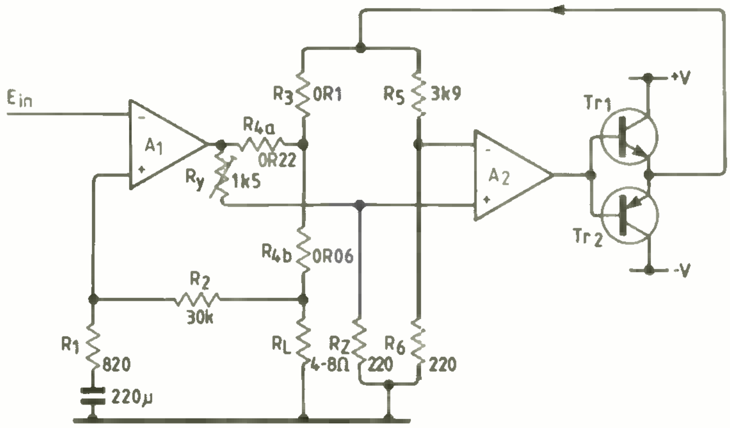


Fig. 8. Technics power amplifier output stage, using the circuit due to Sandman.

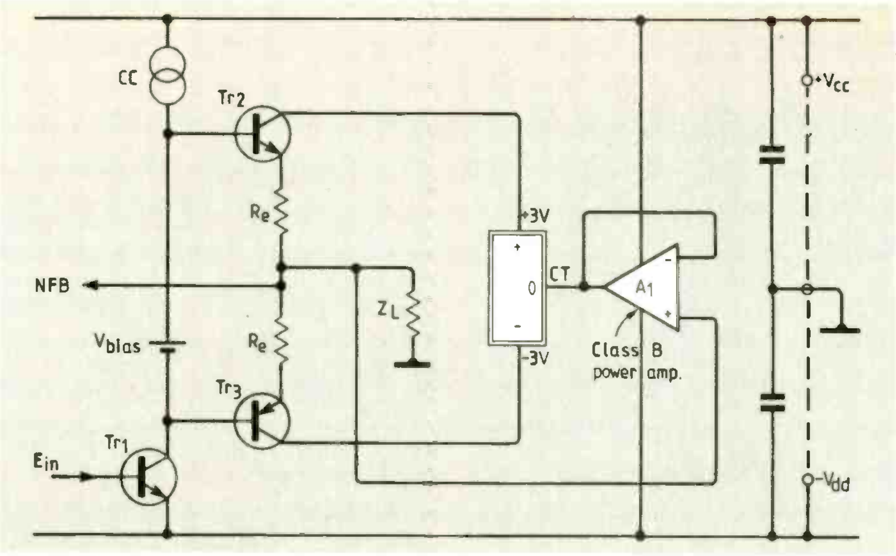


Fig. 9. Floating power-supply pseudo class A system.

centre tap connected to the output of a high-power, unity-gain, class B power amplifier. There will, of course, be crossover-type discontinuities in the way in which this centre-tap voltage follows the input signal, but this will only appear as a modulation of the supply voltage applied to the output transistors, and it is presumed that the effect on the amplifier output will be negligibly small.

However, there is an inherent problem, which is that the load is connected to the 0V line, but the floating power supply is not. Since this is only returned to this line through the class B amplifier, it follows that this latter amplifier is in series with the load at all times.

The system therefore relies, in practice, on the ability of the negative-feedback loop signal to cause the preceding amplifier stages to supply a correcting signal to the class A output devices to remedy the deficiencies introduced by the class B supply-line driver, and these will only be remediable if the class B power supply driver stage is operated in class AB with some remedial quiescent current, which must be preset.

Also, while this system can give a good steady-state performance, it has problems, as have many other exotic designs, in handling steeply rising signals, which make up so much of programme material.

Another scheme which aims to provide the advantages of class A operation but with the economy of class AB is the so-called 'non-switching' layout due to Pioneer, used in their M-90 power amplifier, for example.

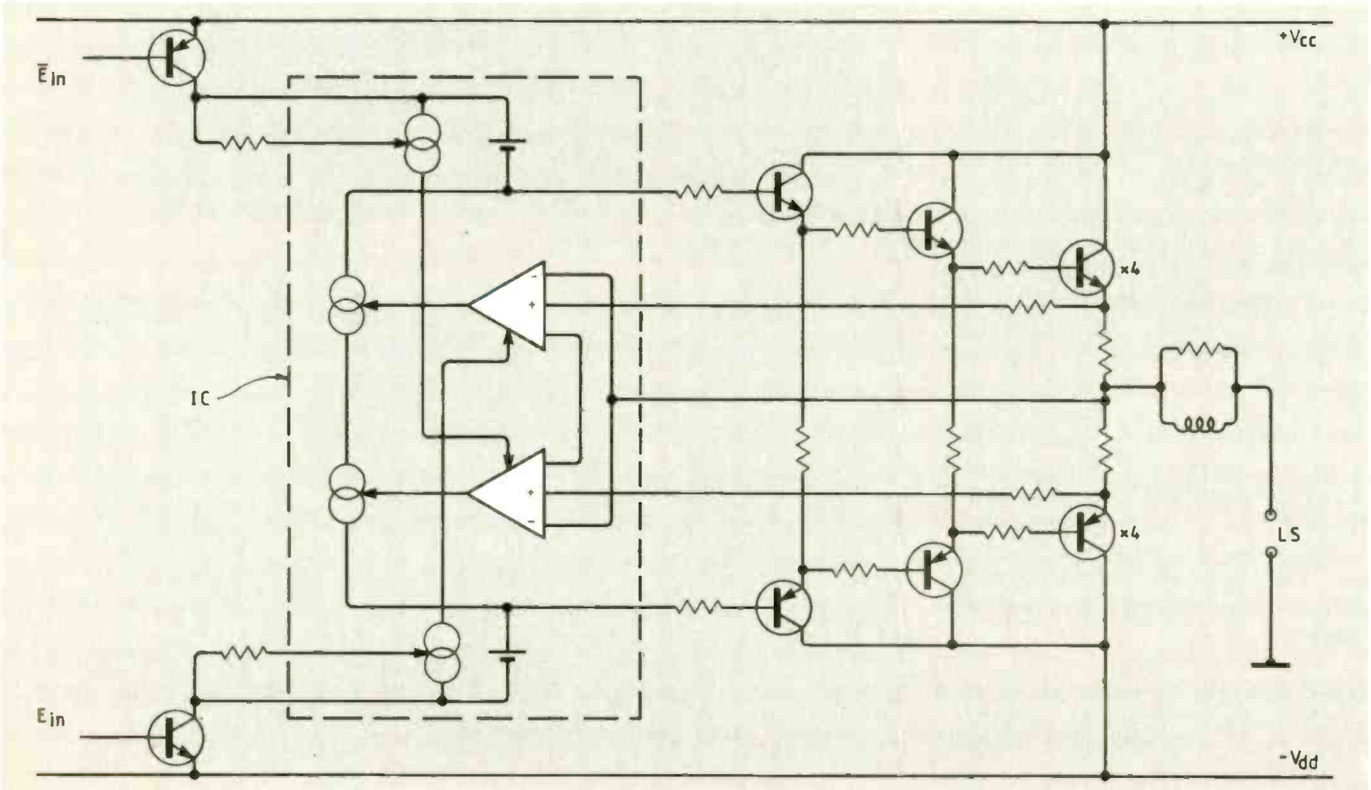
The layout used is shown in **Fig. 10**, in which a purpose-designed IC is used to monitor the quiescent current of each group of output transistors and ensure that it remains at the correct level, never approaching cut-off. This also avoids the need for internal pre-set adjustments.

I will examine some of the remaining aspects of this development in the concluding part of this article. ■

References

1. Blomley, P. *Wireless World*, February 1971, pp. 57-61, and March 1971, pp. 127-131.
2. Black, H.S., US Patents, 1686792 and 2012671.
3. Sandman, A.M. *Wireless World*, October 1974, pp. 367-371.
4. Walker, P.J., *Wireless World*, December 1975, pp. 560-562.
5. Sandman, A.M., *Wireless World*, April 1976, p. 54.
6. Baxandall, P.J., *Wireless World*, July 1976, pp. 60-61.
7. McLoughlin, M., *Wireless World*, September 1983, pp. 39-43, and October 1983, pp. 35-41.
8. Linsley Hood, J.L., *Hi-Fi News and Record Review*, January 1980, pp. 67-71, and December 1980, pp. 83-85.
9. Sandman, A.M., *Wireless World*, September 1982, pp. 38-39.

Fig. 10. Output transistor quiescent-current control in Pioneer M-90 (BK) amplifier.



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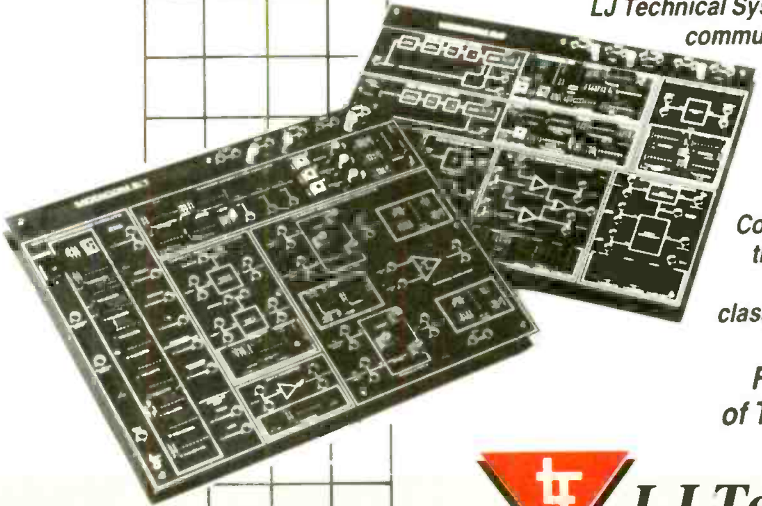

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89 87C51FA
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7-bit resolution D-to-A converter. The MB87085 has a limiter circuit suppressing frequency deviation, filters, digitally controlled volume gain and outputs for compander. Pronto Electronic Systems, 01-554 6222.

12-bit A-to-D converter. Manufactured by Micro Power Systems and designated the MP574A, this 25μs converter has the linear performance and low power consumption of BiCMOS technology. No special selection is needed for ±12V or ±15VDC supply and the digital I/O interfaces are true TTL for good noise immunity. A 10V, 5mA output provides systems reference and there is an on-chip clock reference. The MP574A also features a three-state output buffer. HB Electronics, 0204 25544.

A-to-D converter. Trident Microsystems offers two Teledyne complete integrating A-to-D converters with triplex LCD bar graph drive. A 101-segment LCD bar graph connects directly to the device and provides 1% resolution. The converters operate with 0.1% (TSC825) and 1% (TCS827) resolution and the TCS827 also provides serial data output and duel set points. Trident Microsystems, 0737 765900.

4½ digit BCD A-to-D converter. Pin-compatible with, and including all features of the TSC7135 and TCL735, the low-power, low-cost TSC835 with multiplexed BCD data output has been designed for interfacing to personal computers. The device has been characterized for 200kHz clock operation; conversion rate is 5/s. Greater than 14bit resolution and 100μV sensitivity are quoted. Trident Microsystems, 0737 765900.

Discrete active devices

1.25A switching regulator. The LT1172 100kHz device can be synchronized with a system clock in the range 120 – 160kHz; it operates in the range 3 – 60V and includes the 1.25A switch on chip. Multiple devices can be synchronized for higher outputs. All standard switching configurations are accommodated and packages are 8-pin DIL, 5-lead TO-3 metal can or TO220 plastic. Linear Technology (UK), 0932 765688.

Device selection database. Motorola is distributing, for $2, its second IBM-PC database – one 5.25in disc covering its entire line of bipolar power transistors, power mosfets, small-signal devices, RF devices, optoelectronic devices, rectifiers, zeners, thyristors and sensors. Selection is by part number and parametric searches. Motorola, 0296 395252.

555 timer improved. Two c-mos timers, the 74HC5555 (normal c-mos voltage) and the 74HCT5555 (TTL voltage level inputs), offer improvements in precision and component economy over the bipolar 555 timer. They are comparable to, but improvements upon the 10343. In the new types, a frequency divider is driven by the oscillator, virtually eliminating timing variations due to threshold voltage variations. Philips Components, 01-580 6633.

Generalised VCA The SSM-2014 voltage-controlled amplifier can substitute for any VCA circuit currently available, in most cases also replacing two or more operational amplifiers. It provides true gain to over 50dB. It can operate as a voltage-controlled preamplifier for both high-impedance and balanced low-impedance inputs simultaneously. Class A or AB are selectable. Precision Monolithics, 0276 692392.

Interfaces

Data acquisition. A user-programmable interface between analogue sensors and RS-232 or RS-485 data communications is provided by the DGH 2000 modular data-acquisition and control systems. It has a programmable transfer function which allows the input/output characteristics to be adjusted to fit a particular set of requirements. A family of small data-acquisition modules has its own internal microcomputer and non-volatile memory in which set-up information is held that defines scaling, linearization and calibration. Rhopoint, 0883 722222.

Linear integrated circuits

Tuner chip-set. Five chips from Philips cover all the options for a complete AM/FM tuner. The FM chip set achieves noise-limited sensitivity with a S/N ratio of 26dB at an RF signal input of 2.6μV, better than 60dB at 1mV, harmonic distortion less than 0.3% and AM suppression better than 55dB. Surface-mounted or dil versions are available in quantity prices of $4.40. Philips Components, 01-580 6633.

Pulse-width modulator. An improved version of the industry standard c-mos current-mode pulse-width modulator IC, the TSC170, is now constructed on an epitaxial layer to prevent latch-up when driving an inductive load. Teledyne Semiconductor, 01-571 9596.

Op-amps. Two op-amps intended for use in portable equipment, TLC1078 (dual) and TLC1079 (quad), have been optimized for low power consumption in precise applications. Both devices operate with supply voltages of 1.4V and supply current down to 300μA. Despite this low power consumption, the TLC1078 and TLC1079 are able to drive load currents of ±20mA. Texas Instruments, 0234 223252.

Memory chips

Flash eeprom. Low-cost programming and data storage with a minimum endurance of 100 cycles and optional screening for 1000-cycle endurance are offered on the 48F010 (128Kbyte) and 48F512 (64Kbyte) c-mos flash eeproms from Seeq Technology. Read times are 200, 250 or 350ns. Both use input latches and a single high voltage for writing and erasing. Pronto Electronic Systems, 01-554 6222.

Micro controllers

Programmable controller. Multiprocessor technology in the Simatic S5-155U programmable controller makes it the "cell controller" among Siemens PLCs. Up to four CPUs can be used in parallel, enhancing the S5-155U's performance to include multiprocessing, such as time-optimal processing of each part of a process, thanks to parallel processing. The right processor can be selected for a particular task. All processors have their own memory. Siemens, 0932 752323.

Programmable logic arrays

Double-capacity programmable gate array. The Xilinx XC4000 delivers more than twice the density of the XC3000 family to offer 20 000 gates and is up to twice as fast, following c-mos process advances and architectural improvements. The 4000 series also has on-chip s-ram. Mirco Call, 084 4215405.

Task-oriented microprocessors

Telecom prototyping kits. Eight telecom prototyping kits are intended for use with Mitel ST-BUS range as well as the ISDN Express card board-level products. The first two comprise a speakerphone and handset respectively. There are two magnetics kits with input and output transformers and turnable inductors; two crystal kits; and a DSLIC accessory kit with a transformer and crystal. Mitel Semiconductor, 0291 430000.

Multiplexers

Overvoltage-protected multiplexers. Both the eight-channel single-ended MAX378 and the four-channel MAX379 differential multiplexers are protected to ±60V when powered from ±75V if power fails. They use a special series transistor structure, incorporating extra diodes in series with the fet substrates to block destructive current flows. The three-transistor series switches off when input/output exceeds 2V less than the supply rails. All channels go high impedance when power is lost, so inputs do not load the signal line. Kudos Thame, 0734 351010.

180V, 20A amplifier. Based on a mosfet output stage, the Apex Microtechnolgy PA04 will deliver 20A continuously at an internal dissipation of 200W. From supplies of ±100V, output is 180V peak-to-peak; bandwidth is more than 90kHz at full power; slew rate is typically 50V/ms; THD is 0.01%. Boost voltage pins at input give more drive to the output stage, reducing output saturation voltage – at 20A, it drops from 10V to less than 5V. "Sleep" mode economizes on power. Microelectronics Technology, 0844 278781.

PASSIVE

Wider varistor range. The 2322 range of metal-oxide varistors catalogued by Philips has been widened to cover 14 to 550V RMS and a lacquer insulation now provides 2.5kV isolation. Philips Components, 01-580 6633.

Non-inductive HV resistors. Metallux type 966 cermet resistors from Refac operate non-inductively at up to 20kV DC. Rated at 2W, there are both axial and radial-leaded versions with resistance from 5kΩ to 200GΩ. Tolerances are from ±20 to ±0.5%. Temperature coefficient is 25 ppm/°C and voltage coefficients are down to 1 ppm/V. Refac Electronics, 0962 63141.

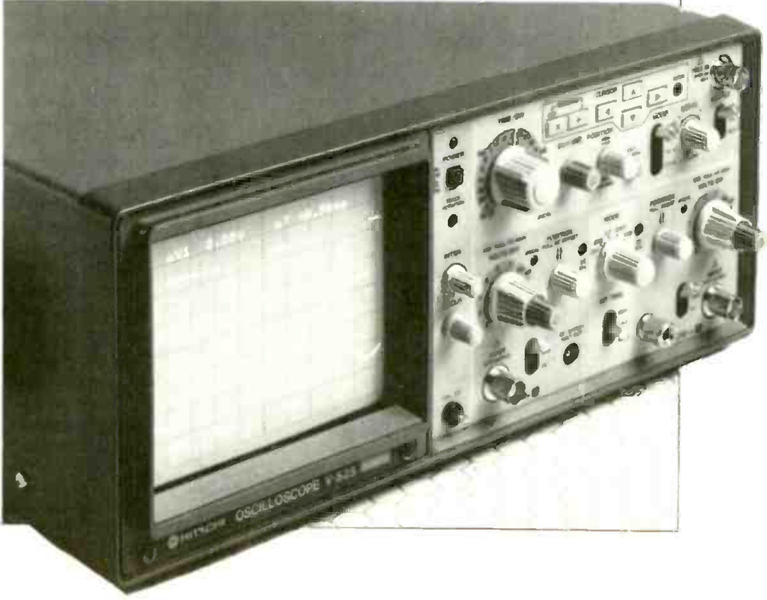
Precision resistors. Metal-can, dip and sip packaging options have been added to the Alpha range of metal-foil precision resistor networks. Metal-can versions include TO18, TO5 and TO8 types and these, along with the 8, 14 and 18 pin dip versions offer hermetic sealing. The conformally coated SIP range has 3, 5, 6 and 11-lead options. Rhopoint, 0883 722222.

Toroidal transformer. Power ratings from 15 to 1000VA, 120/240V 50/60Hz, 55°C maximum operating temperature and diameters of 60 to 164mm covers the standard range of toroids from TTL, with optional foil screen between windings. Toroid Technology, 01-689 8002.

Connectors and cabling

PGA sockets. A modified range of pin-grid array sockets simplifies the insertion and withdrawal of PGAs; they are fitted with six-finger beryllium-copper contacts. The contacts accept and retain short IC leads, tapered entry preventing the leads from breaking. Standard sizes cover from 64 to 124-way models; contact resistance is a

Hitachi's V525 oscilloscope has direct read out of time and voltage differences



maximum of 10mΩ and the current rating is 2A at 20°C. Harwin, 0705 370451.

Displays

Rugged monitor. Compatibility with standard graphics adaptors, including the IBM VGA – from automatic adjustment to graphics board frequencies between 15.5 and 35kHz – is packaged in a rugged steel enclosure, with NEMA 4/12 options on the VU-PAK high-resolution industrial colour monitor. Action Instruments, 0709 820823.

Fixed-frequency monitor. Dynamic focus and astigmatism correction are provided by Hitachi's Hi-Focus 20 in colour monitor. Conventional fixed-focus guns cannot ensure image clarity over the entire screen. Likewise, the conventional circular beam displays an ellipse, the Hi-Focus adjusting this to a circular dot for optimum spot shape over the entire screen. Resolution is 1024 × 768, frequencies 58 – 62Hz. Hitachi, 01-848 8787.

LCD driver. A c-mos circuit that drives LCD displays with direct drive voltage levels, the M6003 from EM Microelectronics Marin accepts serial input data and therefore requires only additional clock and strobe lines. 32 segments may be driven by one M6003 in direct-drive (versions 01/02) whilst the N-way multiplex version (03/04) may drive 32N segments. MCP Electronics, 0734 772345.

Measurement oscilloscope. The 50MHz Hitachi V525 oscilloscope has pushbutton cursor control allowing direct CRT readout of time and voltage difference between the two cursor points. Channel 1 sensitivity and timebase setting are also displayed. Front-panel external voltmeter output allows control of ±100V of DC offset. Vertical sensitivity is variable in ranges 5mV to 5V, and 1mV to 1V. Sweep time is from 0.2μs to 0.2s/div and maximum sweep rate is 20ns. Reltech Instruments, 0480 63570.

Tailor-made LCDs. No minimum cost add-on is Norbain's promise for its design and application service for reflective, transreflective and high-contrast transmissive devices. Norbain Technology, 0734 864411.

Filters

CD filter. The SM5804 series is a c-mos 4-times oversampling digital filter with high stop-band attenuation and low pass-band ripple for CD player applications. The dual-channel 16 bit structure has the input signal two times oversampled in the first-stage 80-tap FIR filter and a further two times sampled in the second-stage 15-tap filter – such that the last stage low-pass filter can be simplified Microelectronics Technology, 0844 278781.

Hardware

Development workstation. The MAT Microcomputer Applications Trainer links into any IBM PC via a single buffer card and provides hardware subsystems in modular form that can be patched together to create large system functions. It is supported by interface modules to motors, sensors and keyboard/display units. E and L Instruments, 0978 833920.

VXIbus family. HP's committment to VXIbus for reducing test-system development time extends to a family of B and C-size mainframes, switches, instrumentation and embedded computers in the 75000 series, supported by HP's TMSL test and measurement systems language firmware and ITG interactive test generator software. The B series products are for low-cost computer-added test applications and are compatible with the high-performance downsized Series C mainframe. Hewlett-Packard, 0344 424898.

Instrumentation

Card-programmable DPM. The IMC 200 series digital panel meter is a 4.5 digit led or LCD metal or plastic housed 1/8 DIN style unit. Plug-in cards accommodate measurements of resistance, mean or true RMS voltage, flow rate, strain, temperature, frequency, and converts to autoranging voltmeter, 0 – 100kHz peak detector and an AC wattmeter. Base Ten Systems, 0252 811010.

Sound level meter. The Castle GA104 satisfies the requirements of BS, IEC and ANSI standards and measures 30 – 140dB in five overlapping ranges, displaying by led. Both A and LIN weighting networks are provided, with fast, slow and peak meter responses, and there is a peak-hold facility. Castle Associates, 0723 584250.

HF measuring receiver to defence standard. The Chase LHR7000 radio noise measuring receiver range is extended to cover British Defence Standard 59-41 by the addition of the defined measurement bandwidths and an external preamplifier. The LHR7002 covers 9kHz – 30MHz, with automatic calibration and a dynamic measurement range of 163dB. Chase Electronics, 01-878 7747.

Accurate load cell. Accuracy of ±0.15% full-scale terminal (0.8% best-fit straight line) with a repeatability of 0.05% is quoted for the JP load cell, which measures up to 909kg in eight calibrated ranges. Full load deflection of only 25 microns gives a high frequency response. Control Transducers, 0234 63909.

High-speed DSO. Digitizing at 800Msamples/s, for under £10 000 on a four-channel oscilloscope, sets a new price/performance standard, says Gould. The 4080 Series instrument offers a store length of 2kwords/channel, capturing signals which are 2.5μ long at a resolution of 1.25ns. It provides dual-timebase operation, a range of signal triggering functions including A divided by N, a handheld waveform processor, and an automatic setup control (which evaluates incoming signals and optimizes controls). Gould Electronics, 01-500 1000.

Asics test enhancement. Release 2.0 Intelligen – a system for automatically generating test vectors for asics – conforms to the JTAG standard. In addition, a hierarchical capability allows higher-level models to be used during the test analysis and generation process, and enhances user-friendliness. HHB Europe, 06284 75374.

Portable logic analyser. Data 1kword deep across 32 channels at up to 25MHz can be captured by the Thandar TA1000 and displayed in both timing and list formats on its 7in CRT screen. It features multi-level triggering with restart plus event and delay count. There are three external clocks with a total of five qualifiers. All acquisition parameters are set up using only two menus. Full IEEE-488, RS232 and Centronics interfaces are standard. IR Group, 0753 580000.

COMPUTER

Vision systems

PC frame grabber. The quick capture range of real-time frame grabber boards and software includes a new IBM PC AT-compatible model. QuickCapture captures, stores and displays live images from video cameras, VCRs and still-video devices. The PC AT model (DT2855) is software-identical to QuickCapture on the PS/2, so that applications developed for one run without alteration on the other. Data Translation, 0734 793838.

Computer board level products

AT-PS/2 compatible with STEbus. The £695 SCPC286 is a single Eurocard mounting a 12MHz 80286, a VLSI implementation of the AT-PS/2's logic, sockets for eprom and a 80287 coprocessor, AT-PS/2 compatible disc and keyboard/mouse interfaces, a loudspeaker and a battery-backed real time clock. The interface to the STEbus is via the two-part DIN41612 connector and includes full multi-arbitration. Arcom Control Systems, 0223 411200.

68008 STEbus CPU. The 1005 processor card from GMT uses the Motorola 68008 CPU as the heart of a system which can be used as an STE slave or master, and as a single-board computer. The GMT-1005 provides the most functional OS/9 engine currently available on the STEbus. The overall design is such that the GMT-1005 is equally suited to use as a development or target system. Because of the addressing capabilities of the 68008, the GMT-1005 can support up to 1Mbyte on-board d-ram, up to 1Mbyte of single-chip eprom, and an optional 2Kbyte sram, while still retaining access to the full 1Mbyte STE memory space. GMT Electronics System, 0372 373603.

Computer systems

Improved HP workstation. The Hewlett-Packard HP332 workstation replaces the HP310 and, using the latest Motorola 16.7MHz MC68030 processor, costs less while improving performance by three to four times. Prices start at £3969, or £2283 for the motherboard which is customer fittable to existing 310 machines. Standard memory is 1MB, expandable to 8MB, and a 68882 floating-point coprocessor can be fitted. It supports HP Basic, HP Pascal and HP-UX. Protek, 01-245 6844.

Programming hardware

Speech processing. The AMT speech development system compresses speech to 1% of conventional digitally processed memory space, through special software techniques. Data rate is 2kbits/s. Applied Microsystems, 01-450 3222.

Software

Neural network development. Networks of arbitrary size and complexity can be generated, and industry standard interfaces allow the user of this PC-based system to import training data and export results easily, for application as a development tool or as an evaluation aid. Input data can be included in the source file or loaded from Lotus 123. Dedicated co-processor boards are in development; current requirements are PC compatible, CGA/EGA/VGA or Hercules graphics cards and Dod 3.0 or greater. Neural Computer Systems, 0234 713298.

HP 310 computers can be updated with 68030 board to improve performance

Building blocks for ISDN

With the introduction of ISDNs, business and consumer users worldwide will soon enjoy the benefits of all-digital telephone and data transmission. John Gingell of Mitel describes some of the semiconductor devices which will make this possible.

The all-digital Integrated Services Digital Network (ISDN) has been much talked about in the last five years but it is only now that suitable integrated circuits have become available for equipment manufacturers to use. Largely this is because of problems which have arisen in trying to achieve worldwide standards for the network.

Setting the standards is the responsibility of CCITT. Its recommendations are published as I.XXX numbers, which refer to various bus and line structures within ISDN. Semiconductor manufacturers have had to wait until such important details as line codes, overhead capability and maintenance operations have been defined.

However, things are now rapidly changing. Standards are being finalized, giving manufacturers the confidence to invest the large sums of money needed to introduce LSI circuits for use in a global ISDN.

Figure 1 shows the model used to define the various interfaces and buses within ISDN. Information to be conveyed from one consumer to another, whether voice or data, is digitized to a rate of 64kbit/s in what is known as a B channel, while the signalling necessary for identification and control is transmitted on a D channel. This D channel is extremely important, since it can convey not only signalling but also simple data or telemetry information, simultaneously with the B channels.

The CCITT has defined a four-wire, 2B + D structure known as the "S" bus, for use inside customers' premises. It will conform to I.430.

Basic data access from the subscriber's network termination unit (NT) to ISDN will use the existing pair of copper wires in the subscriber loop to the local exchange. To achieve full-duplex transmission of the 2B and D channels, digital echo-cancelling will be used over this, the U interface, which will be the last part of ISDN to be implemented. However, the USA has already decided to use a 2-binary, 1-quaternary (2B1Q) line-code to achieve the transmission length required to satisfy all subscribers to a local telephone exchange. This is of the order of 6km minimum. Over such a distance a simple binary code would suffer too much attenuation and so a bandwidth compression scheme is needed.

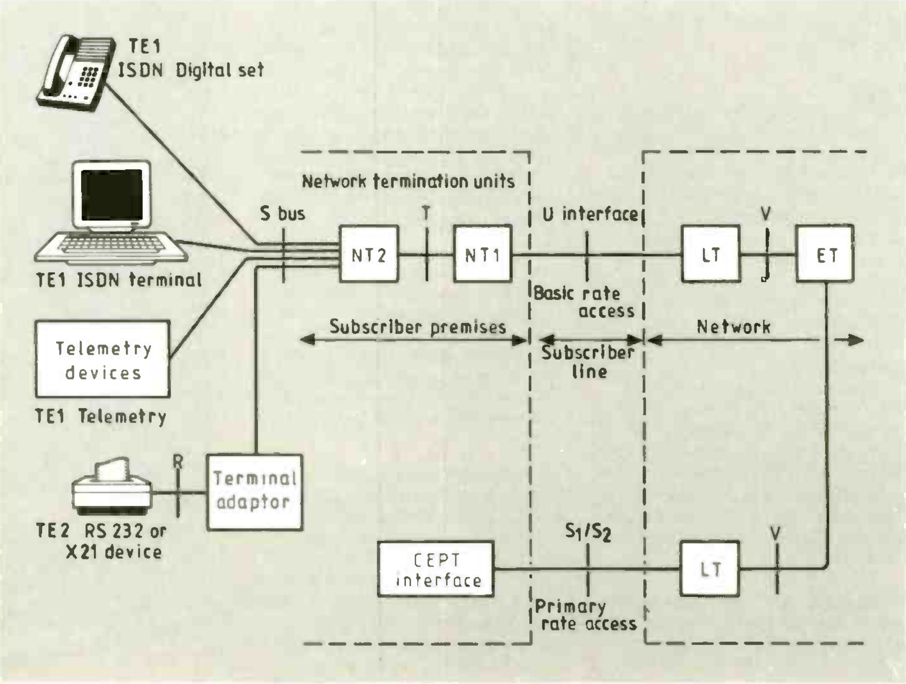
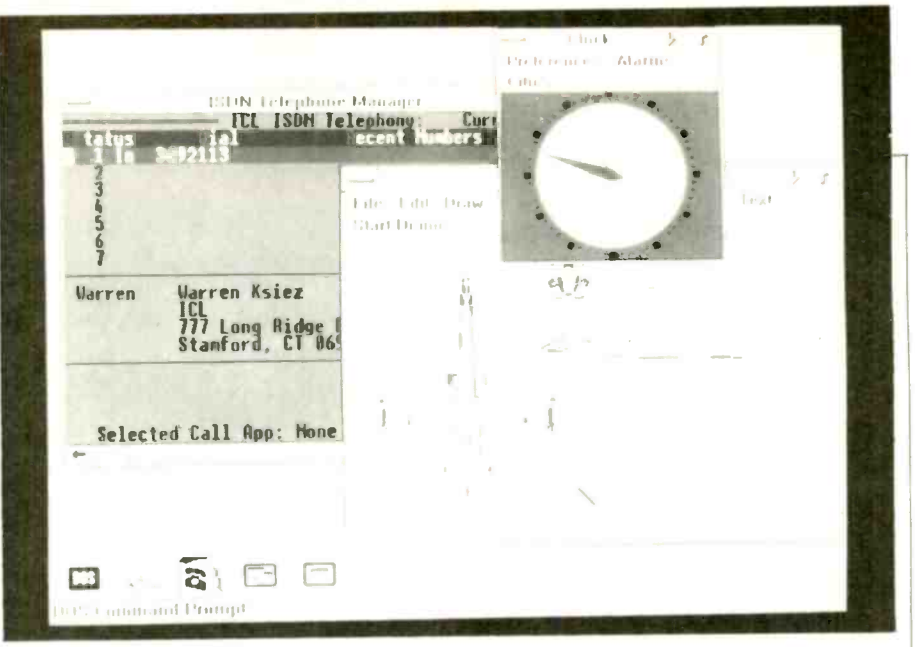


Fig. 1. ISDN user access reference model.



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ICL ISDN Telephony        Curr
 tatus      Dial          ecent Numbers
  1 In  3092113
  2
  3
  4
  5
  6
  7
Warren    Warren Ksiez
          ICL
          777 Long Ridge
          Stamford, CT 06

  Selected Call App: None
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Display from ICL's ISDN workstation – photograph courtesy STC.

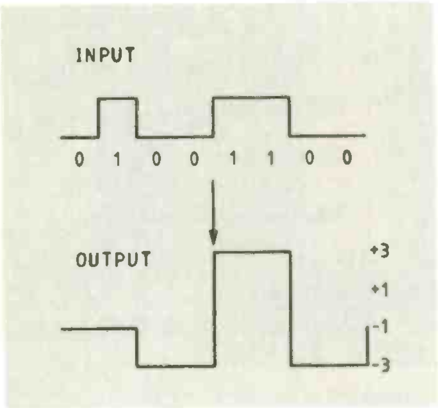


Fig.2. ISDN line coding example: 2-binary, 1-quaternary coding (2B1Q). Two-level binary data at 160kbit/s (top) is encoded as (lower) four-level quaternary data at 80kbaud.

Figure 2 shows how the overall bandwidth needed is reduced by a factor of two with 2B1Q: pairs of binary digits are reduced to a single quaternary level – hence the term 2-binary, 1 quaternary.

To satisfy larger users of communications networks, the high-level multiplexed primary rate access uses 30 B channels. Together with the signalling channels, this gives a bus data bit rate of 2Mbit/s. Readers familiar with British Telecom's digital leased line known as Megastream will already be familiar with this format.

Finally, there is a tremendous market for adapting to ISDN existing data communications equipment which uses RS-232 or V.24 highways. A terminal adaptor will be required, either as a stand-alone box, or for OEM design.

Design tools

Every day, the trade press shows yet more ISDN chips being released: so, for the engineer new to this application, there is a lot of information to be gathered. An easy method of evaluating systems is required. The ISDN Express Card, from Mitel Semiconductor, is one such tool. Designed to plug into an IBM PC's backplane, the board is fully complemented with basic rate and primary rate access devices. Most importantly, all the necessary line transformers and crystal oscillators are also included. The design engineer can see on the PC display details of all internal registers in the semiconductors, making it possible to exercise various options and monitor the subsequent performance without picking up a soldering iron or wire-wrap gun!

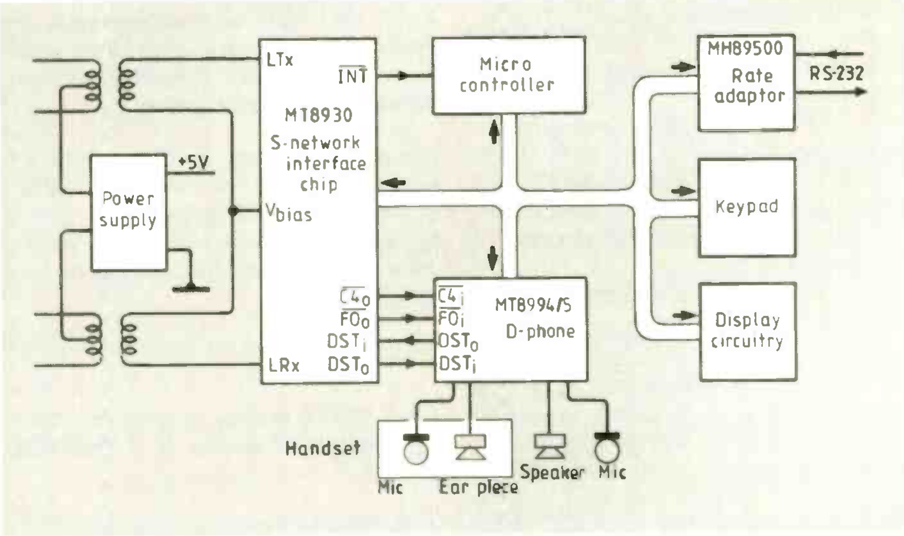


Fig.3. Chip set for an ISDN telephone: hands-free operation and the integration of voice and data transmission are easy to arrange.

To simulate an ISDN connection, two Express Cards can be interlinked via telephone sockets to provide basic rate or primary rate connections. Since an all-digital telephone chip is included on the card the user can actually hear the performance of the ISDN system. All connections are set up by simple keying on the PC, which uses a digital "time-space" switch on the card to connect various interface chips to each other and to the ISDN network.

Component requirements

Line-powering will be an essential feature of an ISDN system. C-mos integrated circuits will therefore be mandatory. The need for mixed analogue and digital circuitry in the same chip will favour semiconductor manufacturers experienced in that area, rather than the typical "state of the art" 1μm-or-less pure digital suppliers. Those processes include double-poly and double-metal applications whose ability to include DSP elements for sophisticated signal handling will be paramount.

To simplify interconnection of all the circuit elements a standardized backplane bus is needed. But here we run into problems, because leading semiconductor manufacturers such as Mitel, AMD, National Semiconductor, Philips and Siemens have adopted different interconnect schemes.

However, there are ways round this for the experienced designer. Manufacturers are providing chips such as Mitel's MT8920, which offers a serial-to-parallel interface with an access time of 100ns.

ISDN telephone sets

An integrated codec filter within the set plus an S interface is the basic requirement for this application. But unless the set can offer additional features, why should the subscriber change?

It is very easy to offer "hands-free" operation and the integration of voice and data at the set (**Fig. 3**). The MT8995 offers a single-rail codec plus a DSP element which controls the hands-free mode and provides generators to give DTMF tones and drive a warbler. The

MH89500 is an R interface module which adapts standard RS-232 data to 64kbit/s and the MT8930 is a c-mos S-network interface chip (SNIC) for simple internal bus running at 2Mbit/s.

Network terminating units

This is where the transfer from echo-cancelling two-wire operation to four-wire subscriber distribution occurs.

Figure 4 shows a typical set-up. The S interface chip is back-to-backed with an echo-cancelling U interface 2B1Q device, the MT8910. A microprocessor is necessary to monitor the maintenance channel, which places an additional 48kbit/s overhead on the 2B+D rate. Although other codes exist for the U interface such as 4B3T and 3B2T, most semiconductor manufacturers have plumped for the 2B1Q and plan to release devices shortly. The race is on to dominate the market place quickly, and once again the Japanese semiconductor industry is conspicuous by its absence.

Primary rate access

As well as a line interface unit and a code converter, the interface to an ISDN primary access must contain buffer circuitry to counteract long-term wander and jitter. The MH89790 is a thick-film hybrid microcircuit which contains all of these functions. **Figure 5** shows this hybrid combined with a digital phase-locked loop (MT8940) and a serial/parallel access chip (MT8920) for connecting a digital 64kbit/s system to a 2Mbit/s line.

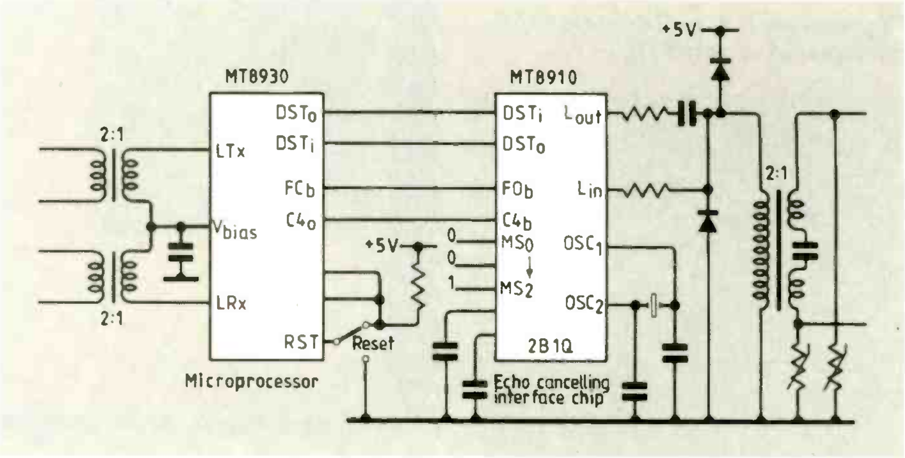
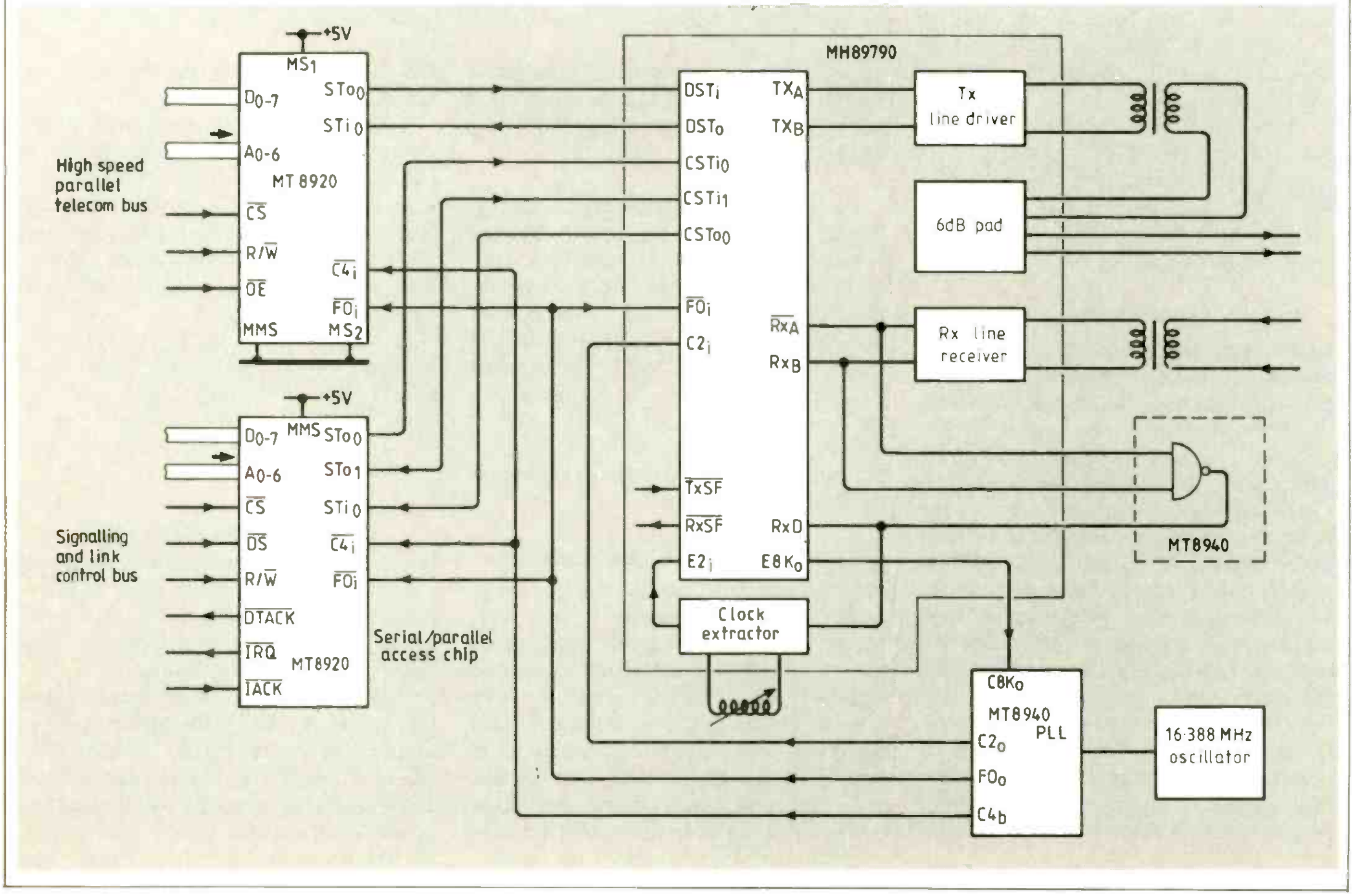


Fig.4. Network terminating unit for ISDN, providing a transition from echo-cancelling two-wire operation to four-wire subscriber distribution.

Semiconductor manufacturers are investing heavily for the future needs of ISDN users, whether they are existing telecomms equipment manufacturers who are changing from analogue to digital, or the massive range of datacomms users who will want access to this simple standard communications network.

Telecomms semiconductor companies will also find themselves offering software for the higher levels of protocol to be used on the ISDN D channel. Signalling will conform to the OSI seven-layer model, with layer 1 being the interchange level and higher layers linking the application to the interchange.

Fig.5. ISDN primary access interface. The MH89790 device is a thick-film hybrid.



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CIRCLE NO. 109 ON REPLY CARD

SMD reworking

Assembling surface-mount components is only part of the story. When a board fails, you need to repair it.

Barry Morris outlines how.

Because surface-mounted devices have no leads to go through the printed-circuit board you do not have to worry about getting solder out of plated-through holes. Does this mean that you can throw away your vacuum desoldering machines? Unfortunately not, because you will still have a fair number of conventional leaded components around for some time, as most manufacturers are still making so called 'mixed-technology' boards, i.e., boards containing a mixture of surface-mounted and leaded devices.

What techniques and equipments are required for these new components? Can you make use of any existing soldering/desoldering equipment? That depends on various factors such as:

- The type and size of components being used.
- Density of components on the PCB.
- Components on both sides of the board.
- The type and style of the printed circuit board; whether it is single or double sided, what the PCB material is made of, whether it is a mixed technology board.
- Skill of the personnel expected to carry out the rework.
- Is the rework carried out on the shopfloor, in the laboratory or maybe in the field?

Rework techniques

When dealing with conventional leaded components, a vacuum operated desoldering machine, with a selection of different sized nozzles to cater for different lead and pad diameters, is generally all that is required for removal.

But unfortunately there isn't one machine or one technique that can be used for all SMDs. The rework procedure is fundamentally different in that instead of removing the solder from

---

Micromachining

Back in 1954, Bell Laboratories etched microminiature structures on silicon, but it is only in the past couple of years that micromachining as a method of making sensors has been taken seriously.

Silicon has near perfect elasticity, strength comparable to steel and a density similar to aluminium. It conducts heat at a uniform and easily measurable rate, making it an ideal material for sensors.

There are already commercial applications of micromachined silicon; you can find it in disposable blood-pressure sensors, tyre leakage detectors and gravity-force meters in jet fighters.

Micromachining has opened up new application areas for pressure and vibration sensing, but it is the new potential applications that could have the most profound effect in the manufacturing world.

Capacitive tactile arrays for robots, for example, have already been produced. Cameras guide a robot arm to an object, but when it comes to telling whether or not the object has been successfully grasped, touch sensors give much more useful information.

Numerous applications like touch sensing are at various stages of development – acceleration measurement, flow sensing, motion detection, etc. – but new devices have been made that as yet have no clear applications. Take the motor with the cross section the size of a human hair, for example, and the gear wheels with teeth the size of blood cells. Could they lead to submarines that travel down blood vessels and carry out microsurgery, or to tape recorders that could be slipped into your pocket without you knowing?

These photographs of work done at Novasensors in Freemont, California will give you some idea of the capabilities of micromachining.

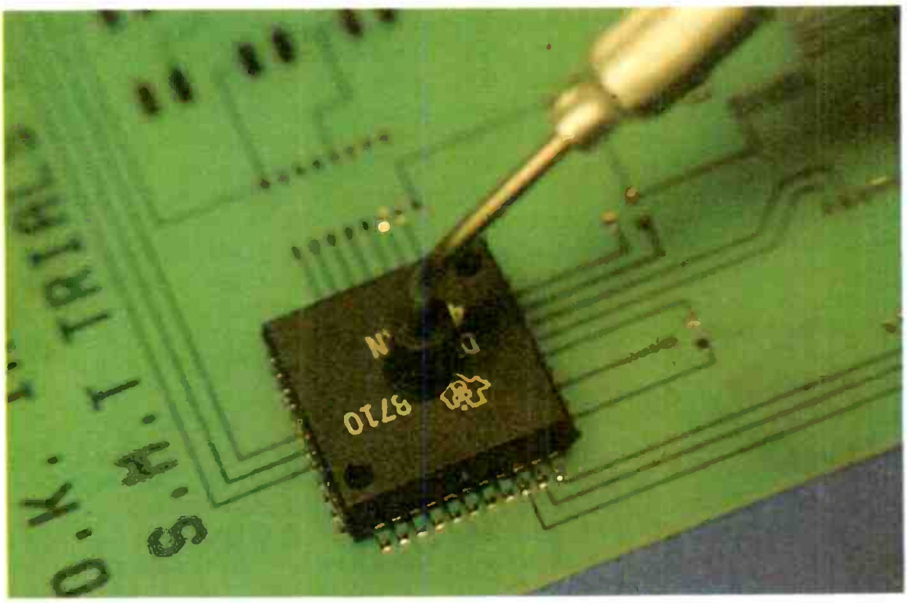
Catheter sensor chips in relation to the hollows on a golf ball.

each joint and then removing the component, with SMDs we do the opposite, you need to simultaneously reflow all the solder connections, remove the component and then remove excess solder.

Care is needed when handling SMD components as they are very fragile. Either use tweezers or a vacuum pencil – not fingers. If a vacuum pencil is not available then tweezers with an angled flat end are preferable to the pointed variety. The tweezers should lightly grip across the body of the component, not the metallising, as this can cause damage.

If you need to check component values, rather than use test probes, it is safer to use specially designed probe/tweezers.

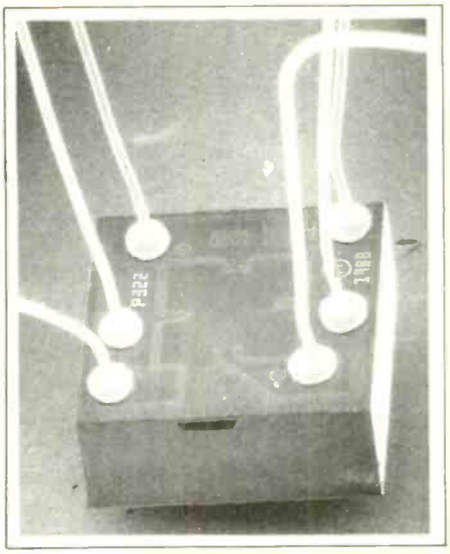
If the assembly to be reworked was wave soldered the components would have been bonded with an adhesive. This will present no problem if you are aware of its presence. Surface-mounting adhesives are designed to soften easily when heated and they have a low shear strength.



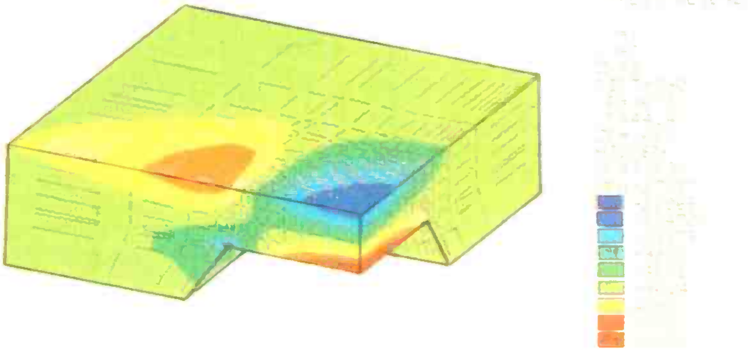
Placing with a vacuum pencil. Surface mount components require special handling techniques due to their small physical size.

There is no need to re-apply adhesive when replacing a component. Occasionally, however, thermally conductive adhesives are used for heat dissipation; if this is the case then adhesive should be re-applied.

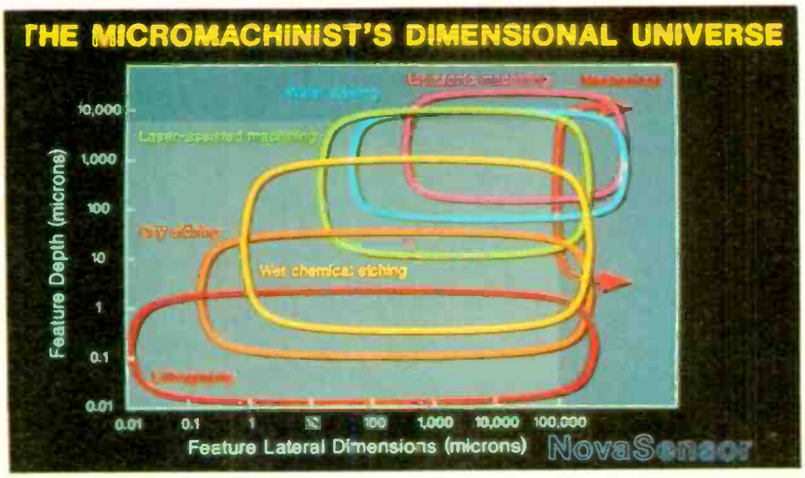
With many of the larger packages that are designed to sit flat on the PCB, such as flat packs and leaded chip carriers, flux applied during initial assembly may



Above: This 1mm-by-1mm pressure-sensor chip is used in a consumer application.



Upper right: Part of the sensor design work, this finite-element analysis shows stresses that occur when the pressure sensor is subjected to vertical load.



Right: Micromachinists have various tools at their disposal.

have been drawn under the package by capillary action and this can act as an adhesive. Application of heat to the bottom of the PCB will help to soften any adhesive or flux present. Underside heating of the substrate is normally recommended for larger components especially when mounted on ceramic substrates, as localized heating can cause stress fractures. Ceramic can also absorb a large amount of heat, causing the reflow operation to be extended unnecessarily.

A range of hot-plates is available and many of the larger hot air machines have an underside heating facility.

Heatsinks on components and other obstructions should, if possible, be removed before rework. If the heatsink cannot be removed, in the case of heat ladders bonded to the substrate, or on copper-invar substrate, then it will be helpful to place the complete assembly in an oven at 60-80°C for 30 minutes. Some larger rework machines have hot-plates capable of pre-heating the overall area of the substrate.

Mild flux should normally be applied to the joint areas before removal – even if using nitrogen. The flux helps the thermal transfer as well as stopping solder spikes (icicles) occurring.

Temperatures of the desoldering operation should be kept as low as possible, 260°C. Most SMDs are capable of withstanding 260°C. for between 5 and 10 seconds.

Components with silver/palladium metallising require soldering with a tin/lead/silver solder. This has a lower melting point than 60/40 tin/lead, of 179°C instead of 188°C. It makes sense to use this solder for all rework operations. Tin/lead/silver, so called LMP solder, is available in wire form – 26 SWG is recommended – as well as in paste form.

Solder paste should be applied from a pressure dispenser with duration and flow controls so that the correct amount of solder is applied to each and every pad. Paste should not be used with direct contact heating methods, as there is a danger that solder that may be between the pins of the component may not be melted. After using solder paste ensure that no solder balling has occurred around the component.

Recent components

Some of the components coming into use such as very-small-outline VSOPs, tape-automated bonding TAB, and Jedec outline flatpacks have fine leads radiating out on a very small pitch of less than 0.025in. This means that manual fitting and removal, while not impossible, will be extremely difficult.

Barry Morris is course director with Advanced Rework Technology of Colchester.

SMD REMOVAL EQUIPMENT

A temperature controlled soldering iron at 260°C can be used to remove simple components, such as chip and MELF devices.

The procedure is to fit a tip to the soldering iron of a size that is just large enough to bridge both ends of the component. Apply a little liquid flux to the connections. Place the soldering iron tip so that its flat face is in contact with both ends of the component connections. When the solder melts remove the component with tweezers, twisting gently, if necessary, to break any adhesive bond. Allow the PCB to cool for a few minutes and remove any excess solder with desoldering braid.

Replacement is a simple method of applying a little flux to the connections and placing the new component into position. The soldering iron should be fitted with a small tip which is liberally tinned. It is then placed into position to come into contact with the copper pad and gently brought near to the end of the component until the solder flows. To minimise any damage make sure that the tip does not come into direct contact with the component.

There are numerous alternatives to the soldering iron.

Soldering irons with special tips

Advantage: can be used to remove a variety of components as long as a tip of the correct size and shape is available, making them suitable for field use.

Disadvantages: cannot be used for the larger ICs, especially flat packs, chip carriers and tape automated bonding components. Replacement is carried out with a soldering iron fitted with a small tip, but unless great care is taken, there is a possibility of short circuits occurring.

Components that can be removed with this technique are cubic-chip, MELF, SOT, SOIC and smaller PLCCs of up to 44 pins.

Vacuum-desoldering machine

With special reflow heads, a vacuum desoldering machine can be used.

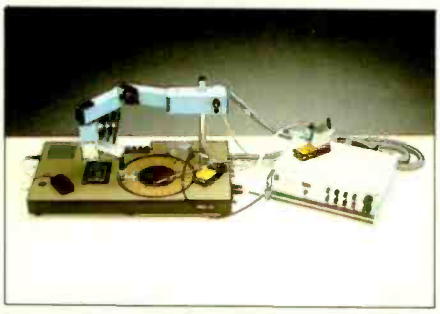
Advantages: This type of machine may already be available in the workshop. A cheap simple technique for removing SOICs and flat packs. Some machines can blow hot air for use as a hot-air pencil, described later.

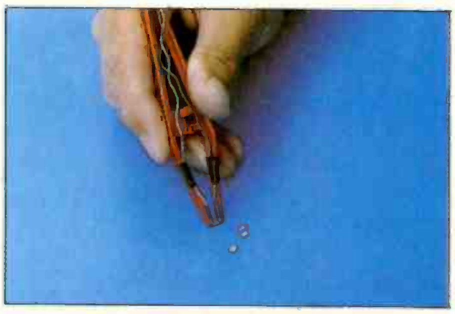
Disadvantages: needs a degree of operator skill. As with the previous technique this cannot be used to replace a component.

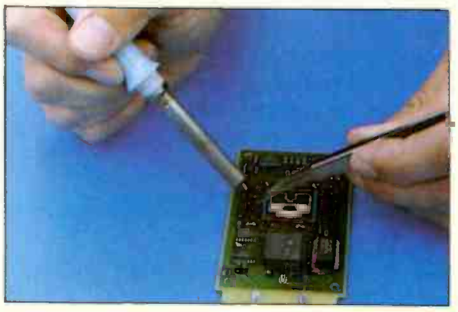
Components removed: SOIC, quad flat packs.

Heated tweezers

Two types are available, one providing pulse heat and the other continuous.







From left to right, top to bottom, a hot-gas manual pick-and-place machine for small-volume users (Weller), tweezers modified for probing surface-mount devices, a vacuum pencil and specially formed tweezers for surface-mount component handling, a solder-paste dispenser (dispensing paste manually is difficult) and a hot-air pencil for manual soldering.

SMT – dream or reality

Some would disagree with Andrew Turner's comment about washing machines but on the whole, he makes some pertinent points about surface mount technology.

Surface-mount components and the technology to place them on to the PCB and solder them into position have been around for some years. Looking to the future, equipment manufacturers have instigated development programmes to ensure that their companies are in a strong position to meet a growing trend. And component manufacturers and suppliers have predicted dramatic growth for surface-mounted components of all types and are daily adding to their list of component types.

These factors would seem to suggest that unless your products are designed for surface-mount or you are in the process of changing over then you will be out on a limb, clinging to the old-fashioned technology of wire-leaded components. But until prices fall, the only advantage for most potential SMD users is reduced board size; the ability to pack ever more sophisticated circuitry into a smaller space is fine if you are manufacturing hand-held radios, but it is not exactly useful if your product is a washing machine.

For some companies surface-mount technology was a necessity and they are heavily committed. However, examination of component supplier figures, while showing substantial growth in SMDs, also shows growth in leaded components.

As an equipment manufacturer we have a range that encompasses both leaded components (component-preforming equipment) and SMD technology, (pick-and-place machines, infrared reflow and twin-wave solderers) and yet while being encouraged by the numbers of companies talking about SMD technology we are discouraged by the lack of action.

When we developed component-preforming equipment we were one of a small number of companies world wide struggling to keep pace with the demand; with SMD technology we are one of a rapidly growing number of manufacturers/suppliers chasing a market yet to convince itself that its moving in the right direction. The choice of equipment is large and growing, most of it being imported, with many different suppliers offering manual, semi-automatic and fully automatic machines and systems.

There are of course still major problems with SMD, not the least of which is heat dissipation. We have seen a large increase in demand for thick-lead preforming equipment, much of which is caused by growth in switch-mode power-supply business. Demand is particularly high for equipment that can handle power diodes with 1.5mm leads; a minute surface-mount component capable of dissipating the power of such large leaded diodes is impracticable.

Eventually I have no doubt that SMD technology will be used by everyone, but that time seems to get further away as time passes.

Andrew Turner is Sales Manager with Elite Engineering of Fareham.

Advantages: relatively cheap, fast, portable.
Disadvantages: cannot be used for replacement, care needed to ensure that the tips do not mark the board.
Components removed: cubic and MELF components, SOTs.

Hot-gas pencil
These devices include portable gas-operated tools.
Advantages: relatively cheap, portable, non-contact method, can be used for a range of components and can be used to replace some components.
Disadvantages: low thermal transfer, heats whole component, needs some skill.
Components removed: cubic and MELF components, SOTs and SOICs with up to 16 connections.

Thermal/hot-bar soldering
Advantage: contact heating, heats only component connections, ideal for flat pack removal and replacement, most machines have vacuum pick up and allow precise alignment of component; fast, 3-4 seconds for reflow.
Disadvantages: limited, cannot be used for field work. Expensive.
Components removed: quad flat-packs, TAB.

Hot air machine
Advantages: can be used for a large range of components, the only technique that can be used for large PLCCs and LCCCs, heat focus heads give localised heating, many machines have either a built in hot plate or a bottom mounted hot air jet, most machines have vacuum pick up for the component. Some have timers to semi-automate the gas flow.
Disadvantages: expensive, long time for reflow (typically 30 seconds), not recommended for TAB, quite large (bench mounting) therefore they cannot be used in the field, specific heads required for each component.
Components removed: will remove and refit most components, but it is not ideal for the smaller cubic, MELF and SOT packages.

Focused infra-red
Advantages: can be used for a large range of components, no need for separate heads for different components (adjustable iris), non-contact heating, faster than hot air, built in hot plate.
Disadvantages: care needed in use to avoid overheating component body.

Angled side cutters
These can be used for the removal of SOICs, PLCCs and most leaded components.
Advantages: small, cheap, portable.
Disadvantages: damages the component. Care needed to ensure that the PCB is not damaged. Replacement is with a soldering iron (difficult to realign).

Heat gun
Most components can be removed by directing the hot air stream at the component to be removed.
Advantages: easily portable, most workshops already have them.
Disadvantages: difficult to control the temperature, the hot air can spread to adjacent components as well as the PCB, danger of damage to the assembly, although the area can be masked by using either temporary solder mask or polyimide tape over adjacent areas. To help to overcome any overheating problem, a temperature sensitive lacquer can be applied to the component corners to indicate when the reflow temperature has been reached.

Disappearing robots

Britain's labour costs are slowing down the introduction of robots in the electronics industry; are we in danger of falling behind our competitors? John Dwyer, editor of the FT's Advanced Manufacturing newsletter, reports.

The British industrial robot industry is a hazardous area that ranks with any of those ships full of dioxins that keep turning up in Wales. In the early 1980s the robot was seen as the symbol of UK industrial regeneration. British industry, perhaps to its credit, didn't take much notice. The list of liquidations and receiverships lengthened.

At the UK robot industry's once-every-two-year exhibition earlier this year it seemed the picture was changing. Even UK-based robot-systems sellers were talking about expanding markets. The main reason is the lack of myriad tiny competitors willing to quote silly low prices for industrial robot installations.

Most of the survivors still think there's a killing to be made in the UK automated-assembly market. The main target is the electronics industry. In particular, they are looking at the market for the automatic insertion of odd-form components into printed circuit boards (PCBs), though other possibilities include assembly systems for electromechanical components such as switches and for domestic-appliance companies such as Black & Decker.

Makers of high-accuracy assembly robots have long predicted big sales from such applications. These have materialised in Germany and Japan but not in the UK.

All types of assembly accounted for 87 of the 620 robots installed in the UK in 1987. In 1988 the number of robots installed in the electrical and electronics industries dropped 63 per cent to 32, despite an 18 per cent rise in the total robot market. UK manufacturers bought 731 robots last year (well below the 1984 peak), taking the total to 5034. That's how many the depressed US market buys in a year.

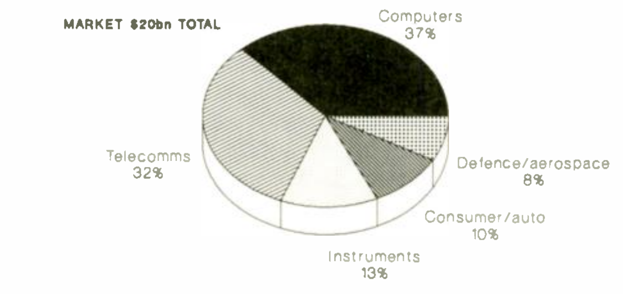
Ironically, the British Robot Association has a theory that UK manufacturers are now buying robots to replace labour which is in short supply rather than, as happened in the early 1980s, labour which is over-abundant. BRA chairman David Teale of IBM says humans find "board-stuffing" too repetitive and a machine can do it more quickly and reliably.

This is not the whole story. The latest PCBs hold surface-mounted devices (SMDs). These have to be placed more accurately than humans can manage. Surface-mount economics require high throughput using dedicated machines that can mount standard components at a rate of eight to 12 thousand an hour. Not robots. A robot can manage about three a minute, so its use is confined to inserting large, odd-form components.

Multi-head grippers improve a robot's work rate. But heavier components, such as transformers, plus the weight of the gripper itself, begin to affect the speed of the robot. And if a head heavy with gripper and components presses an SMD too hard on to the board, solder is squeezed out from under it and, when the board is heated to make the solder melt, spreads to adjacent circuit tracks.

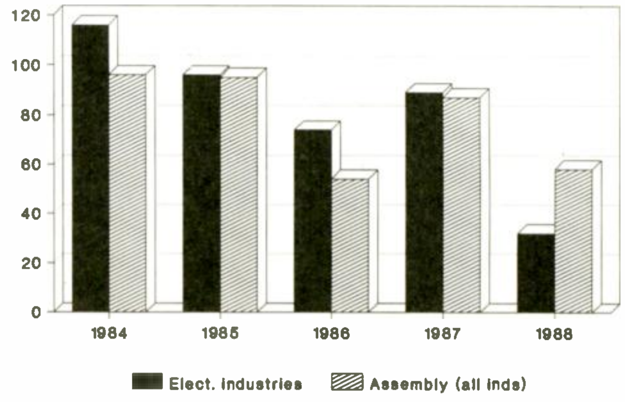
One big barrier to assembly automation is that products are not designed for it. But the inherent problem in the UK market is that, by the time a company has redesigned a product to make it simple enough even for a robot to assemble, humans make an even better (and cheaper) job of it. A CBI report a year ago showed that UK total unit costs are the same as those of the UK's best competitors, even though UK labour costs are about two-thirds of those in competitor countries. Philip Binding, UK sales manager of Swiss robot maker

PCB PRODUCTION
WORLD MARKET (1990)



Source: Benn's Electronics Data

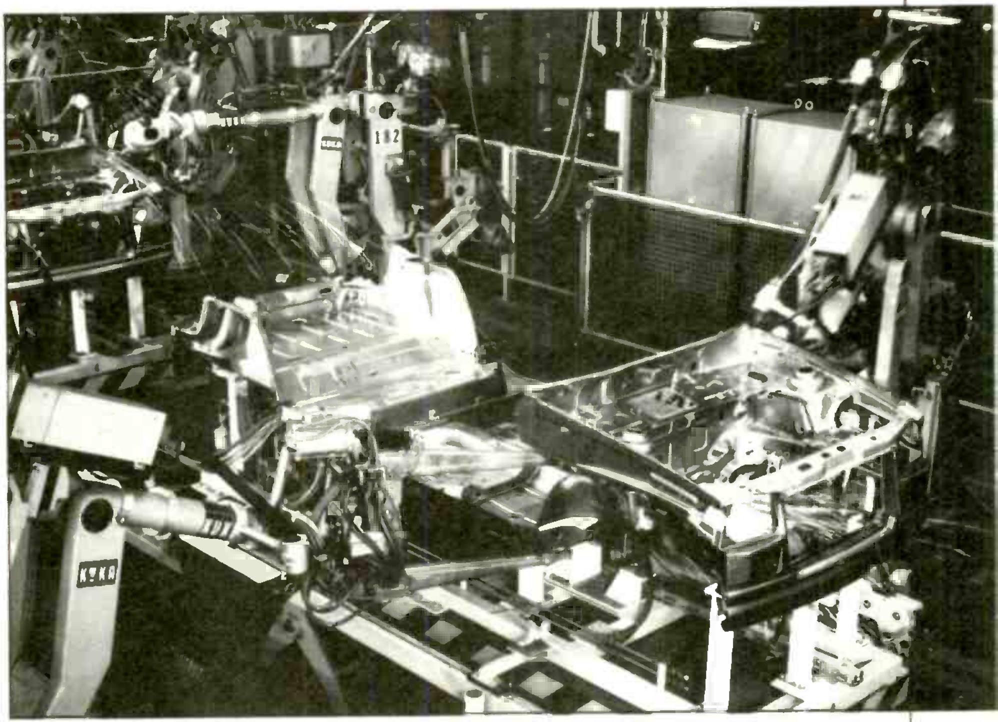
UK ROBOT INSTALLATIONS



Source British Robot Association

Staubli Unimation, acknowledges that "the only people with lower labour rates than the UK are the Spanish."

The result of all this is a lot of inward investment in the UK by electronics companies like Korean TV maker Tatung. Its factory in Telford is an organisational showpiece but uses very little automation – just rows of women stuffing PCBs. Two years ago, Unimation's sales and support business moved to West Germany and the future of its Telford operation was in doubt. Now its successor, Staubli Unimation, expects to be selling 1000 machines a year by 1992 against a current rate of 450 a year. Ironically, the low UK labour rates that have stifled the UK robot business have made the UK an ideal place to make the robots for export to places where rewards on the shop floor are treated as seriously as those in the boardroom.



Robots are good – and cheap enough – at delicate little jobs like this.

Is SMT for you?

There are no short cuts to surface-mount technology, argues Martin Wickham, but starting small is the safest option.

The take-up of surface mount technology (SMT) has certainly not been at the optimistic rate which pundits predicted in the early eighties, but it continues to make substantial inroads into many sectors of the electronics industry. Indeed there are few voices, if any, who would disagree with the synopsis that SMT will become the primary method of assembling electronic circuits.

Current estimates of its penetration into the UK electronics assembly market run at about 12-15%. The majority of this usage is in mixed technology: the use of both surface mount and conventional leaded components on the same printed circuit board. Estimates for world-wide production are higher, with some reports already putting Far East usage of surface mount over the 50% mark. There's no doubt, surface mount has come to stay.

The three main reasons for this slower than expected take-up of the technology relate to the perceived costs of SMT.

Capital Investment. Most of the design, assembly, inspection and test equipment needed on an SMT production line are new or improved items. Even wave soldering machines may need to be upgraded to get the best from SMT. Although boards can be and in many cases are assembled manually, implementation budgets of less than £30 000 will certainly not cover quality automated pick and place equipment.

Component Costs. The increased costs of some SM components deters many potential users. A quick totting up of the catalogue prices of SM equivalents of the components on an existing board suggests a 50% increase in the bill and the investigation stops there. But some SM components already cost less than their conventional equivalents. When SMT becomes the dominant technology, OEMs will find themselves paying a premium on conventional components.

Devaluation of Investments. Many companies have already made extensive investments in automated assembly equipment for conventional components and extremely persuasive arguments are required to justify additional investment on equipment which may prematurely be devalued by this new spending.

Despite these problems SMT has been implemented successfully in many sectors of electronics. It is misleading to quote specific examples as nearly every user has its own "application specific" reasons for working with the technology. However, a number of common themes can be drawn;

Smaller Size. It is probably the greater component densities achievable with SMT that has been the most common reason for the take-up of the technology in the UK. The lead certainly came from the defence and telecoms sectors of industry and has more recently expanded into other areas. Many products such as pocket telephones, radio pagers and high density computer drives would not be feasible without SMT.

Less Weight. Reduced size often means reduced weight and for many applications, particularly aerospace, this has been a major influence. A pocket phone would weigh over 2½kg if built with conventional electronics; some pocket phones currently weigh less than ½kg.

Greater Speed. The much closer spacing of components assembled with SMT means that circuits have shorter signal paths and less parasitic reactances (lead inductance and capacitance), giving better high frequency performance.

Improved Costs. Many users do pay a price premium for their denser circuits, but others have used SMT to lower manufacturing costs. Those OEMs who don't need the sophisticated high-density approach, can opt to lay out their designs in as much space as possible. This makes assembly easier and post-soldering yields much higher.

Because the placement of an SM device does not require manipulation of its leads as its conventional equivalent does, SMT lends itself to low cost, automated assembly. This is the main reason for its popularity in the Far East.

In the UK, at least one manufacturer has lowered costs as a result of SMT. By redesigning its PCBs for SMT, the company has increased the number of functional modules on the board in the same physical area. Although this results in redundancy, it has meant that one board covers a variety of applications that previously needed a range of boards.

Manufacturing a smaller variety of boards has meant a 20% increase in yield, less work-in-progress, less rework, shorter lead times and less scrap*. Not only did this improve manufacturing costs, but it also led to a better quality product.

Keeping Up With The Jones's. For many OEMs, the decision to opt for SMT is taken for them by their competitors. When their market rivals introduce a product into the marketplace which incorporates SMT, unless their own products follow suit, they can lose a significant market share. In many cases there has been no reason for using SMT other than as a marketing tool.

No Other Choice. Unfortunately some companies have been forced to use the technology because components are only available in SM format. High pin count devices such as memory and display drivers fall into this category.

Other Issues. The decision on whether or not to introduce SMT is certainly not one to be taken lightly. If an existing design is fulfilling its specification adequately, it probably wouldn't be sensible to redesign it for SMT as the costs would be prohibitive. But for new designs, the choice is not so easy. At present there may be no driving force at all to use SMT, but in the future there may well be cost, technological or marketing benefits. There are no short cuts in the implementation process. There is a learning curve to be climbed and the earlier a company can scale the curve, the quicker they will be able to profit from the benefits of surface mount.

Those companies who start at the "low tech" end of surface mount, just assembling a few devices at a time, and then build up to more complex boards, usually achieve a successful and relatively inexpensive introduction of SMT. The real recipe for disaster is the 100% surface mount board first time. It may not break a company but it will also certainly cost them a great deal.

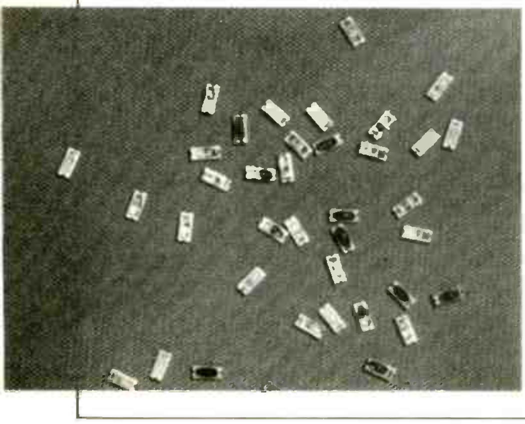
*Proceedings of the "Surface Mount in Context" Seminar,. London, March 16th '88.

Martin Wickham is Secretary and Technical Officer of the NPL's Surface Mount Club.

Make a start with SMDs

There are numerous ways of getting into surface-mount technology, and plenty of things to watch out for. Terry Pruce discusses entry options and pitfalls.

Surface-mount technology is a method of production that capitalizes on advances in component design and production techniques. Components are smaller, more robust and show a better resistance to heat than conventional leaded parts. Because they do not have leads, they depend upon the solder joint for their mechanical fixing.



With leds this size – 3 by 1.3 by 0.9mm – you could easily make your own displays.

The placement of surface-mount devices is relational, as opposed to the go/no-go process of trying to stuff leaded components through holes. Easing this critical process has enabled assembly equipment manufacturers to build 'pick-and-place' machines for less cost than their equivalent automatic-insertion machines. For example, a fully-automatic PC controller to place 2000 components per hour can be purchased for around £11 000.

A manufacturer using surface-mount technology benefits in lower costs and improved reliability. As well as lower capital cost to achieve the same output as with leaded components, there is also lower board material cost; small SMDs need less space, which leads to higher component density. Lower production costs, greater flexibility and smaller work space, result in lower running costs and more efficient use of manpower.

Surface-mount devices use less materials and modern production technology gives greater yields. At the moment, some SMDs command small premiums since their usage volumes are lower than their leaded equivalents, but this should soon disappear. Surface-mount devices do not require drilled holes, so that only electrical vias are necessary. This makes it practicable to use both sides of a PCB with SMDs, each side being a separate circuit; the lack of holes also aids layout. The most obvious advantages are with multilayer boards, where one or two layers could be saved to give a significant reduction in PCB cost. Since the components have no leads, there are no lead failures, so rework and maintenance are reduced.

Prototyping with SMDs

Prototyping with SMDs is fun: once you get over the shock of seeing such small parts you realise that the components are rugged, the finished circuits are elegant and, because surface-mount components are so small, you can afford to be generous in your layout.

Making a good SMT circuit is easy – no need to drill holes and no mirror-image tracking, since the SMDs sit on the copper. Removing components is easy too, since you are working on the component side of the board. There are no wires to pull through holes, and parts such as chip resistors and capacitors are simple to heat and lift off. Integrated circuits can be lifted by heating each pin and slipping a feeler gauge between pin and track.

Technically, shorter leads give better HF performance, with reduced parasitic capacitance and inductance. Closer grouping also allows faster processing speeds.

How to do it

For surface-mount assembly, you need tweezers, a reflow oven and solder cream or a small soldering iron with a fine tip and fine solder, and a vision aid.

You do not need expensive placement machines. SMDs can be hand placed; most hybrid manufacturers have been hand placing for years on low-volume products.

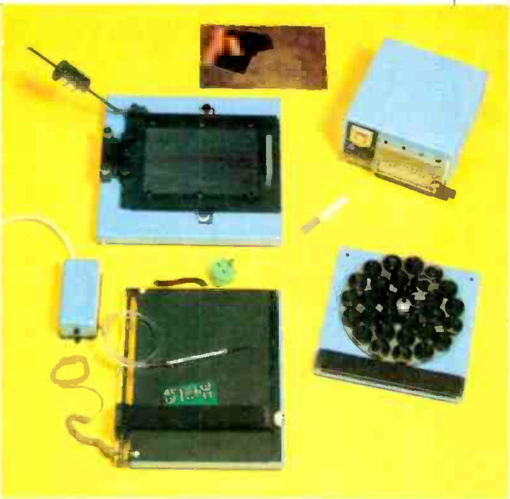
If you are using a reflow oven, solder cream is applied to the PCB footprints either by silk screening/stencilling or by a dispenser. The devices are hand placed and the board is placed in the oven and watched until reflow is complete.

Double-sided prototypes use solder creams with two different melting points. The higher temperature paste is used first, the oven temperature is then reduced to the lower melting point, the reverse side of the board is cleaned and the process is repeated.

Hand soldering SMDs with an iron is the cheapest way to make prototypes. I suggest that pre-tinning the pads avoids shorting problems with fine-pitch ICs; tinned pads then contain sufficient solder to ensure a reliable joint which only needs a mildly activated flux and heat to complete the reflow process.

Chip capacitors and resistors, being made of ceramic, conduct heat very quickly, so do not linger or you may find that you are desoldering one end while trying to solder the other. Transistors are so small that nerves can get in the way; try tacking one pin down and then going round all the pins producing nice bright joints. Do not use excessive solder; it is simply not needed.

Integrated circuits can be tacked on in the same way, or you can use a piece of Blue Tack to one side or underneath to hold the part in place. Pretinned pads should provide sufficient solder.



Surface-mount start-up kit, consisting of an infra-red reflow oven, a vacuum pick-up pencil, anti-static handling equipment and a screen printer.

Further reading

Surface Mount Technology – The future of electronics assembly, by C. H. Mangin and S. McClelland, is a comprehensive manual covering every aspect of SMT from economics and circuit design to soldering and testing. The publishers are IFS.

Soldering Handbook, by Ray Skipp, publishers BSP, contains a chapter dedicated to surface mount.

Terry Pruce is Marketing Director of Flint Distribution, which concentrates solely on surface-mount technology.

DISTRIBUTOR

There are some very good, indeed excellent distributors. I am very mindful of that fact, but all of them are hindered by their lack of appreciation of the process sensitivity of SMDs. Tarnishing is a very major problem; poor component solderability is the major cause of unreliable joints.

Remember that small solderable areas and gentle fluxes cannot overcome even slightly reduced solderability.

The way a distributor handles even top-quality components can severely affect their solderability. Sweat deposits, coughing/sneezing, damp storage conditions and long shelf life in a dusty or static-prone environment can cause the hardiest of parts to fail. Even loose components in plastic bags pick up contamination from the bag and each other.

When do you detect a problem? Is it in goods inwards, or on the rework bench? Both are very costly – the latter extremely so. Finding that you have a problem is where the fun begins – is it the process, is it the part, is it the temperature profile, the board, the flux, the cleaning? There are so many variables.

Insist on the following: only buy parts still sealed in their taped packaging: this does not mean a full reel, just get your distributor to cut off the tape at the quantity you require. Protected by the tape the SMDs are less likely to tarnish from touch.

Buy from British Standards approved distributors and insist on a certificate of conformance, giving maker, batch number and date code. Remember that BS conformance does not cover ageing.

Give all incoming SMDs a visual inspection and check their tape-peel strength. Take particular care over parts more than six months old and maintain good hygiene through to production. Continue batch traceability to final test. It also helps to visit your suppliers once a year or so.

AVAILABILITY OF SURFACE-MOUNT COMPONENTS

Best availability. Resistors of 2% tolerance, 0.125W and 0.1W. MLC capacitors at 50V 10pF-100nF, both in 0805/1206 sizes. Tantalum 10nF to 100µF.

Good availability. Popular SOT23s, HC/HCT, 4000B logic, popular linears, memories, microprocessors, rectifier diodes, resistors 1% E24, MLC capacitors sizes 1210 and 1812, 10079F-47079F.

Problem areas. E96 1% resistors, 0.25W resistors and less than 100 ppm stability, SOT89 packages, LS TTL, inductors, mini-melf zeners, mini-melf resistors and capacitors, and capacitors over 100V.

Keep to leaded. Anything high power (over 1W), capacitors over 100µF, and anything overpriced.

Why is availability so important?

There is a weakness in SMT. It is at the start of the process prior to reflow or component placement. Solder creams and glues are applied by non-intelligent means, i.e. screen printing, so all component sites receive their application at the same time. These creams/glues contain solvents which evaporate within hours of application. Hence this method demands that all components are there ready to be used at the same time.

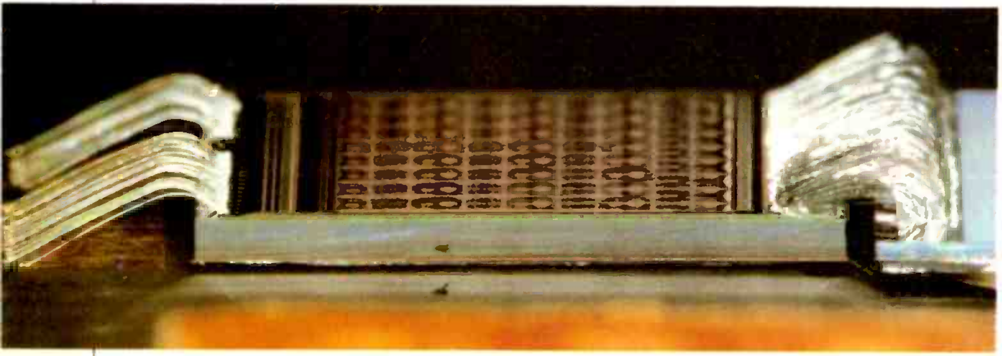
To have manual operatives chipping off glue blobs or hand placing and then reflowing is not on so, if one component is missing, no boards will be produced. The line stops, output is curtailed and profits plummet.

Rutherford Appleton Laboratory

Martin Eccles

The Science and Research Council's largest ▶ research establishment is Rutherford Appleton Laboratory in Didcot. It provides a wide range of experimental and support facilities to scientists and engineers both here and overseas.

Most of RAL's work is carried out for educational establishments but a small yet increasing proportion is done in conjunction with industry. Rutherford Appleton's major research areas are space, particle physics, neutron scattering and computing. The laboratory's other research programmes include lasers, climatology, radio propagation, image processing, microelectronics, wind energy and superconductivity.

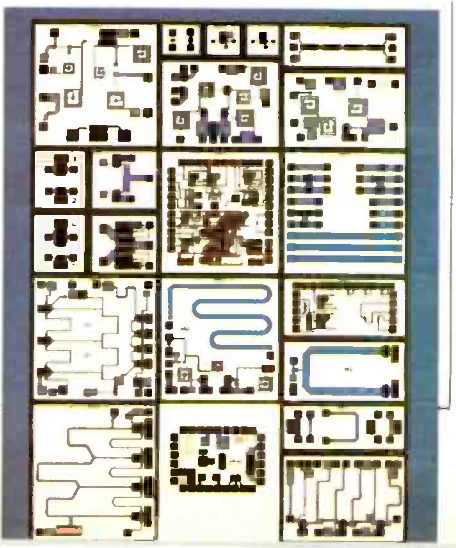


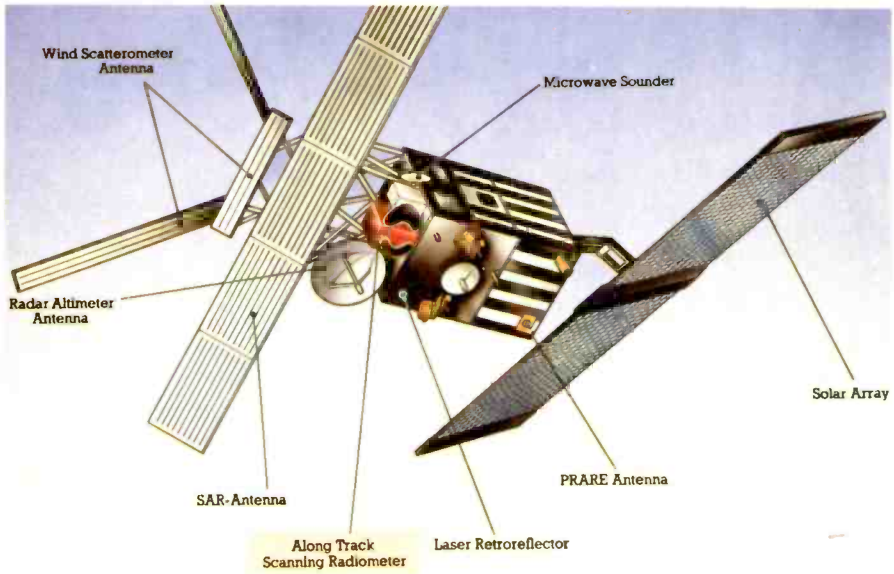
◀ Rutherford Appleton is heavily involved with CERN's LEP project described in last month's Research Notes.

One of the LEP collider's detectors is DELPHI. Its microvertex detector is located at the centre of the giant 6.2m diameter solenoid and consists of 55 000 silicon strip detectors in a small 30×30cm barrel. It detect the position of elementary particle tracks passing radially through the barrel with an accuracy of 3μm.

Energy deposited by each particle is measured by integrating the charge deposited on each strip with an accuracy of 1000 electrons. These analogue signals are read out by 55 000 preamplifiers connected to the detectors and located inside the barrel. One of the 128-channel low power (0.5mW/channel) readout chips designed at RAL is shown wire bonded to a silicon strip detector.

The Commission of the European Communities jointly awarded RAL a contract to form the service organisation to support the European VLSI Design Action recently launched as part of the ESPRIT programme. Objectives of the action are to provide on a European scale access for academic institutions to industrial processing facilities and training in VLSI design for about 3000 additional engineers per year. A total of 118 European universities and polytechnics including 38 from the UK have been selected to take part. RAL will provide direct support to the UK participants. An example of the first GaAs MMIC multi-project chip coodinated by RAL for UK universities under an existing national scheme is shown. ▼

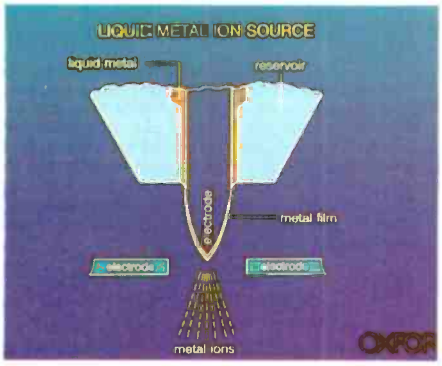


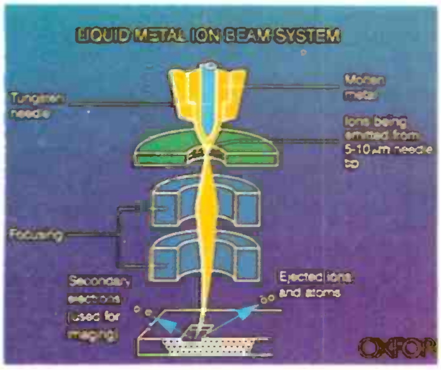


Monitoring of global warming is vital but it is not a job that can be done in a short time scale. This apparatus – called Along Track Scanning Radiometer, or ATSR – is an infra-red scanner that will measure sea-surface temperature to within a half kelvin but it will not be operational until 1990.

European Space Agency's first remote-sensing satellite, ERS-1, will carry the radiometer. In order to correct the effects of the atmosphere, ATSR actually has two scanning paths, one looking directly down at the sea and one looking at an angle. The difference between the two scans is used to calculate what effect the atmosphere is having.

Satellite equipment doesn't usually contain state-of-the-art electronics – in the interests of reliability it is better to use tried and tested apparatus. The most innovative device on the radiometer is the cooler for the infra-red detector. It is the first long-life helium pump specified for space use. The pump was developed jointly by RAL and Oxford University, and B Ae now has a licence to produce it commercially.

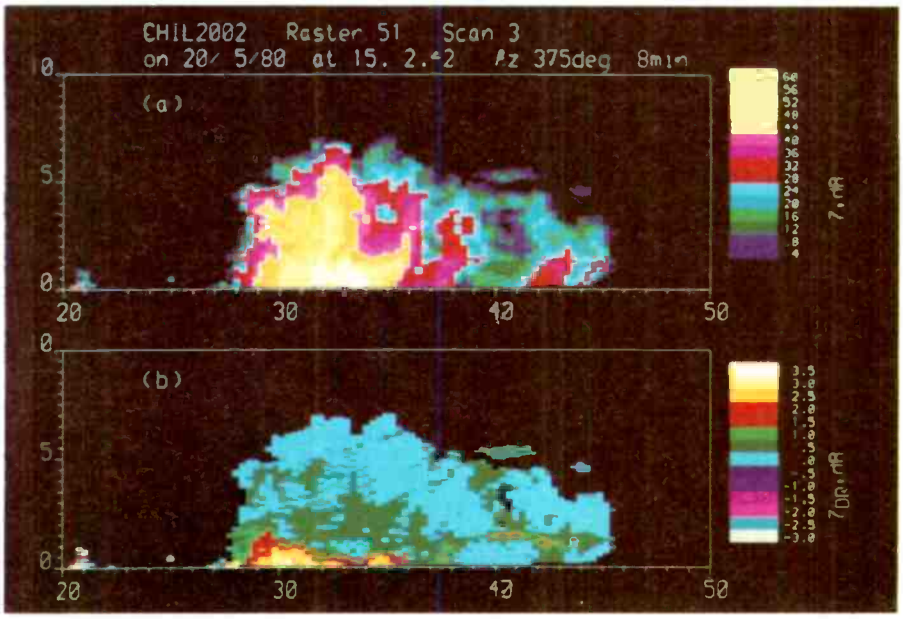




▲When masks for chip manufacture are made they are rarely perfect first time and need to be trimmed. Existing repair systems use a laser to zap unwanted areas with a resolution of 1-2µm.

Equipment implementing the new ion-beam technique depicted here has just been installed in RAL's electron-beam lithography facility. Not only can it remove opaque sections with a resolution of 0.1µm but, by the introduction of carbon into the focussed galium ion beam, it can build up opaque sections.

Much of the development work for the Oxford Instruments ion-beam machine was done at RAL.



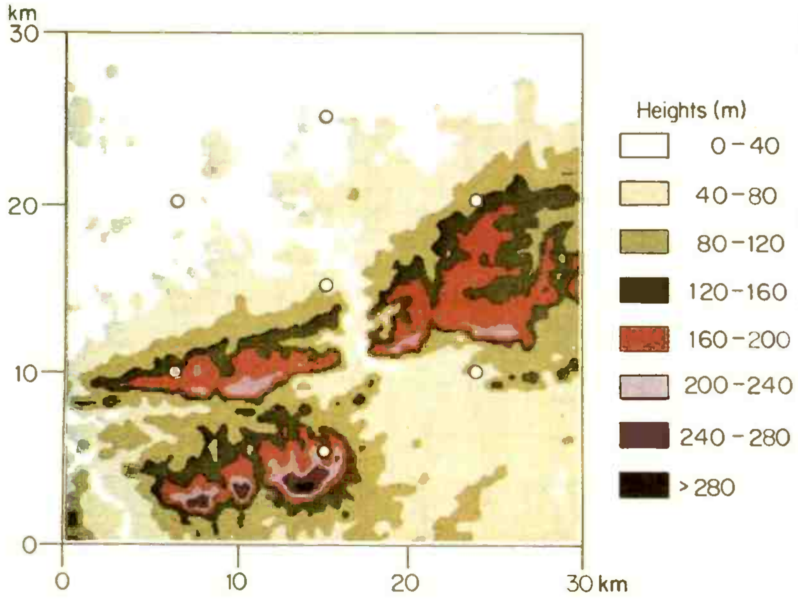
▲ Current weather radar systems can map out water concentrations in the atmosphere but give no information about whether the water droplets are ice or not. As a result of recent dual-polarization radar developments at RAL, meterorologists can now determine at what height water droplets are freezing.

You can see from these photographs that conventional techniques, top, only indicate where the water droplets are in the atmosphere whereas dual-polarization radar, bottom, allows you to see at what height the water droplets become ice; with frozen water there is little difference between radar returns from horizontal or vertically-polarized beams, hence the predominantly blue area higher up.

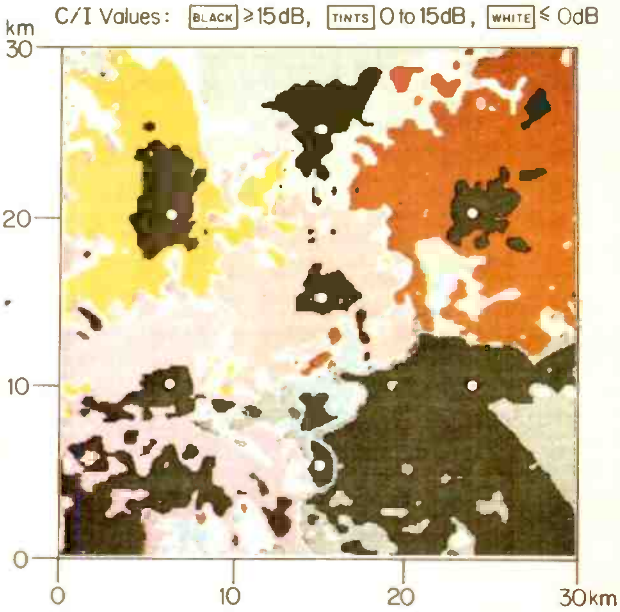
Researches are currently investigating differential and cross-polar returns with a view to examining droplet orientation as well as size, distribution and type.

With the ultimate aim of reducing cell size in cellular radio, RAL's Radio Propagation Studies division has been evaluating models for predicting propagation. This photo shows predictions for seven cells on terrain around Dorking.

▼



Dorking terrain features and model transmitter locations



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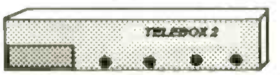

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Relative frequency shift keying

Extremely low bit-error rate, approaching Shannon's limit for an ideal system, is achieved in a new digital communication system described by F.R. Connor by using the relative frequency and phase information between two signals to separate signal power and noise power.

Information transmission in the Shannon sense can be regarded as absolute because it refers essentially to the use of a single communication channel, defined by a bandwidth W, a signal power S and a noise power N. The signal power and noise power are inextricably mixed together and ultimately the S/N ratio largely determines the quality of transmission.

Since noise has the greatest disturbing effect on the quality of transmission, it appeared to the author that one possible way of increasing the S/N ratio was to reduce N independently of S by using negative feedback, because there is a practical limit on the amount S can be increased.

In the world of communication, noise represents the physical background in which information is received. Thus, by applying the notion of relativity to information theory, it might be possible to receive information with an extremely small error rate or virtually error-free, regardless of the noise background present in the Universe, in much the same way as the Special Theory of Relativity allows the physical laws of nature to be determined correctly and independently of the physical background or frame of reference used.

To apply the ideas of relativity to information (see panel) it is necessary to transmit information by means of two channels; information can then be extracted at the receiver in a relative sense[3]. Sum and difference signals are produced, the difference containing the signal information while the sum contains noise only. The noise is fed back to cancel the input noise using a high gain negative feedback loop.

In a digital communication system, it is well known that the optimum system for transmitting digital data is coherent phase-shift keying[4] which requires a 9dB signal-to-noise ratio at the detector for an error probability of 10^{-5}. However, one disadvantage of the system is the requirement of a good phase reference at the receiver. This is difficult to achieve in practice and so some degradation is obtained by extracting a phase reference from the transmitted signal or by using differential phase-shift keying. A close alternative to coherent PSK is coherent FSK, which is inferior in performance to coherent PSK by about 3dB.

In this new system, which is called relative frequency-shift keying[3], two novel techniques are used to improve the performance of a coherent FSK system. The first technique employs precise *a priori* information at the transmitter by means of an accurately known offset frequency ω_0, while the second technique employs redundancy by transmitting a second carrier signal. The two carrier signals are shifted in frequency by the digital information to be transmitted.

At the receiver, the carrier signals are separated and correlated to produce sum and difference signals, the difference signal yielding the digital information and the sum signal containing no digital information, but only noise. The noise voltage is extracted and applied to the input of the final IF stage via a high-gain negative-feedback loop, reducing the input noise and producing a considerable improvement in the signal-to-noise ratio at the final detector. Furthermore, due to this, an extremely low bit-error rate can be achieved for the system.

System description

In **Fig. 1**, ω_c is a carrier frequency and ω_b is the bit-rate frequency of the digital data. The carrier signal and the data signal are fed into the data modulator, which shifts the frequency of the carrier. During the transmission of logic 1, the

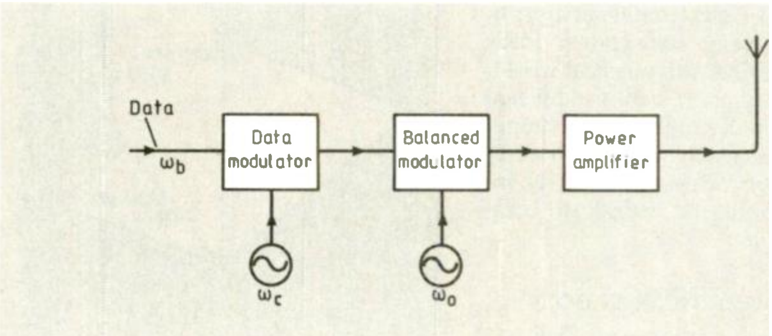

Fig. 1. Transmitter of the RFSK system. Output is two offset carriers, frequencies of which depend on data being transmitted.

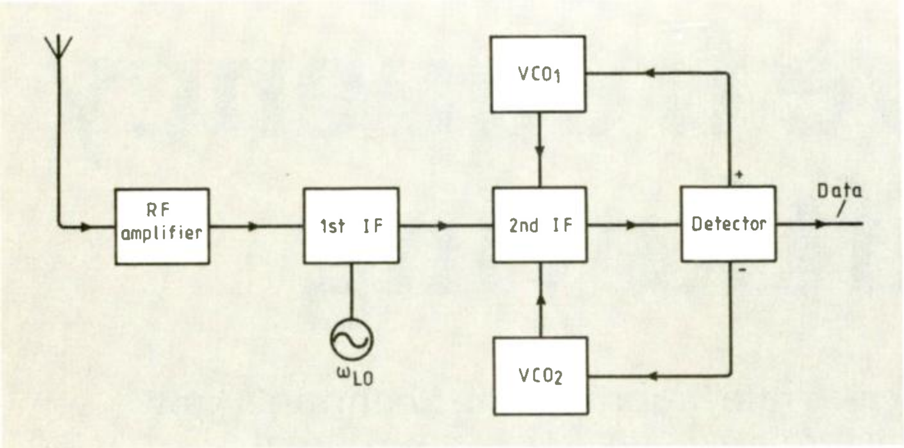

Fig. 2. RFSK receiver, which separates data and noise, the noise being fed back.

carrier frequency is shifted by ω_s and during the transmission of logic 0 the carrier frequency is unaffected.

Outputs from the data modulator and from a very stable frequency source at a frequency ω_o are fed into a balanced modulator. Its output consists of two offset carriers at upper and lower frequencies ω_u and ω_l respectively, where $\omega_u = (\omega_c+\omega_o+\omega_s)$ and $\omega_l = (\omega_c-\omega_o+\omega_s)$ during the transmission of logic 1 or $\omega_u = (\omega_c+\omega_o)$ and $\omega_l = (\omega_c - \omega_o)$ during the transmission of logic 0. The two offset carriers are subsequently amplified in a linear power amplifier prior to radiation from the antenna.

In **Fig. 2,** the receiver consists of an RF stage, two IF stages and a detector stage. The offset carriers, after RF amplification, are downconverted in the first IF stage, using an IF of ω_i and a local oscillator frequency ω_{LO} where $\omega_i = (\omega_{LO} - \omega_c)$ and $\omega_u<\omega_{LO}>\omega_l$. At the second IF stage, the two offset carriers are downconverted to the main offset frequency ω_o by the two VCOs, which are both set at ω_i.

At the detector stage, sum and difference signals are produced. The sum signal frequency is only perturbed by noise and it is used to drive the two VCOs in push-pull by negative feedback to cancel the input noise at the second IF stage and to set the two VCOs at the precise initial value of ω_i. The corresponding difference signal yields the digital data at the bit-rate frequency of ω_b.

At the detector stage shown in **Fig. 3,** the two downconverted offset carriers

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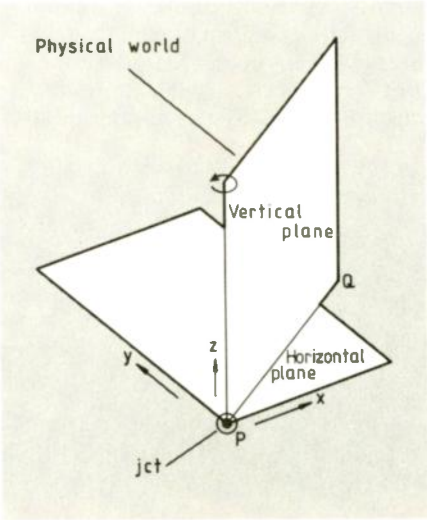
Relativity and information

It is well-known that mechanical problems can be solved by using electrical analogues and circuit theory. For example, a vibrating mechanical system can be reduced to a study of electrical oscillations; the electrical solution is then used to design the mechanical system. Again, there is a close link between the state of molecules in a gas as determined by statistical mechanics and the concept of entropy. Similar ideas were put forward by Shannon and form the basis of entropy in information theory[1]. Likewise, some of the ideas of Newtonian mechanics such as action at a distance and the inverse square law have been applied directly to the field of electromagnetism.

It is therefore interesting to see whether it is possible to solve other electrical or electromagnetic problems by using well-known ideas established for the physical world. For example, the well established Special Theory of Relativity[2] might be of value in solving the important problem of receiving error-free information in the world of communication.

Relativity theory

According to the Special Theory of relativity as postulated by Einstein, Minkowski and others, only relative space and time exists in which observations are made relative to the observer's frame of reference. So that the physical laws of nature are the same for all observers, whether stationary or moving with uniform motion, it is necessary to formulate a four-dimensional system of space-time defined by (x,y,z,jct) where $j = \sqrt{-1}$ and c is the velocity of light, for describing motion in the physical world in which all velocities are considered to be relative to the frame of reference used, with the exception of the velocity of light which is assumed *a priori* to be constant and independent of the frame of reference used.



The three coordinates and time reference point of the physical world.

The physical world is illustrated geometrically by the three space co-ordinates (x,y,z) which define the horizontal and vertical orthogonal planes. The imaginary dimension (jct) is shown as a 'point in time' and it can move in any arbitary direction such as PQ during clock time. In such a system, it can be shown that the quantity Q defined by

$$Q=x^2+y^2+z^2-c^2t^2$$

is invariant under a Lorentz transformation.

Information theory

The concepts of entropy, coding and information rate in communication systems which are due to Shannon form the basis of information theory. The transmission of information has been quantified by Shannon and the most important feature of his theory is its definition of the maximum rate of information transmission R in terms of a channel capacity C.

Shannon observed that for the transmission of information at a rate $R < C$, an arbitrarily small bit-error probability may be achieved by adopting a sufficiently complex coding scheme. However,

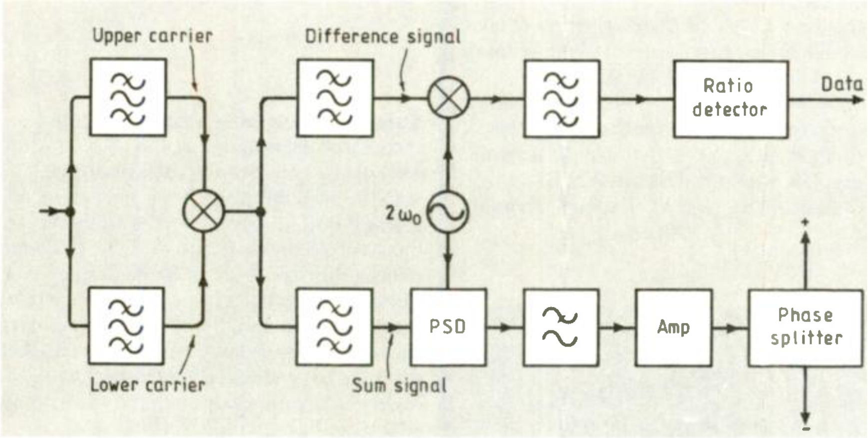


Fig. 3. RFSK detector. Amplitude noise removed by limiting, phase noise by feedback.

are separated by filters and multiplied in a product detector to yield sum and difference signals. The difference signal, after band-pass filtering, is upconverted in a mixer by a stable source at a frequency of $2\omega_o$. It is then filtered by a band-pass filter and fed into a ratio detector which converts the frequency shift of $2\omega_s$ or zero into digital data. At the same time, the sum signal, after band-pass filtering, is fed into a phase-sensitive detector, together with the output from the stable source at a frequency of $2\omega_o$. The phase-noise output voltage is smoothed by a low-pass filter and amplified by a high-gain amplifier, whose output signal is fed to a phase-splitter which yields two equal outputs in antiphase to drive the VCOs in push-pull, cancelling the input phase noise at the second IF stage. Thus, amplitude noise is removed from the digital data by amplitude limiting and phase noise is greatly reduced by negative feedback.

Results

It is shown in Appendix A that the effect of negative feedback is to reduce the received phase noise by the factor K^2_F where $K_F > 1$ is the feedback voltage gain. As the signal power is unaffected by the feedback loop, this increases the signal-to-noise ratio at the detector by the same factor K^2_F. So Shannon's famous equation[1] can be modified to yield

$$C \leqslant W_b \log_2 [1 + K^2_F (S/N)] \text{ bit/s}$$

where W_b is the base bandwidth of the

---

for a rate $R > C$, this is not possible. The most important relationship derived by Shannon is the communication capacity C defined by

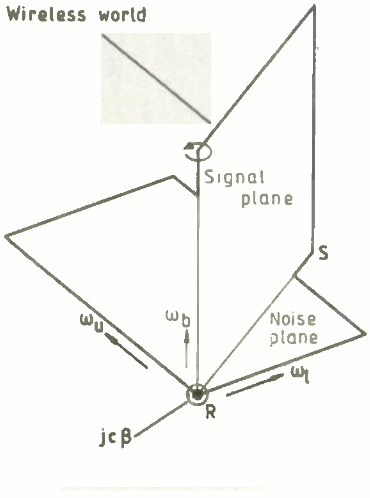
$$C \leqslant W_C \log_2 (1 + S/N) \text{ bit/s}$$

where W_C is the channel bandwidth, S is the signal power and N is the noise power in the system.

Most communication systems designed so far are concerned with maximizing the value of C for a given W, S and N. Shannon further stated that the parameters W, S and N set a limit on the transmission rate but not on its accuracy, provided the S/N ratio is large enough. Hence, considerable work has been undertaken to devise coding schemes to achieve a higher degree of accuracy in transmission.

Relative information theory

Since information is essentially a physical quantity associated with energy, the movement of information from one point in space to another point in space can be likened to the movement of a physical object from one point to another in space. An important link between the physical world and the communication world is the Doppler effect, whereby the physical movement of an object in space can be associated with a frequency shift. Equally well, it might be argued that the frequency shift of an electromagnetic wave due to signal modulation can also be associated with a physical entity such as information. Just as a theory exists for the movement of physical objects which is known as the Special Theory of Relativity, an analogous theory exists for the movement of information which the author proposes to call Relative Information Theory. The basic features of this new hypothesis are described hereafter.



Three signal and noise coordinates and point in phase of the "wireless world".

Postulates

- There is a similarity between the physical world of relative motion and the wireless world of relative information.
- Relative information can be obtained from two signals with frequency and phase information.
- Signal power and noise power can be effectively separated by using sum and difference signals.

Geometrical model

The 'wireless world' of communication is illustrated geometrically as a four-dimensional frequency/phase system defined by $(\omega_l, \omega_u, \omega_b, jc\beta)$ where ω_l, ω_u are the lower and upper carrier frequencies, ω_b is the bit rate frequency, $\beta = \omega_o/c$ is the phase-change coefficient of free space and ω_o is the offset frequency assumed *a priori* to be constant. The three orthogonal frequencies $(\omega_l\ \omega_u, \omega_b)$ define the signal and noise planes which are considered to be orthogonal because signal power can be separated from noise power by using relative frequency and phase information. The imaginary fourth dimension $(jc\beta)$ is shown as a 'point in phase' which can change in any arbitrary direction such as RS between transmitter and receiver.

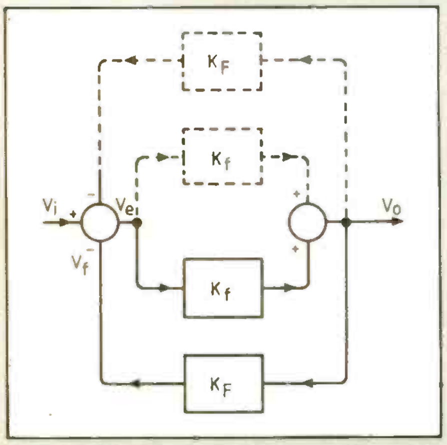
digital information, since the feedback is applied only over the base bandwidth of the digital signals. Furthermore, as the effective signal-to-noise ratio has been greatly increased, it is shown in Appendix B that the probability of error can be greatly reduced ■

References

1. Shannon C.E., Mathematical theory of communication, *Bell System Technical Journal*, 27, 379-423 and 623-423, 1948.
2. Balmain K.G., Electromagnetic waves and radiating systems, Prentice-Hall, 1968.
3. Connor F.R., Relative frequency-shift keying, UK patent no GB 2174872 B.
4. Connor F.R., Noise, Edward Arnold, 1982.

Appendix A

Any random noise voltage can be considered in terms of an amplitude component and a phase component, relative to an accompanying carrier signal. In the relative frequency-shift keying (RFSK) system, the amplitude component is removed by amplitude limiting, while the phase component gives rise to phase noise, which is important because it produces digital errors in the system.



Combined feedback loops reduce phase-noise voltage by K_F.

In the RFSK system, noise voltages in the two channels are correlated prior to the detector. Hence, by the superposition theorem, the two channels can be combined and treated as a single-loop feedback system if the noise voltages shown have their combined RMS values.

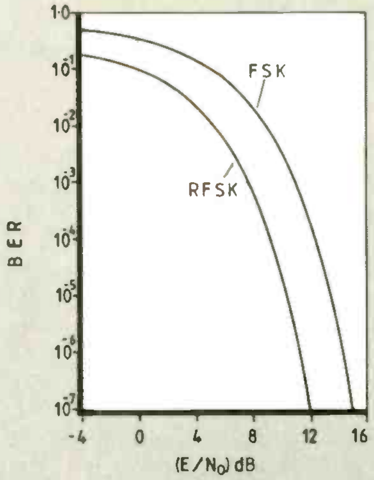
Referring to the diagram let v_i be input phase noise voltage; v_f, feedback phase noise voltage; v_e, phase noise error voltage; v_o, output phase noise voltage; K_f, forward voltage gain; and K_F feedback voltage gain.

Now
$$v_e = v_i - v_f$$
$$v_o = K_f v_e$$
$$v_f = K_F v_o$$
or
$$v_i = v_e + v_f = v_e(1 + K_f K_F)$$
and
$$\frac{v_e}{v_i} = \frac{1}{1 + K_f K_F}$$
with
$$v_o = \frac{K_f v_i}{1 + K_f K_F} = \frac{v_i}{K_F + 1/K_f}$$
or
$$v_o \approx \frac{v_i}{K_F} \quad (\text{since } K_F > 1/K_f)$$

The output phase-noise voltage has been reduced by the factor K_F relative to the input phase-noise voltage due to negative feedback. The corresponding output phase noise *power* is therefore reduced by the factor K^2_F.

Appendix B

Each offset carrier in the RFSK system can be regarded as part of a non-coherent FSK system with an error probability $P_e = \frac{1}{2} \exp - E/2N_o$ where E is the energy per bit and N_o is the noise power spectral density. As the frequency errors in the two offset carriers are uncorrelated, especially if the two offset carriers are well separated, the joint error probability is given by $P_e.P_e = P^2_e$. Thus, we obtain bit-error rate which is plotted below.



Bit-error rates for RFSK and FSK compared.

Furthermore, let $(S/N)_o$ be the signal-to-noise ratio (open-loop), $(S/N)_c$ the signal-to-noise ratio (closed loop) and K_F the feedback voltage gain. Now, we have

$$(S/N)_o = \frac{E/T}{N_oB} = \frac{E.R}{N_oB}$$

where T is the bit duration, R is the bit rate and B is the noise bandwidth. Hence

$$E/N_o = (B/R)(S/N)_o$$

and

$$BER = \tfrac{1}{4} \exp (B/R)(S/N)_o$$

As the signal power is unaffected by the feedback loop, from Appendix A we obtain

$$(S/N)_c = K^2{}_F(S/N)_o$$

and on closed-loop we have

$$BER = \tfrac{1}{4} \exp - (B/R)(S/N)_c$$
$$= \tfrac{1}{4} \exp - (B/R)\, K^2{}_F(S/N)_o$$

Typically, if $B/R = 4$, $K_F = 8$ and $(S/N)_o = 1$ (at the input to the detector), we obtain by calculation

$$BER = 10^{-100}$$

which is extremely small.

European Scrambling Systems, circuits, tactics and techniques, by J.W.A. McCormac. Guidebook to the world of satellite and cable television encryption, giving detailed insight into the methods used by the professional pirate – i.e. the designer of unauthorized descramblers for sale to the public. The author's principal message is that those who design scrambling systems for the likes of Sky Television, Filmnet and the rest tend to produce schemes which look highly secure on paper but have weak points which can be exploited by the knowledgeable and determined pirate. Invariably this is due to a failure to consider the system from the pirate's point of view.

Techniques described in the book include both electronic ones (don't bother to protect your system with a ram back-up battery which disconnects when someone removes the lid – real hackers regard that as kids' stuff) and the human variety (you can extract a surprising amount of information from willing sources in cable companies by cultivating the right telephone manner – but don't bother trying it in an Irish accent).

Unfortunately the book is much let down by poor presentation and poor organization of its material. The author revisits topics again and again; yet since he allows us no index, no page numbering and few section headings (pages are reproduced from his laser-printed original), it is difficult for the reader to return to earlier points which have stuck in the mind. Anecdotes and references are tantalizingly difficult to follow up because they are frequently unattributed even when there can have been no possibility of incriminating anyone: one paragraph refers, for example, to "a design for a MAAST descrambler... published in a well-known English language magazine" without saying which one or when – can it have been *E&WW*? Circuit diagrams, where given, are incomplete or in block form only; indeed, there are few illustrations except in a chapter devoted to techniques for receiving the new Irish multi-point video distribution systems on 2.5-2.68GHz.

Quite a lot of space is wasted on computer-generated tables which sprawl diffusely over page after page, and on frequent episodes of sniping at "amateur" hackers and system designers. Thomson, the French consumer electronics company, is spelt with an intrusive p throughout. At £29, even including postage, the price seems very high.

"European Scrambling Systems" is published by FM Media Services, VSL House, Cookstown Industrial Estate, Tallaght, Co. Dublin, Republic of Ireland (280 pages, A5, soft covers) and is available by post from J. Vincent Technical Books, 24 River Gardens, Purley, Reading RG8 8BX, tel. 0734-414468, at £29 (payable by Access, Mastercard, UK cheque etc.); airmail costs £1 extra within Europe, £3 outside. The same supplier offers a range of other publications on this and related topics.

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Refer Electronics World + Wireless World March 1989 216–218 & Nov. 1989 pp 1109–1111

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Photo Courtesy of DEC

PIONEERS

Grace M. Hopper: originator of the first compiler and computer language to use English statements.

She used to give away nanoseconds but with the advance of technology they have been replaced by picoseconds, packaged for her by DEC. She holds strong opinions, regarding "we've always done it this way," and "it can't be done" as a bull regards a red rag. She even has a clock that runs anticlockwise to show that conventions can be broken, and she is the darling of the American programming fraternity. Though she has received numerous medals and awards and honorary degrees (eight in 1984 alone) she regards her greatest honour as having served in the United States Navy from which she retired as a rear-admiral. And you have probably never heard of her.

If you love programming in machine code, read no further. If you don't, and if you think computer languages should look like English instead of hieroglyphics, then you have good reason to be thankful to Grace Hopper. Almost from the day the first one was built she has held that computers should help people get answers instead of making life more difficult. She wrote the first compiler, the first program to look like English, and it became the basis of Cobol, one of the most popular computer languages of all time.

When, at the age of 79, she began a new career with the Digital Equipment Corporation, its vice president observed: "she has accomplished and experienced so much that younger people who associate with her will have the opportunity to learn at a rapid pace, whether they want to or not."

She was born Grace Brewster Murray on the 9th December, 1906 in New York City, the oldest of three children. Her father was a insurance broker and the family had a summer home in New Hampshire where they spent their holidays. She attended private school in New York City before graduating with a BA from Vassar College in New York State in 1928, having studied mathematics, physics and engineering. This was followed by an MA in 1930 and a PhD in mathematics in 1934, both from Yale. A PhD in mathematics was a rarity then (Yale awarded about two a year) and for a woman to get one was remarkable. But Grace Hopper is a remarkable woman.

After marrying Vincent Foster Hopper in 1930 (they divorced in 1945) she began a career teaching mathematics at Vassar where she climbed the ladder until taking leave of absence to join the US Naval Reserve in December 1943. That was to be the major turning point in her life. The Navy, and sorting out Naval computer programs, were to become the dominant features of her life and the foundations on which her renown rests.

After the compulsory period of training and commissioning as a junior-grade Lieutenant she was drafted to the bureau of Ordance Computation Project at Harvard, home of the electromechanical Harvard Mk I or ASCC computer. It was a monster of a machine and for a long time was thought to be the first general-purpose computer to have been built. When she eventually found it, in a laboratory basement, she met the Commander – the now famous Howard Aiken. The Navy had ignored his plea that Hopper should not waste time on Naval training when he had work for her to do. "Where the hell have you been?" were his welcoming words.

Aiken was a tough taskmaster, she recalls, and immediately gave her a problem to solve on the computer "by next Thursday." Fortunately she was rescued by two young ensigns who were already coding the machine and today she is still proud to have been "the third

MAKE A NANOSECOND

One of the charming things about Grace Hopper is her custom of giving away nanoseconds. You can make one yourself, it's simply a piece of wire 11.78 inches long – the maximum distance light or electricity can travel in one nanosecond. With the advance of technology she had to change her gifts to picoseconds, one thousandth of a nanosecond. That presented a problem until she thought of grains of pepper. DEC had some packets made up for her said to hold 1000 grains, "but I don't think they ever counted 'em".

Continued over page ▶

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DC/AC Voltmeter:	5 to 50V
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Measurement Indication:	ANALOGUE: brightness stripe against calibrated scale superimposed on picture tube The stripe length is proportional to the sync peak of the video signal.
Video Output:	BNC connector. 1Vpp maximum on 75Ω
DC Output:	+12V/50mA maximum. Power supply source for boosters and converters.
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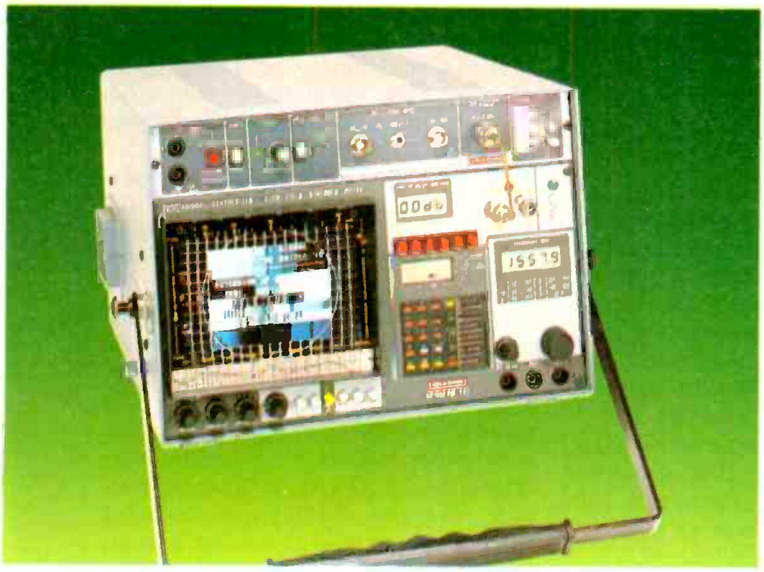

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programmer on the first large-scale digital computer".

The Mark I was followed by II and III. One story Grace Hopper likes to relate is the origin of the term "debugging" a computer. In the hot summer of 1945 a moth got into one of the relays of the Mark II and was "beaten to death". After that whenever they had to explain lack of progress to Aiken "we told him that we were debugging the computer". It was probably not the earliest use of the term "bug" to describe a problem, but Grace believes it to be the origin of the term "debugging a computer".

At the end of the war, when she was told she was too old to continue her Naval career, she declined to return to Vassar and instead joined Harvard, continuing to work on the Mark II and III. She still has a high regard for the Mk II, "No-one has done as well since," she maintains, referring to its logic design, and recommends designers to read its manual.

In 1949 she entered the brand new world of commercial computers, joining the Eckert-Mauchly Computer Corporation where the builders of the famous Eniac were constructing the Univac I (Universal Automatic Computer). Univac was the first large American commercial computer. It was very successful even if it did virtually bankrupt the company, which was sold to Remington Rand in 1950. In turn they were taken over by the Sperry Corporation. Grace stayed with what was now the Univac division throughout all the changes.

"We quickly realised that management wouldn't know what a list was, and we changed that word to 'file' and kept 'files' so they'd understand alright."

It was in 1952 that she developed the first compiler – the A-0, soon followed by A-1 and A-2. The compilers translated a program into machine-readable code. Now it was obvious to anyone with a grain of sense that computers cannot write programs, so "I had a running compiler and nobody would touch it because, they carefully told me, computers could only do arithmetic; they could not do programs." Changing management's ideas of what computers can and cannot do was to be a frequent problem, but one she has cracked many times.

"A ship is safe in port, but that is not what ships are built for."

As computers became faster it was obvious to her that ways were needed to make programming easier and faster. The days of needing a PhD in mathematics to program a machine had to be numbered. There were not enough PhDs around!

Convinced that the real problem was to produce correct programs fast and to get answers for people fast (a fact she believes we have lost sight of) she wanted a way of programming which could be used by "plain, ordinary people, who had problems they wanted to solve," be they engineers, business people, or whatever.

In December 1953 she and her colleagues proposed to their management that mathematical programs should be written in mathematical notation and data processing programs in English statements. They got nowhere, because "computers couldn't understand English words". By early 1955 she had gone ahead anyway ("you can always apologise later") and produced a pilot version of a compiler B-0, complete with a short program written with English statements, to show to management.

Thinking the program looked rather small, Grace and her team produced French and German versions as well, only to be met with the view that "A respectable American computer, built in Philadelphia, Pennsylvania, could not possible understand French or German!" To the programmers it was a simple substitution of bit patterns, to management it was a move into foreign languages. It took four months to get approval for an English-only version.

The B-0 (B for business) compiler was renamed Flow-matic by the sales department and as such it is known. "You can't do anything about the sales department," says Grace, "you just have to let 'em go ahead". It was the first computer language to use English statements. By 1957 there were at least three computer languages in use in the USA including Fortran and Flow-matic; only the last mentioned used English.

As more machines and more people became involved with computing, there was an increasing need for universal languages which would run on any computer. In April 1959 a meeting of half a dozen people, including Grace Hopper, decided to call together representatives from competing organizations to agree on a common business-oriented language. The next month about 40 delegates met for two days and started to define what was needed. This was the origin of Cobol. They also agreed on the need to make maximum use of simple English. Short-range, medium-range and long-range language development committees were set up, together with an executive committee. Grace was one of two advisers to the executive committee.

The outcome was Cobol 60, produced by the short-range committee. Although Grace Hopper was not a member of the committee, she and her Flow-matic strongly influenced Cobol. It is not stretching a point too far to describe Flow-matic as the root from which Cobol grew, though Hopper did not invent it. Grace has sometimes been called "Grandma Cobol". The executive committee, renamed Codasyl, is I believe, still going strong and Grace Hopper has long been associated with it.

Throughout her career in industry she maintained her career in the Navy reserve until they retired her in January 1966. Eighteen months later she was recalled to active duty for six months to standardize the Navy's computer programs. As the *New York Times* expressed it, "to impose discipline on a Babel of computer languages." The six months stretched a little bit; she retired from the navy for the second time 20 years later, in August 1986, aged 79. Within a month she had joined DEC as a senior consultant!

She will not lie down and has little respect for those who stop learning at 40, 50, or 60. "I like learning," she says, "I always have." And she loves gadgets, "I have to find out how they work." She even admits that in her heart, when she first saw the Harvard Mark I, her reaction was, "Gee, that's the prettiest gadget I ever saw."

Further reading
History of Programming Languages, by R.L. Wexelblat (Ed), Academic Press, 1981
ACM SIGPLAN Conference Proceedings, June 1-3, 1978.
Abacus, vol.2, no. 1, pp7-18

Next: Karl Ferdinand Braun

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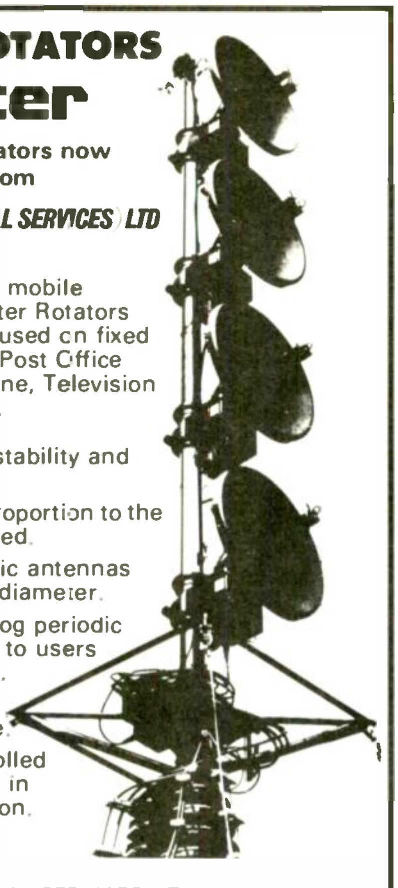

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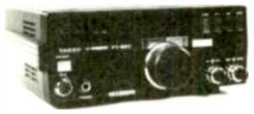

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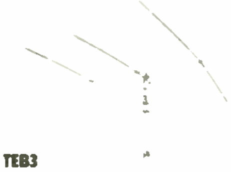

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Sigma-delta conversion

Sigma-delta analogue to digital converters offer a magical combination of high resolution and sampling rate at low cost.

Ralph Weir

Quick ADCs traditionally use flash conversion or successive approximation. Both rely on complex analogue circuitry, possibly with laser trimming and other costly production techniques. Sigma-delta converters represent a radically different approach. Much of the circuitry is digital – in the case of the Motorola DSP56ADC16, only 10 per cent of the device is analogue.

A simple approach to analogue to digital conversion would be to compare the output of a dac with the input signal. If the input were smaller, a controller could decrease the output of the dac, if larger, it could increase the output of the dac. In this way, the ADC could iteratively find the input voltage, but would need to perform many comparisons before finding a result. This is similar to the technique used in successive approximation.

A system for doing this is shown in **Fig. 1**. Here, the dac's output is subtracted from the input. The resulting voltage is then compared with a reference, and the output used to control the increment or decrement of the dac value. When the dac's value reaches the required resolution, the control logic will hunt about the true value. When this condition is detected, the control logic may signal a new output.

Suppose the dac generates accurate outputs although contaminated with high frequency noise above the sampling rate. If this gets into the comparator, it will cause random changes in the dac output value. This must not be allowed to happen, so a low pass filter (integrator) is used to reduce the noise level.

If the filter is placed as in **Fig.2**, it will process any noise being fed to the comparator from either signal or reference inputs. As the filter only removes noise outside the bandwidth of the ADC, it does not affect the signal itself: it supplements the antialiasing filters commonly used to protect an ADC from out of band signals.

So far, the putative ADC relies on a dac to produce DC levels for the comparator, but with filtering for noise removal. This makes it only slightly different to a successive approximation converter. However, the filter principle can be used to simplify the dac, the expensive section of a successive approximation converter.

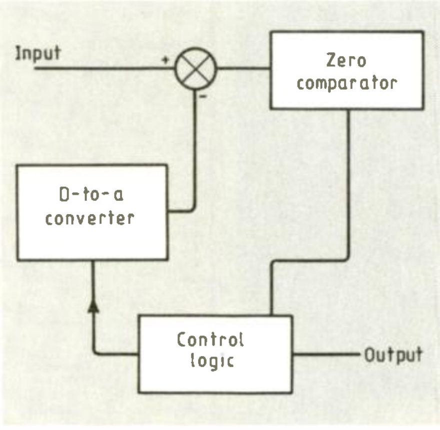


Fig. 1. In one of the simplest possible ADC implementations, a dac generates a reference that is compared with the input and used to update the dac output. Eventually the dac's control value converges toward the required result.

A direct voltage is applied to the modulator, say 3/4V, as in the previous example. Assuming that the single-bit dac's output and the integrator's output are both initially zero, the input signal passes through the integrator, and at time 1T trips the comparator to the high state. At this stage, the integrator's output is 3/4V, and the dac output is driven high.

Setting the dac's output high applies −1/4V to the integrator's inputs, so its output decreases until the comparator changes state. As the output is at 3/4V, the integrator must swing 1V before its output is negative, but the slew rate of the output is −(¼)V/T. Thus, the transition takes four time intervals, and the comparator switches to the low state at 5T, with the integrator's output at −1/4V.

Once, again, this applies 3/4V to the integrator's inputs. The integrator then swings 3/4V in a single time interval, reaching 1/2V at 6T. The comparator switches, and the process begins again. The integrator now falls into a repetitive cycle, taking 3T to trigger the comparator low, followed by 1T to drive it high. This process is shown in **Fig.3.**

Looking at the final output over several samples, we see a pulse train whose mean value settles to the level of the input signal. Thus, the analogue input has been converted to a binary bit stream. The input and output of the modulator could be regarded as identical, but with the output corrupted by noise.

In fact, there are two main apparent noise sources. The first is the square wave produced by the modulator itself. This is of a very high frequency, typically in the megahertz region, and is usually removed by the decimation filters described later.

The second noise source is introduced by the modulator falling into a repetitive cycle. This cycle may have a frequency which could introduce noise into the output lowering the effectiveness of the straight sigma-delta modulator on low frequencies. (At higher frequencies, the modulator does not have time to fall into a cycle, so the problem is eradicated). There are a number of different approaches to reducing this noise. The solution to the problem emerges later.

Consider a typical bit stream. For three quarters of the time, the signal is at 1V, while the rest of the time, the signal is zero. Obviously, the average value of this is 3/4V but, if this was meant to be 3/4V DC, it has been contaminated with very heavy high frequency noise. The waveform has two discrete levels: 1V and zero. Any other voltage can be synthesized using the same binary technique.

The precision of the output voltage simply depends by how much the period of the underlying square wave is shorter than the period of the integrator. Such a waveform is said to be sigma-delta modulated.

This technique can replace a multi-bit dac. Special control logic and a single bit dac can effectively emulate a multi-bit dac. Circuit complexity has been traded between analogue and digital circuits. The control logic can be implemented by a single signal path, connecting the output of the comparator directly to the input of the single-bit dac.

To see how the completed circuit operates, consider a simple example. To avoid confusing the issue with complex mathematics, we will reduce the integrator so that its output slew rate is V_{in}/T, where V_{in} is the input voltage to the modulator, and T is the sample rate.

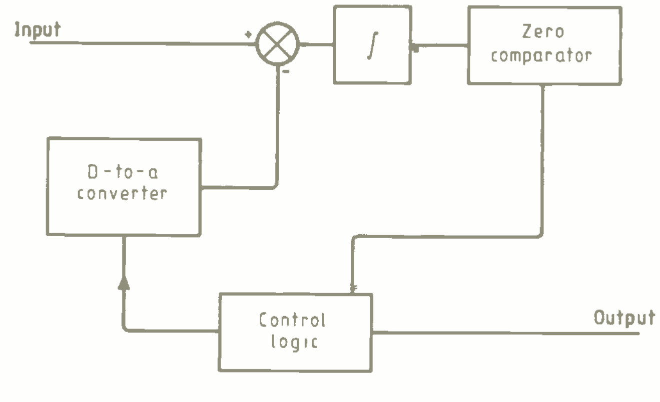


Fig. 2. Enhancing the ADC of Fig. 1 by the addition of a smoothing filter as shown improves immunity to noise from either the dac or the input signal.

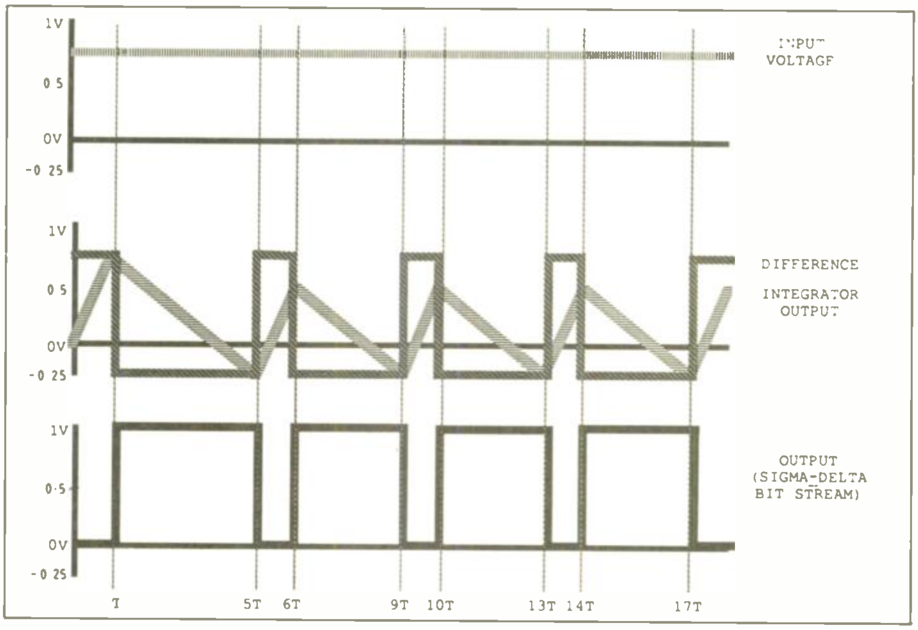


Fig. 3. Using a one-bit ADC, Fig. 2's ADC operates very simply. In response to a positive input, the integrator's output climbs. At the next comparison interval, the result is positive. The control logic sets the output high, applying a small negative voltage to the integrator. This slowly ramps down and for the tree comparisons, no change is seen by the comparator. On the fourth comparison, the output changes state again, resulting in a repeating pattern with average value 0.8V.

Applying the technique

Single bit comparators and dacs are relatively straightforward to implement in silicon. A switched-capacitor filter makes for a very compact sigma-delta modulator capable of running at very high sampling rates.

However, the data stream is of little use for further processing in its raw form requiring decode to a multi-bit format for most applications. The high speed allows for some sacrifice of sampling rate to achieve this.

This seemingly complex task is performed by a relatively simple digital filter. The filter used has a very high input sampling rate, a much lower output sample rate, and a low pass characteristic. Such a filter is known as a decimating filter, and the ratio of the two sampling rates is known as the oversampling ratio.

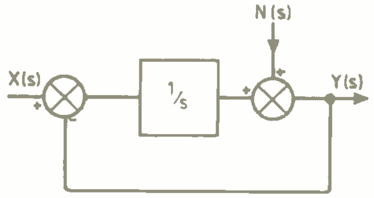


Fig. 4. The sigma-delta modulator passes signal and noise according to the transfer functions shown. Signal is low-pass filtered, while noise is high-pass filtered, helping to reduce in-band noise of the modulator and significantly improve the ADC's performance.

The mathematical equation which allows the calculation of the oversampling ratio, and hence the number of samples required to attain a given output resolution, is not as straightforward as it might at first appear. One would expect that for n-bit resolution 2^n bits would be required to represent a signal. This is in fact excessive, and may be reduced considerably.

Deriving the sigma-delta modulator as in **Fig.4**, the signal transfer function for the modulator simplifies to:

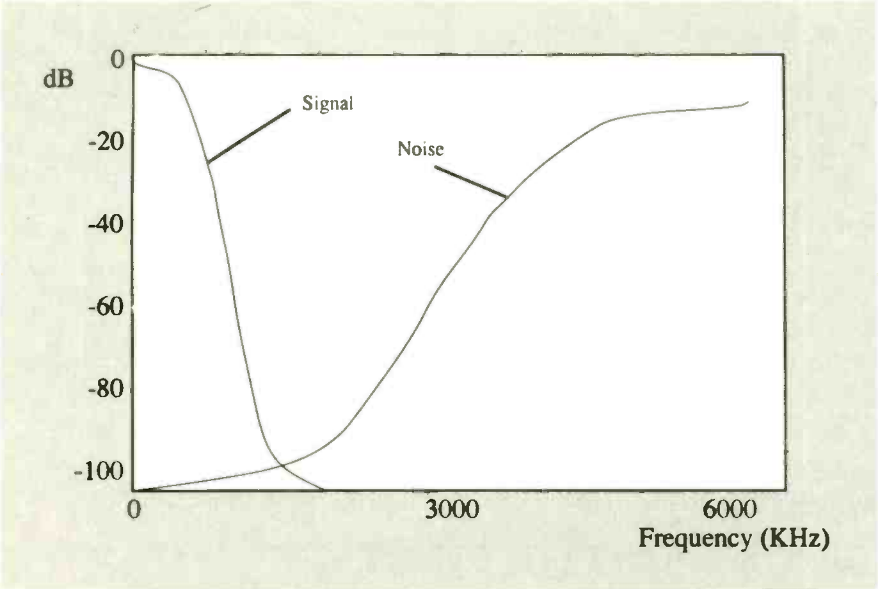


Fig. 5. Noise generated by the single-bit dac has been removed with the sigma-delta modulator. The signal has been low-pass filtered, reducing the need for anti-aliasing filters.

$$\frac{Y(s)}{X(s)} = \frac{1}{s+1}$$

This is the s-domain representation of a first-order low-pass filter. Deriving the noise transfer function for the same modulator produces:

$$\frac{Y(s)}{N(s)} = \frac{s}{s+1}$$

This is the s-domain representation of a simple high-pass filter.

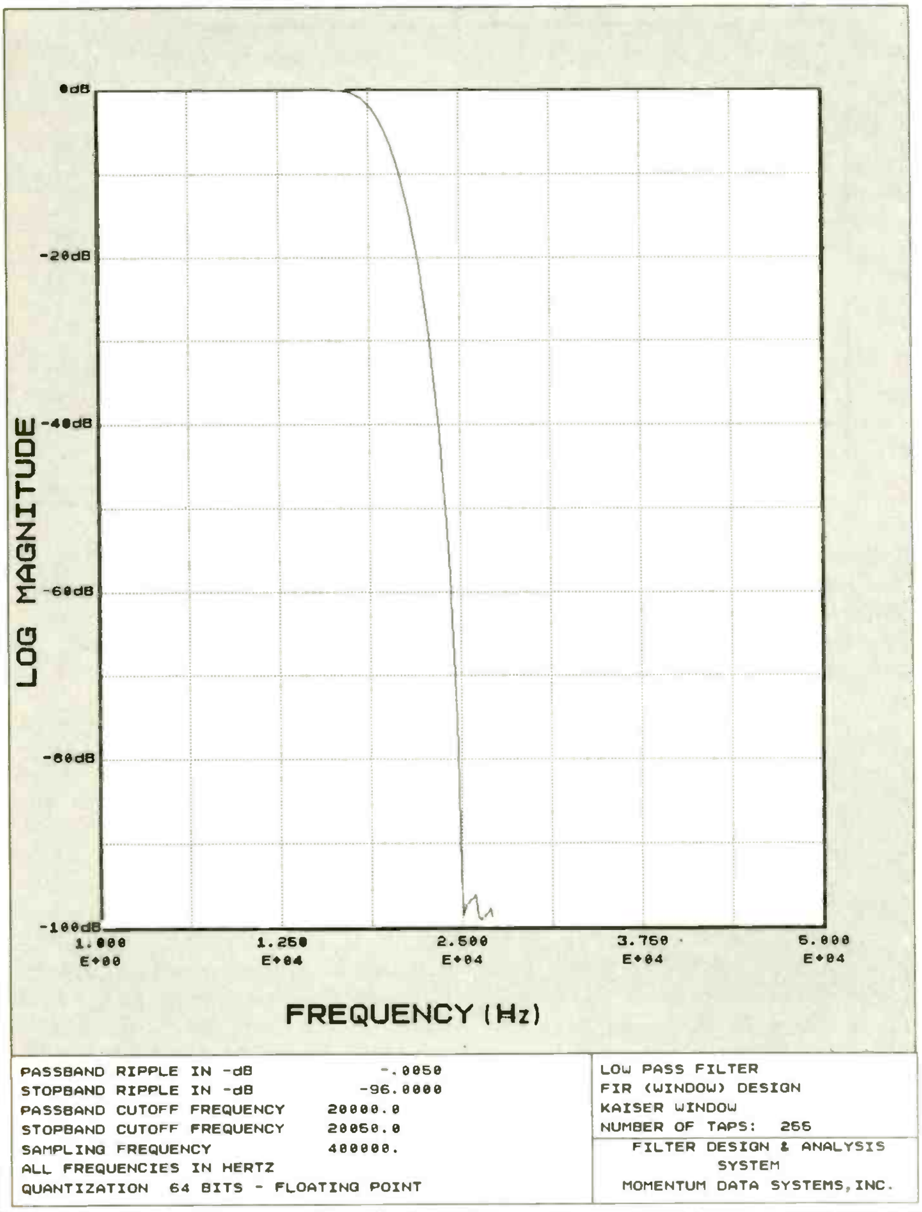
Plotting the transfer functions produces the result shown in **Fig.5.** Here, the signal is attenuated at higher frequencies, while the noise is shaped so that very little of its content is in the low frequency region.

By nesting modulators inside each other, higher order modulators may be implemented. These have higher order filters in the signal and noise paths, so the effect of splitting the noise from the signal is accentuated. This allows later circuitry to be simplified, as will be seen later. However, as the modulator is recursive, great care has to be taken to prevent the modulator becoming unstable. Motorola's engineers have been able to develop a stable third-order device, which greatly simplifies post processing of the signal.

An oversampling ratio of 64 was finally used in conjunction with the third-order modulator, giving an input sampling rate of 6.4MHz. This choice also simplified the later post processing required on the serial bit stream to produce the more useful parallel byte output.

A 64:1 decimation filter capable of attenuating the out-of-band noise by the required 96dB would have required something in excess of 2800 taps. In view of this, the task of decimation has been split between two filters, the first with an oversampling ratio of 16, the second with an oversampling ratio of 4.

Splitting the task of decimation filtering in this way gave the opportunity of adding another feature to the device – a higher output sample rate, but with



```
PASSBAND RIPPLE IN -dB              -.0050
STOPBAND RIPPLE IN -dB            -96.0000
PASSBAND CUTOFF FREQUENCY      20000.0
STOPBAND CUTOFF FREQUENCY      20050.0
SAMPLING FREQUENCY             400000.
ALL FREQUENCIES IN HERTZ
QUANTIZATION   64 BITS - FLOATING POINT
```

```
LOW PASS FILTER
FIR (WINDOW) DESIGN
KAISER WINDOW
NUMBER OF TAPS:   255
   FILTER DESIGN & ANALYSIS
          SYSTEM
  MOMENTUM DATA SYSTEMS, INC.
```

Fig. 7. The very sharp cut-off at 50kHz protects the ADC's output from signals in the higher band. Input to this second decimation filter is protected by the 16:1 primary filter which attenuates signals in the 50-1600kHz band.

reduced resolution. Taking the 16:1 decimator first, an output sample rate of 400kHz may be achieved from the 6.4MHz input rate. Using this oversampling ratio results in 12-bit resolution, but with a much increased sample rate. This gives the working block diagram shown in **Fig.6**.

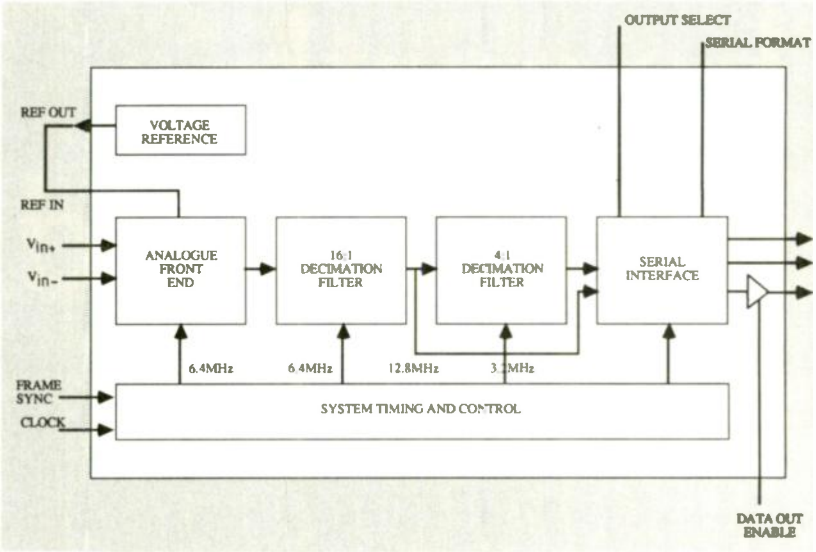


Fig. 6. Motorola's implementation of a sigma-delta ADC (50ADC16) gives 16-bit resolution at a 100kHz sampling rate, and alleviates the need for complex anti-aliasing or sample and hold circuitry.

Aliasing

In most applications, an anti-aliasing filter is required to prevent signals above sampling rate from reaching the converter. In the case of an audio converter sampling at 100kHz with 16-bit resolution, the best approximation to the required performance would demand a 30-pole Bessel filter. Implementing such a device in analogue circuitry is expensive, and brings problems of stability with temperature and time.

The sigma-delta ADC overcomes the problem neatly. The third-order integrator used in the modulator attenuates any high frequency noise entering the device while still in the analogue domain. However, the conversion takes place at a very high rate. In the case of the DSP56ADC16, the sample rate of 6.4MHz allows signals of up to 1.6MHz to be represented digitally, although resolution outside the device's 100kHz operating bandwidth is obviously reduced. These signals are filtered digitally to the Nyquist rate as part of the decimation process removing any signal which may alias. As this is performed at well above the sampling rate, Nyquist's theorem is not violated.

Fig.7 is the transfer function of the second decimation filter with an input sample rate of 400kHz. A very sharp cutoff can be seen at 50kHz, protecting the ADC's output from signals in the 50-200kHz band. The input to this filter is protected by the 16:1 primary decimation filter, which attenuates out of band signals in the 50-1600kHz range.

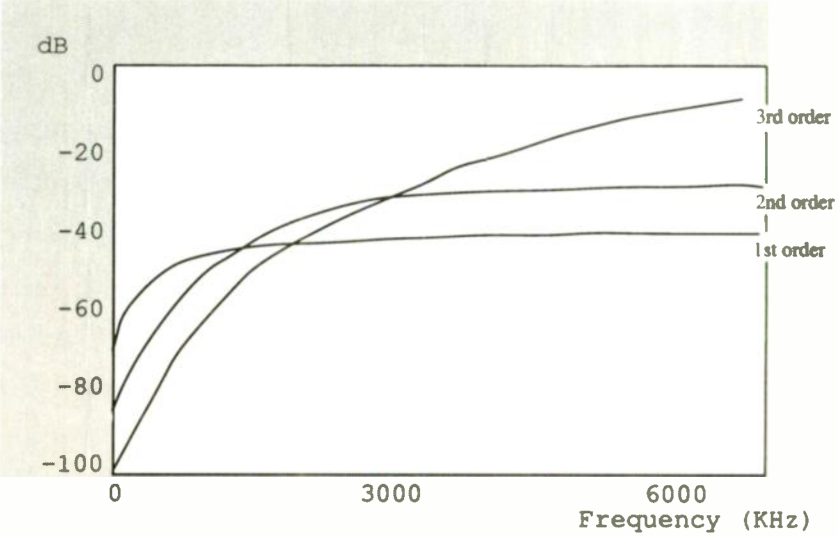


Fig. 8. Higher order delta-sigma modulators have lower in-band noise, but higher out-of-band noise. This is a desirable feature; however, higher order modulators are increasingly unstable. The 56ADC16's third-order modulator gives good performance at a reasonable price.

Noise performance

A feature of the sigma-delta modulator is that the modulator itself shapes the quantization noise at the output. Typical curves showing noise spectra from sigma-delta modulators are given in **Fig.8.** As can be seen, the modulator produces little noise at low frequencies, but signicantly more at higher frequencies – a direct result of the high pass noise transfer function mentioned earlier. As we did not take this factor into account in the above analysis, the in-band noise generated by the converter is far lower than suggested.

Overall the sigma-delta converter produces less quantization noise than its conventional counterpart although there is a problem when digitizing close to DC. This state allows the sigma-delta modulator to generate repetitive outputs. If these have a long enough period, they will generate noise which falls into the converter's bandwidth corrupting the output signal.

The DSP56ADC16 includes additional circuitry to prevent this. The input signal is mixed with a small dither signal which prevents the modulator from ever receiving true DC. This greatly improves the small signal and low frequency performance.

Further reading

1. C D. Thomson, A VLSI sigma-delta A/D converter for audio and signal processing applications, ICASSP 1989.

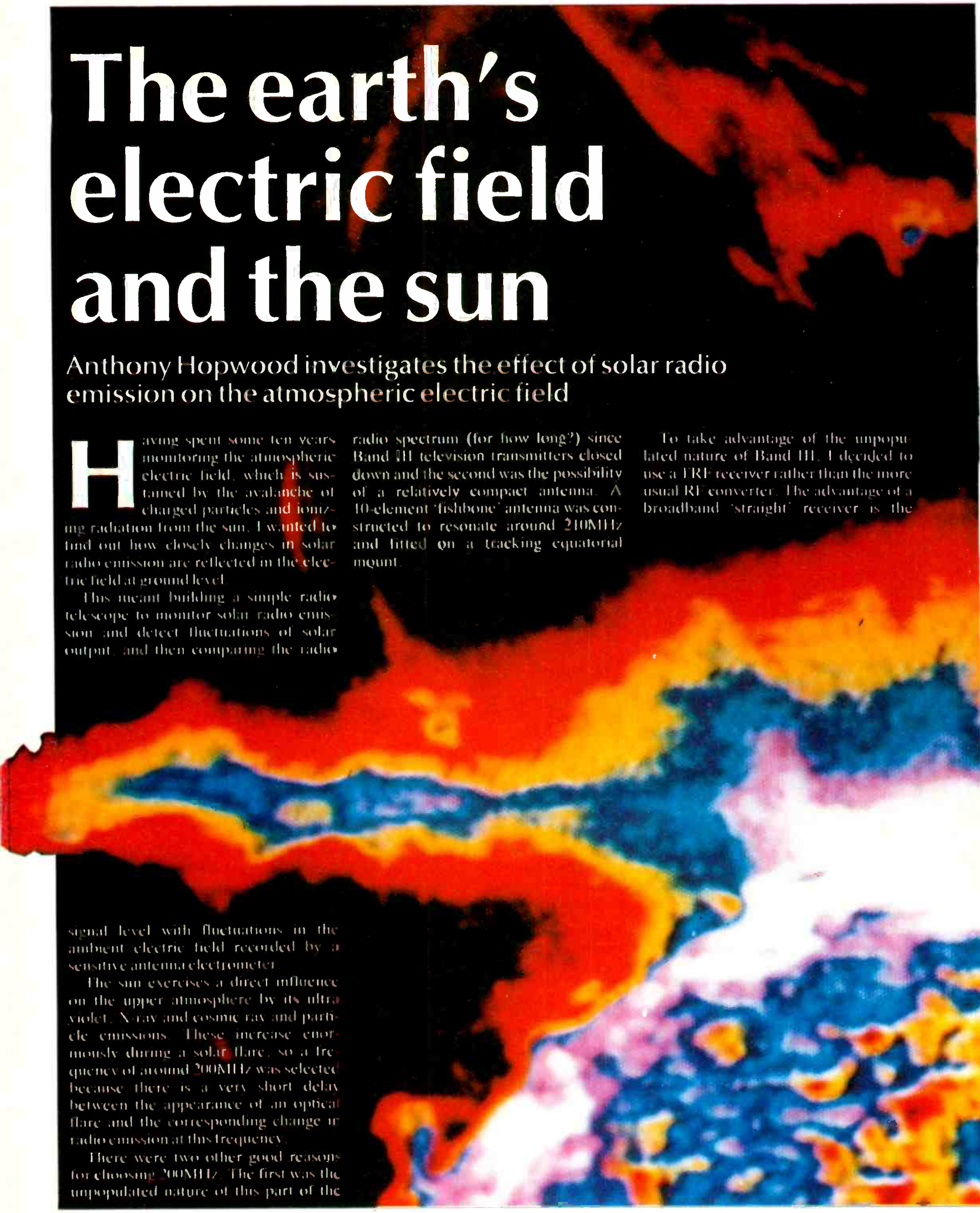
2. J.C. Candy, A use of double integration in sigma-delta modulation, *IEEE Transactions on Communications*, vol Com-33, no 3, March 1985.

3. Yasayuki Matsuya et al, A 16-bit oversampling ADC technology using triple integration noise shaping, *IEEE Journal of Solid State Circuits*, vol SC-22, no 6, December 1987.

Ralph Weir works for Motorola, East Kilbride.

The earth's electric field and the sun

Anthony Hopwood investigates the effect of solar radio emission on the atmospheric electric field



Having spent some ten years monitoring the atmospheric electric field, which is sustained by the avalanche of charged particles and ionizing radiation from the sun, I wanted to find out how closely changes in solar radio emission are reflected in the electric field at ground level.

This meant building a simple radio telescope to monitor solar radio emission and detect fluctuations of solar output, and then comparing the radio signal level with fluctuations in the ambient electric field recorded by a sensitive antenna electrometer.

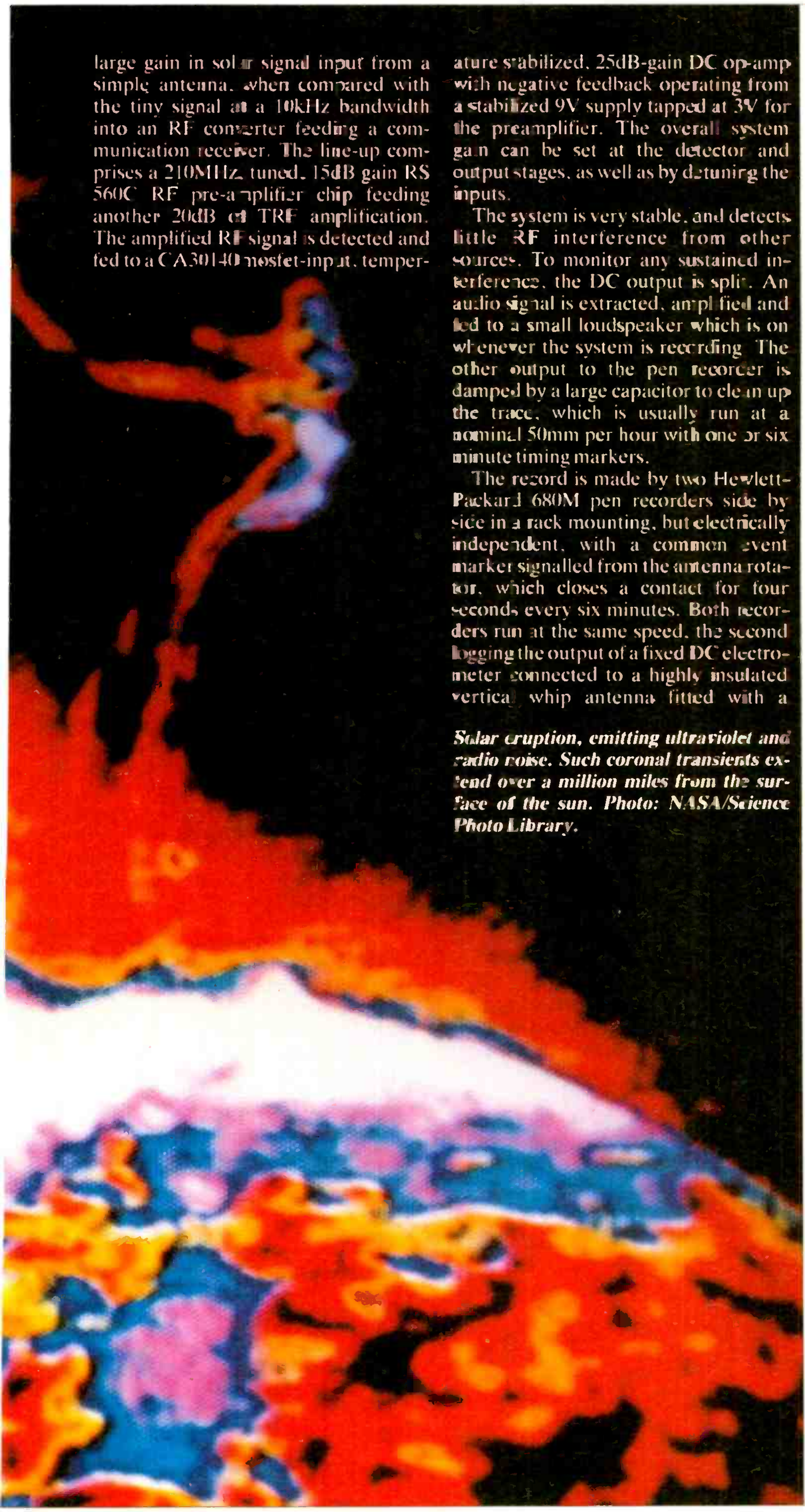
The sun exercises a direct influence on the upper atmosphere by its ultra violet, X-ray and cosmic ray and particle emissions. These increase enormously during a solar flare, so a frequency of around 200MHz was selected because there is a very short delay between the appearance of an optical flare and the corresponding change in radio emission at this frequency.

There were two other good reasons for choosing 200MHz. The first was the unpopulated nature of this part of the radio spectrum (for how long?) since Band III television transmitters closed down and the second was the possibility of a relatively compact antenna. A 10-element 'fishbone' antenna was constructed to resonate around 210MHz and fitted on a tracking equatorial mount.

To take advantage of the unpopulated nature of Band III, I decided to use a TRF receiver rather than the more usual RF converter. The advantage of a broadband 'straight' receiver is the large gain in solar signal input from a simple antenna, when compared with the tiny signal at a 10kHz bandwidth into an RF converter feeding a communication receiver. The line-up comprises a 210MHz tuned, 15dB gain RS 560C RF pre-amplifier chip feeding another 20dB of TRF amplification. The amplified RF signal is detected and fed to a CA30140 mosfet-input, temperature stabilized, 25dB-gain DC op-amp with negative feedback operating from a stabilized 9V supply tapped at 3V for the preamplifier. The overall system gain can be set at the detector and output stages, as well as by detuning the inputs.

The system is very stable, and detects little RF interference from other sources. To monitor any sustained interference, the DC output is split. An audio signal is extracted, amplified and fed to a small loudspeaker which is on whenever the system is recording. The other output to the pen recorder is damped by a large capacitor to clean up the trace, which is usually run at a nominal 50mm per hour with one or six minute timing markers.

The record is made by two Hewlett-Packard 680M pen recorders side by side in a rack mounting, but electrically independent, with a common event marker signalled from the antenna rotator, which closes a contact for four seconds every six minutes. Both recorders run at the same speed, the second logging the output of a fixed DC electrometer connected to a highly insulated vertical whip antenna fitted with a radioactive atmosphere coupling plate.



Solar eruption, emitting ultraviolet and radio noise. Such coronal transients extend over a million miles from the surface of the sun. Photo: NASA/Science Photo Library.

Over the last few weeks, synchronized recordings have shown that there is a very close link between the atmospheric electric field and solar radio emission. Getting clear evidence of that link has not been so easy, since the atmospheric potential varies widely with the weather, and often totally masks any minor solar effects. The best conditions are when the weather is quiet and bright and when the atmospheric baseline holds steady with a clear sky and little convective cloud.

The sun's radio emission at 210MHz is effectively a continuous analogue of the nuclear turmoil on its visible surface. In practice, most of the radio noise comes from the highly disturbed regions round sunspots. When a flare occurs, it is immediately visible, but the intense burst of ultraviolet and X-radiation it releases blocks local radio emission for a short while. This drop in emission is often the first radio signal of a flare, shown in **Fig. 1**.

On earth, the arrival of a burst of ionizing radiation or charged particles alters the atmospheric electric field. The recordings show that the lag between a radio transient and a change in the ground electric field is from less than one to about eight minutes. This suggests that there are several modes of short-term atmospheric excitation, the fastest being the ultra violet and X-ray component which arrives with the visible component of the flare at the speed of light. This is followed by various particle emissions travelling at different speeds down to about half the speed of light.

At this stage it has not been possible to detail the individual arrivals without more sophisticated equipment. This would require a multichannel system with separate sensors logging radio, UV, cosmic rays and electric field.

Although very basic, the recordings do show the surprising fidelity of the ionospheric response to the thousands of daily small nuclear events on the visible solar disc. The synchronized recordings were made at a nominal 50 mm/h with increasing output positive-going. The ionizing component of a typical small flare causes a decrease in atmospheric voltage as the ionosphere is momentarily 'lowered'. The negative spikes associated with changes in solar emission during a sequence of disturbances starting at 1030BST on 26 April 1989 are well shown in **Fig. 2**.

The effect of an isolated event is nicely shown on linked traces taken around midday on 2 May, 1989, **Fig. 3**.

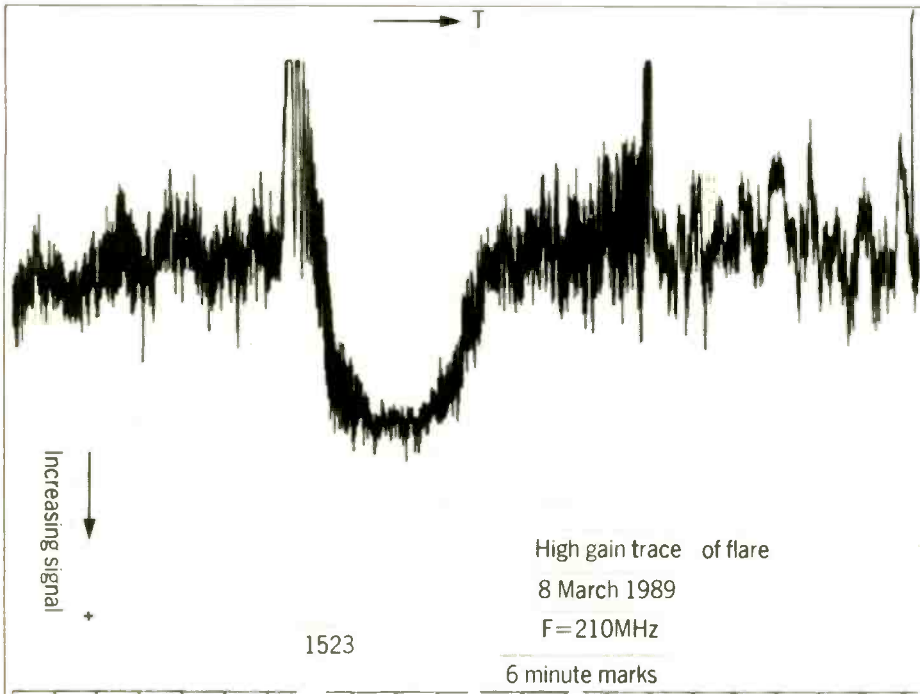


Fig. 1. UV and X-radiation from a flare blocks terrestrial radio for a time.

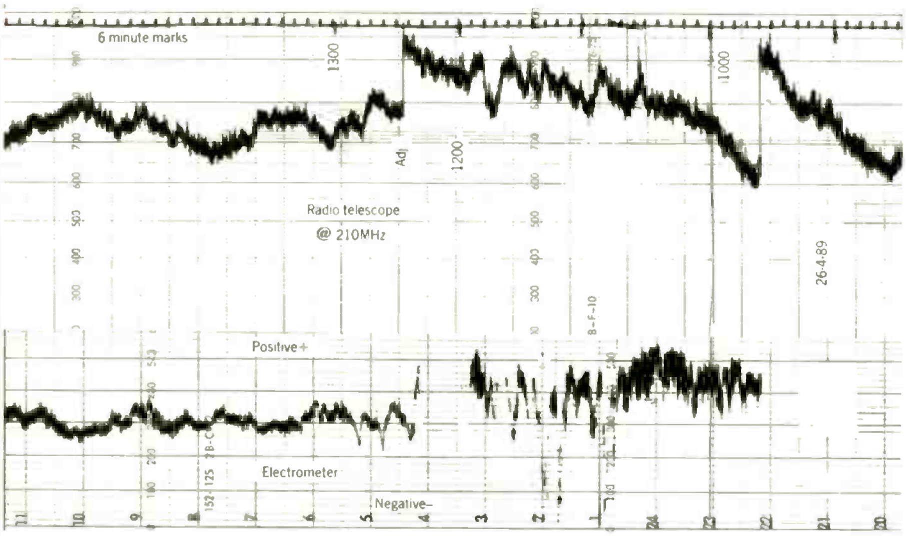


Fig. 2. Negative spikes in atmospheric voltage caused by a change in solar emission.

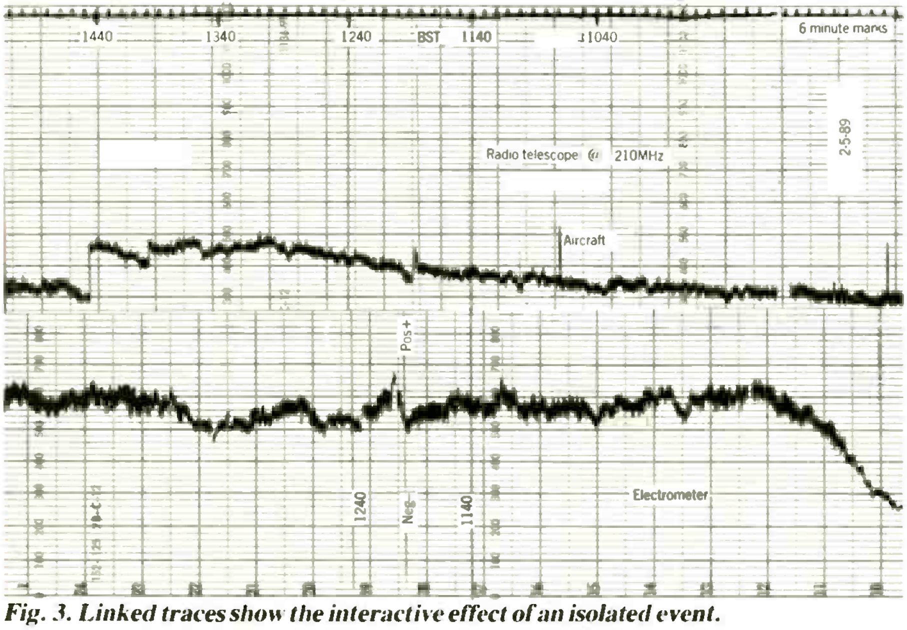


Fig. 3. Linked traces show the interactive effect of an isolated event.

A comparison between Figs. 2 & 3 shows that atmospheric response to solar emissions varies widely – sometimes the electrometer signal change is disproportionately large compared with the radio signature, and vice versa; this is largely due to the condition of the ionosphere at the time of arrival. Towards noon, ionization is nearing the daily maximum, so a small increase in solar emission may trigger a large alteration, possibly in the form of a transient E layer.

These notes are intended to stimulate further research into the fine grain of the interaction between the atmospheric electric field and solar emission. A great deal of this research is open to amateurs, because the equipment needed is modest. More sophisticated equipment will show greater detail, but whatever the installation, if a continuous log is kept, the chances are that at least one major solar flare will be recorded as we approach sunspot maximum. In addition, experience will be gained on the electrometer's reaction to the initial flare and the later ionospheric and auroral effects, so that the electrometer can be used as a simple early-warning system of major ionospheric disturbances.

The ideal set-up would be a multichannel system recording the electric field, magnetic deviation, solar radio, UV, and cosmic ray emission, ionospheric sounding and 50MHz lift – this really would give a fascinating profile of the whole gamut of solar effects on our planet.

The neglected field of electrometry also offers the prospect of a simple and accurate log of the health of the beleaguered ozone layer, because a properly co-ordinated network of electrometer stations will show long-term alterations in the average electric field at ground level, which will be directly proportional to solar UV and ionizing radiation penetration. ■

Further reading

The fishbone antenna is described in Radio Engineering by F.E. Terman, McGraw-Hill, 1937, chapter XV.
Observational radio astronomy, by J.P. Wild, volume VII of Electronics and Electron Physics, 1955, Academic Press.
Radio Astronomy, F. Graham Smith, Penguin, 1960.
The Sun as never seen before, Edward Gibson, National Geographic, vol. 146, no 4. Skylab report.

Negative resistance in AF filters

John Dent shows how the use of gyrators can produce band-stop filters of very high Q.

Frequency-dependent negative resistors (FDNRs) are generally regarded as a vaguely interesting technical oddity with little relevance to practical design but, as will be seen, their usefulness deserves wider appreciation. They are a variation of the gyrator circuit (see the explanatory panel), which by means of network phase manipulation, "rotates" a capacitive reactance to appear as inductive at the output terminals of the network. That is, a synthetic inductance is produced from a capacitive circuit element.

The basic gyrator is shown in **Fig. 1** and, provided all resistors are equal, $L=R^2C$, with L in henries, C in farads and R in ohms. Resistor R_5 is often made variable to provide a means of tuning the inductor, which in this configuration has one side grounded. Since the "gyration" relies on phase relationships, both op-amps should be in the same package to ensure good phase tracking with temperature variation and, for this reason, the effect can only be obtained up to about 50kHz.

Negative resistance

Most commonly available op-amps are suitable and one particularly useful device is the Raytheon RC4136 which, when used at low audio frequencies, can provide hundreds of henrys with a very high Q. When polystyrene capacitors are used in the gyrator circuit, Q's in the range of 1500-2000 are realisable. If the basic gyrator circuit is rearranged as in **Fig**. 2 an unusual circuit element is produced which exhibits the characteristics of a negative resistor. The value of the negative resistor is frequency dependent and is given by

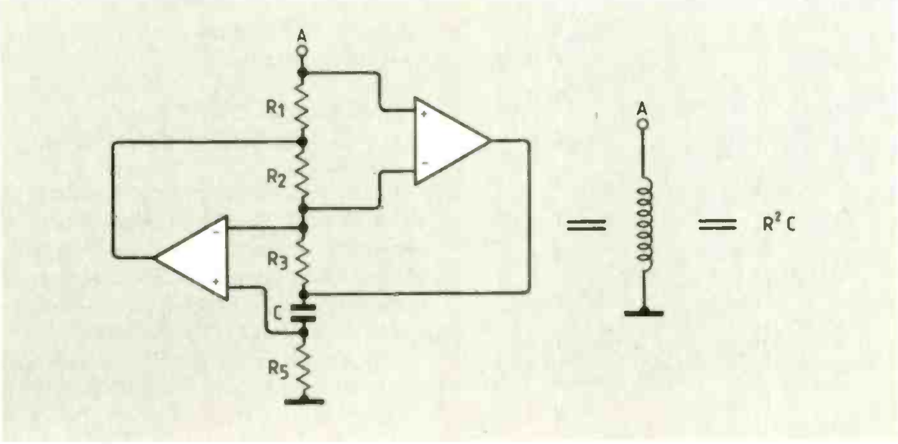
$$-R = \frac{1}{(2\pi f)^2 D}$$

where $D = R_2R_4C_1C_3/R_5$ (f in Hz. R in ohms and C in farads).

A practical application for this circuit now suggests itself. By connecting a resistor which is equal in ohmic value but regarded as algebraically opposite in sign(positive) to the FDNR at point A, then a path having zero impedance at a particular frequency will exist. Since the FDNR is ground-referred then, in theory, there is zero transmission and a perfect notching network is obtained. Practically, of course, an infinite notch is not obtainable because of imperfections in phase relationships but, by grouping several FDNRs together in cascade, band-stop filters with greater than 70dB of suppression are obtainable.

This type of filter has significant advantages over other types; for instance, the transmission response of the notch is very stable, provided good quality polystyrene capacitors and resis-

Fig. 1. Basic gyrator, which simulates an inductor with one earthy end.



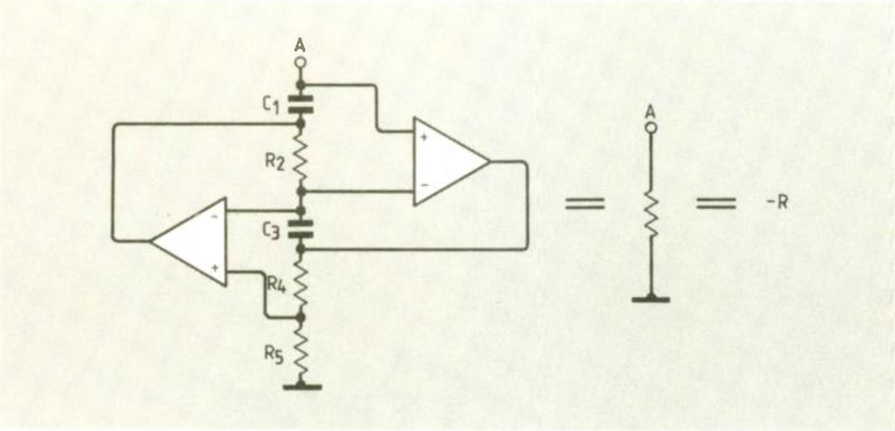


Fig. 2. Re-arranging circuit of Fig 1. produces a negative resistance.

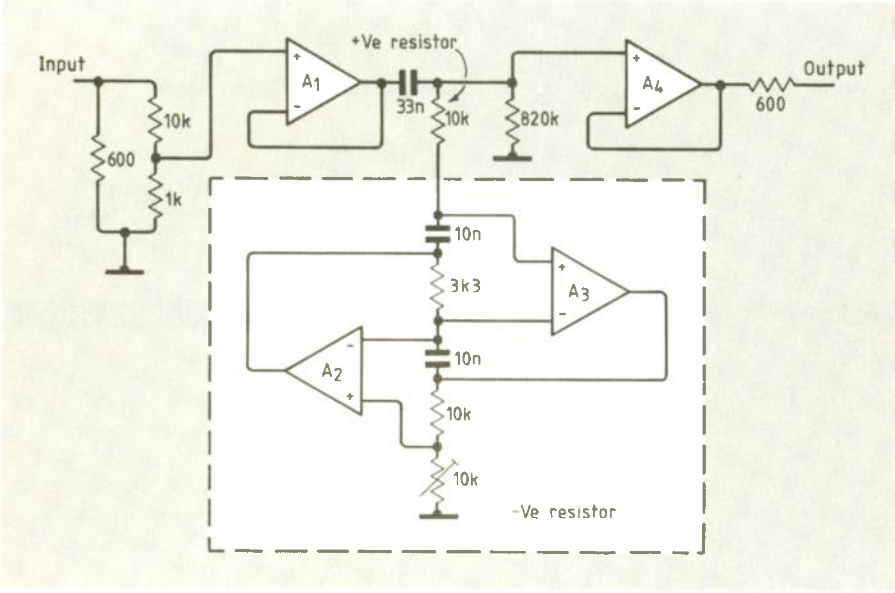


Fig. 3. Practical circuit of 2.8kHz band- stop filter, with trough of over 30dB.

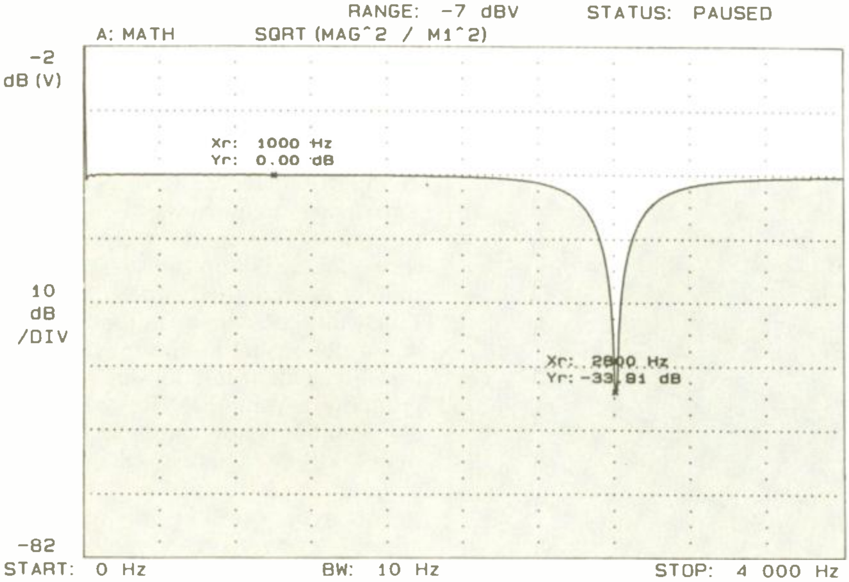


Fig.4. Frequency response of 30dB 2.8kHz filter.

tors are used, and is practically independent of op-amp characteristics. When using other types of band-stop filters, it is often necessary to use complicated tables and equations to obtain the required response from the filter and passive types require wound inductors which are expensive and bulky (and difficult to obtain for prototypes). Using FDNRs, the design becomes much simpler, since a group can be arranged on and around a particular frequency to obtain the required shape and notch characteristic, and this arrangement readily tolerates component ageing.

With FDNRs there are a few practical points which will assist filter realisation: firstly, components connected directly to the FDNR exhibit different properties, that is resistors appear as inductors and capacitors act as resistors. However, this is not a problem since, to couple a signal into each FDNR section, some resistance would normally be needed which, due to the element transformation mentioned above, requires a small value of capacitor. Secondly, the FDNR needs a DC path to ground to establish biasing for the op-amps, so a true resistance must be used, which appears inductive. If a high value of resistor is used (typically 820kΩ), then its inductive shunting effect is negligible; it may, if required, be lowered in value to provide low-frequency roll-off.

Examples

Suppose a notch filter must provide more than 30dB depth at 2.8kHz and the input and output impedances should be 600Ω.

A value for negative resistance is chosen. It can be of any value, but fast suppression occurs with values around 10kΩ.

From the equation $-R = 1/((2\pi f)^2 D)$ a value for D is required.

$$D = \frac{1}{(2\pi f)^2 R}$$

(the sign is dropped since only magnitude is important).

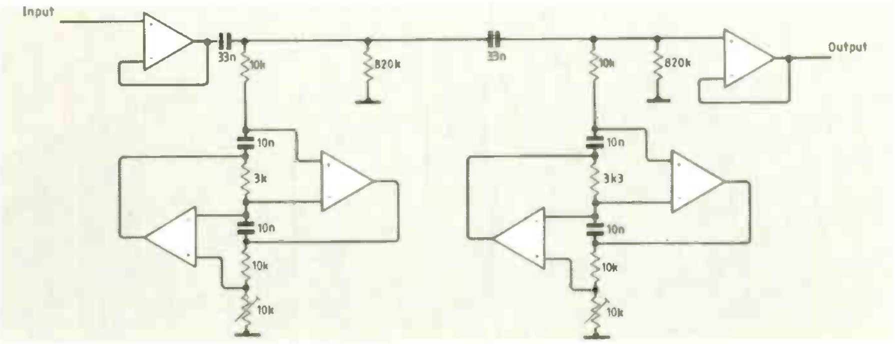
$$D = \frac{1}{(2 \times 3.1459 \times 2800)^2 \times 10 \times 10^3}$$

$$D = 3.222 \times 10^{-13}$$

From this the component values in the practical circuit of **Fig. 3** can be obtained. Values for R_4, R_5, C_1 and C_3 can now be assumed. Best results occur if the resistors R_4 and R_5 are made equal to the required negative resistor and C_1, C_3 should be good quality polystyrene capacitors; a suitable value is 10,000pF

From $D = R_2 R_4 C_1 C_3/R_5$, the value for R_2 can be calculated. Re-arranging

Fig. 5. Twin-gyrator filter will provide either two notches or a single notch with greater depth.



this equation gives:

$$R_2 = \frac{D \times R_5}{R_4 \times C_1 \times C_3}$$

$$R_2 = \frac{3.222 \times 10^{-13} \times 10 \times 10^3}{10 \times 10^3 \times 10 \times 10^{-9} \times 10 \times 10^{-9}}$$

$$R_2 = 3222\Omega$$

The nearest preferred value for R_2 is 3.3kΩ and a 10kΩ potentiometer will be used for R_5 to allow for the discrepancy.

This FDNR notch filter uses only a single stage. The input is provided from the voltage follower A_1 which is coupled to the positive resistive element via the 0.033μF capacitor (this, as discussed, appears resistive.)

The 820kΩ resistor provides the required DC bias path. Voltage follower A_4 provides buffering so that the FDNR is not damped. Op-amps A_2 and A_3 are

Fig. 6. Response of twin notch filter using two FDNRs.

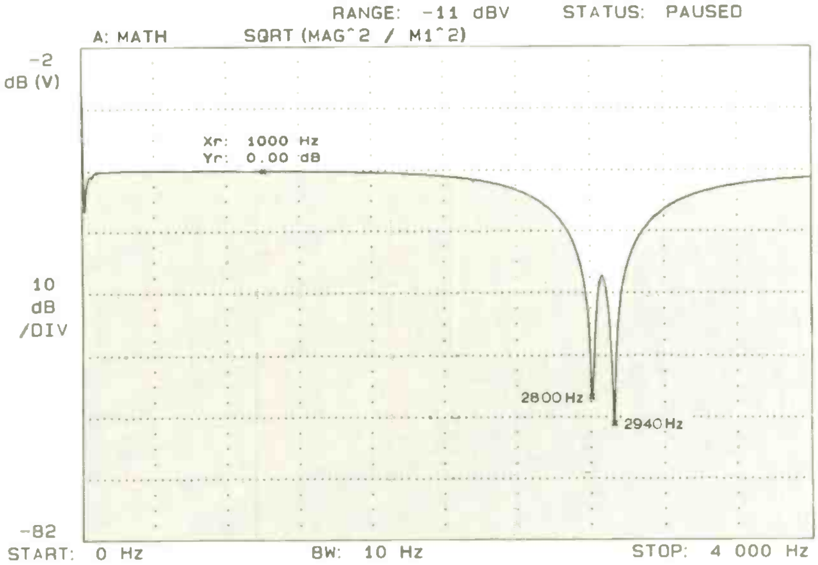
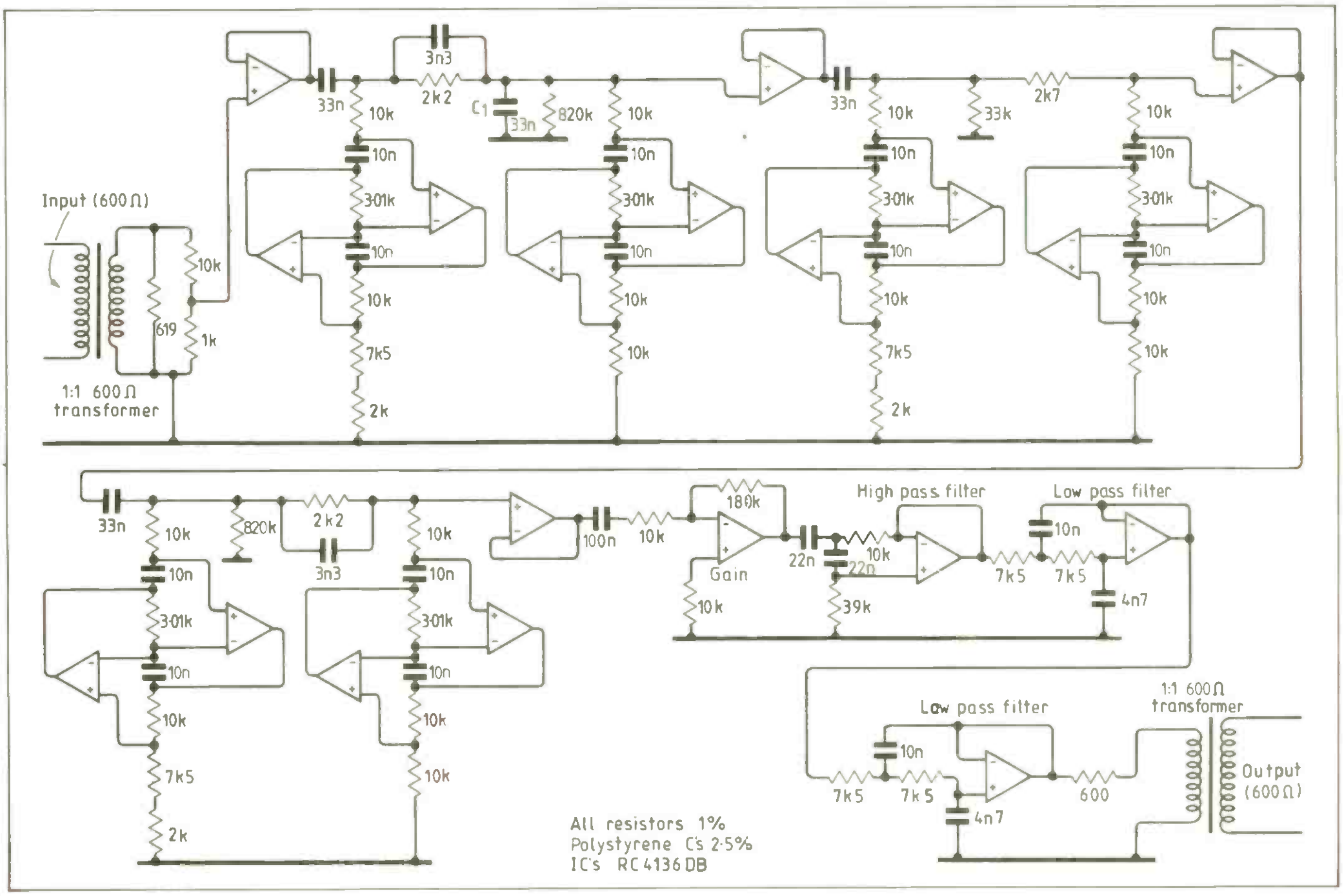


Fig. 7. Filter using three pairs of gyrators to suppress 2820Hz and 2940Hz.



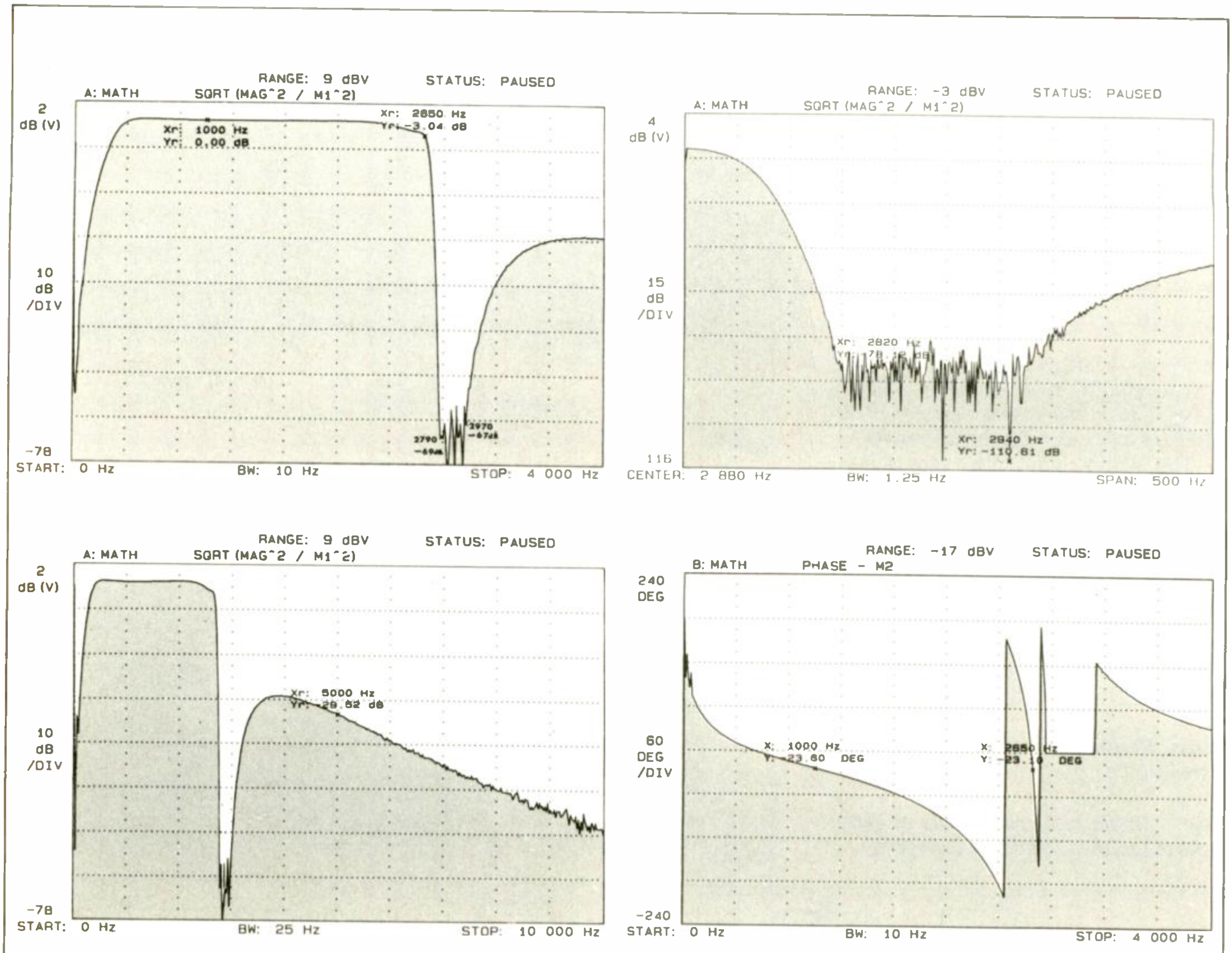


Fig.8-11. Speech and tone filter plots, showing a linear response to 4kHz, a linear plot of the notch, a linear response to 10kHz and phase response to 4kHz.

the FDNR active elements. The variable resistor varies the frequency of the notch. The frequency response is shown in **Fig 4.**

A twin FDNR filter. This uses two FDNR stages shown in **Fig. 5** which operate as in the first example. This time each section may either be adjusted to provide separate notches or to make both notches coincide to provide a single notch of some 50dB of suppression. **Figure 6** shows the two notches adjusted at 2880Hz and 2940Hz.

Speech and tone filter. A filter was required to interface with British Telecom telephone lines to pass a speech baseband and tones occurring at 2820 and 2940Hz. A level response for the filter was required from 300Hz up to about 2650HZ, after which a sharp cut-off was required with at least 60dB of suppression at the two tone frequencies. The response must also meet BT spectral requirements for low and high-frequency roll-off. The circuit is shown in **Fig. 7.**

To obtain greater than 60dB of suppression, three FDNRs for each tone frequency are required. Each section is then arranged in pairs similar to the twin filter with the first stage tuned to 2820 and the next to 2940Hz. This is buffered with a voltage follower and then fed to the next stage, which is similar to the first; the final stage is also aligned as in the first case. Resistors R_1, R_2 and R_3 provide 'lift' at 2600Hz to make the response level before transition into the notch. Adding R_4, which appears inductive and C_1, which appears resistive provides extra roll-off below 300Hz. After the final FDNR, some gain is provided to bring the levels back to that of the input; high and low-pass filters are then incorporated to shape the upper and lower frequency response to meet BT line specification. **Figures 8 to 11** show the characteristics.

As can be seen, the FDNR provides very good notch filters and their use in filter design should be much more widely appreciated, not least because of the simple way they may be cascaded to provide the desired frequency response.

References

1. Zverez, Anatol. I., Handbook of Filter Synthesis, John Wiley & Sons, New York 1967.
2. Troughton, R.H., *Electronics & Wireless World* November 1987, p1127, Gyrators in band-pass filter design.

GYRATORS

The gyrator is formed from the positive impedance converter, its main use being to replace wound inductors at audio frequencies, particularly where large values of inductance are required.

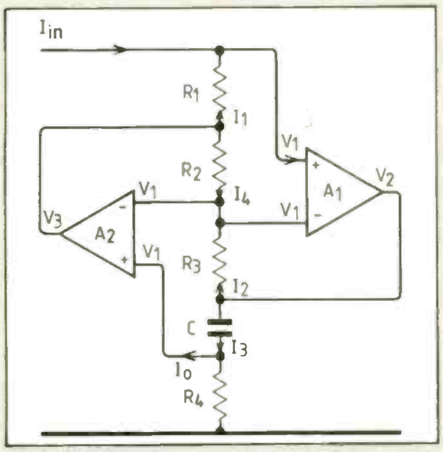


Fig. 12. Basic gyrator circuit.

The circuit, shown in Fig. 12 requires four resistors, one capacitor and two operational amplifiers. Its effect is to transmogrify the reactance of the capacitor into an inductive reactance at the output terminals.

The gyrator can be analysed if it is assumed that: the input resistance is infinite; the voltage gain is infinite; the bandwidth is infinite; the output resistance is zero; and the input offset is zero. This gives

$$(V_1-V_2)/R_3=I_2 \quad (A)$$
$$(V_1-V_3)/R_2=I_4 \quad (B)$$
$$(V_1-V_3)/R_1=I_1 \quad (C)$$

Since the input impedance of the op-amp is infinite,

$$I_2=I_4 \text{ and } I_{in}=I_1$$

From (C)

$$V_1-V_3 = R_1I_1 = R_1 I_{in}$$

Divide both sides by R_2

$$\frac{(V_1-V_3)}{R_2} = \frac{R_1-I_{in}}{R_2}$$

Since $I_2=I_4$, equation (A) is equal to equation (B).

$$\frac{(V_1 \cdot V_2)}{R_3} = \frac{(V_1 \cdot V_3)}{R_2} = \frac{(R_1 I_{in})}{R_2} \quad (D)$$

$V_1-V_2=I_3=j\omega c$ and $I_3=V_1/R_4$

$$V_1-V_2 = \frac{V_1}{j\omega C R_4}$$

Divide both sides by R_3

$$\frac{(V_1-V_2)}{R_3} = \frac{V_1}{j\omega C R_4 R_3}$$

The left hand term is now that of equation (D).

$$\frac{R_1 I_{in}}{R_2} = \frac{V_1}{j\omega C R_3 R_4}$$

Now cross multiply,

$$\frac{V_1}{I_{in}} = \frac{j\omega C R_1 R_3 R_4}{R_2}$$

But $V_1 = V_{in}$

$$\frac{V_{in}}{I_{in}} = Z_{in} = j\omega(C R_1 R_3/R_2) R_4$$

therefore $L = (C R_1 R_3/R_2) R_4$

If all the resistors in the gyrator circuit are made equal then the expression can be reduced

$$L=CR_1R_4$$
$$L=CR^2$$

Polystyrene capacitors are best used for C, since their temperature coefficient is equal and opposite in sign to that of the resistors; therefore, the overall temperature coefficient is approximately zero.

Practical example

A simulated inductor is required to have an inductance of 50mH and to resonate with 0.22µF at 100Hz. The value of C in Fig.13 can be arbitrarily chosen and should be a polystyrene type. A suitable value, which is readily available is 10,000pF.

R now calculated from $L=R^2C$:

$$R = \sqrt{\frac{50 \times 10^{-3}}{10 \times 10^{-9}}} = 2.236 \text{ k}\Omega$$

The nearest preferred value to this is 2.2 kΩ and the discrepancy can be compensated for by allowing R_4 to be a 5kΩ variable. This simulated inductor can be used in the same way that any ground-referred inductor can be used with AC signals.

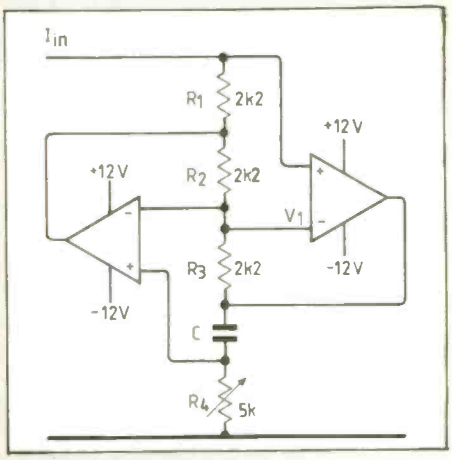


Fig. 13. Gyrator calculated to provide a simulated inductance of 50mH.

The resonance formula is transposed to

$$L = \frac{\left(\frac{1}{2\pi f_o}\right)}{C}$$

$$L = \frac{\left(\frac{1}{2 \times \pi \times 100}\right)^2}{0.22 \times 10^{-6}} = 11.514 \text{ H}$$

The gyrator circuit components are calculated from $L = R^2 C$. Again C can be chosen to be 10,000pF.

$$R = \sqrt{\frac{L}{C}} = \sqrt{\frac{11.514}{10 \times 10^{-9}}} = 33.93\text{k}\Omega$$

To allow the gyrator to be ungrounded the circuit must be configured as in Fig. 14. Circuit values are calculated as for a ground referred gyrator. The gyrator circuit can now be used in virtually any AF circuit even where "floating" inductance is required.

Reference

Antoniou. A., "Modelling of a Gyrator Circuit", *Wireless World* September, 1973.

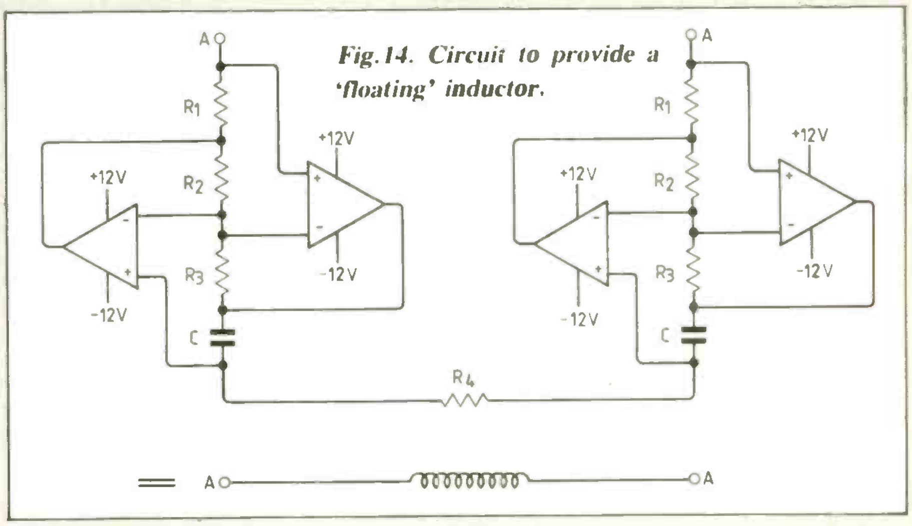


Fig. 14. Circuit to provide a 'floating' inductor.

Green plea

Your October issue mentioned that the Third World is a reluctant political issue, and you then turned your attention to the development of green awareness. I feel it is important to point out that the global tragedy of hunger and poverty can be placed on the political agenda, if people express their concern about it.

I belong to a group called Results, which encourages people to write letters, meet their MPs, and generally inform others about the 38 000 people who die each day from preventable causes – and the many more who survive in appalling conditions.

I urge all readers of this letter to take action and express their concern. For further information on Results, readers are invited to contact me direct.

Richard Prosser
40 Henry Street
Kenilworth

More audio?

I refer to your comment piece in October's *EW + WW*. Professional electronics engineers are a civilised breed, but it is unfortunate that so many of them are employed in industries associated with the manufacture or delivery of things which go bang and kill people.

While no amount of verbal or written exhortation on earth will stop this, I feel that it is important for publications such as yours to maintain an awareness in the use of electronics to improve the quality of human life rather than increase human slaughter.

While a great deal of your output can already be said to have achieved this, what has been lacking in recent months – and even years – is the level of output in print which used to be the case in the good old days, when scarcely an issue went by without an article by JLH, Nelson-Jones, D Self, B Duncan or others.

The use of electronics to further the quality of sound reproduction is all about getting sheer enjoyment from life, from the designers and writers of the articles who push their design to the nth super degree so that they are proud to put their name to it, via the hobbyist with his 25W iron and his kitchen table in eager anticipation of the end result, to the listeners who will surely include those who have no technical training, but who are thankful that others took so much trouble so that they could get more enjoyment from their Beethoven, big bands, Beatles, or the blues.

Please let us have, henceforward, as a matter of editorial policy, a steady stream (not the occasional tidal wave or prolonged drought) of articles, particularly constructional articles, concerned with (domestic) audio engineering.

M. Peacock
Teledyne Semiconductor
Southall

E ≈ mc^2

Over the years, the editors of *EW + WW* have gained a unique and world-wide reputation for publishing articles and letters that criticise so-called Modern Physics.

They are no longer alone. The American Institute of Physics, in its June issue of *Physics Today*, has published an article 'The concepts of mass' which states: "... the famous formula E=mc^2 has to be taken with a large grain of salt."

The article concludes by saying : "...Every year millions of boys and girls throughout the world are taught special relativity in such a way that they miss the essence of the subject. Archaic and confusing notions are hammered into their heads. It is our duty – the duty of professional physicists – to stop this process."

If, as I hope, the world's physicists are now prepared to have a long hard look at relativity theory, then the first credits must go to the editors and contributors to *EW + WW*.

John Ferguson
Camberley,
Surrey.

Shifting waves

After reading E W Silvertooth's article in May's *EW + WW*, I am led to wonder whether the Sagnac effect is displayed in the radio spectrum. Are not light and radio waves the same phenomenon?

If this is so, radio waves could change frequency along parallels and not along meridians. At the equatorial parallel, the change would be 15.43Hz approximately, for a 10MHz transmitter.

Can this be true? I have never heard of such a phenomenon. Furthermore, in the direction of Leo constellation, the change would be more than 1kHz.

Mosca Fabio
Trieste
Italy

Zener bender

The aim of my May letter was to draw attention to the peculiarity of the BSI symbol for a Zener diode. BSI draws it with the cathode line horizontal, bending its right extremity down through a right angle.

Now circuit symbols are intelligently chosen, even to the point of incorporating graphs. Thus the symbol in the middle of a nand gate is the input-output V-V graph. The US symbol for the Zener is an I-V graph: the left extremity of the horizontal line is bent down and the right extremity up. Very sensible. But BSI seems to have lost the meaning of these graphical bends. If they wish to bend down just one end of the line on the symbol, it must be the left end!

As printed my letter did not mention the Zener, and did merit much of Mr Best's criticism in his August letter. We do however differ on one point: I still maintain that when we are free to design languages, it is better nowadays to create one international language rather than several local ones.

This applies to circuit symbols. It follows that BSI is not competent to legislate on them – its authority is too local. Disaster must follow its attempts at control. Look what has happened to BSI gates and resistors! Its Zener is worse – it actually appears to be wrong.

Michael Mcloughlin
Haberdashers' Aske's School
St Albans

Mac's sloware

Your May *EW + WW* editorial carried interesting coverage of the evolving semiconductor techologies. While most of what you say is correct, I do not agree with your praise for the Apple Mac. I have used 68000's in many things and its a very fast and useful chip. I have a VME bus system at home amongst others.

The MAC 68000 software however is so very slow. I would fire a technical writer using a base model Mac, as they are spending half their paid time waiting for the machine, crippled by poor software, to do something. Even a big hard disk doesn't seem to help much.

I do like the Mac's windows and user interface scheme but not the implementation costs. The Mac's applications numerical interface standard which I've re-nicknamed "insane" makes some numerically bound jobs run ten times slower. Two to three times slower I could live with perhaps but not ten times.

I have been in the instrumentation/computer industry for twenty years and have designed and built a

continued on p. 1210

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ECF80	1.15
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ECF202	1.85
ECF801	0.85
ECF804	6.50
ECF805	2.50
ECF806	10.25
ECH3	4.50
ECH4	4.50
ECH35	3.50
ECH42	1.50
ECH81	1.75
ECH83	1.50
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ECH200	1.50
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ECL86	1.50
ECL805	0.95
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EF22	3.50
EF39	1.50
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EF42	3.50
EF50	2.50
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EF72	3.50
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EF80	0.55
EF83	3.95
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EL84 SIEMENS	2.50
EL85	4.50
EL86	1.75
EL90	1.75
EL91	4.50
EL95	1.75
EL152	15.00
EL360	6.75
EL500	1.95
EL504	1.95
EL509	5.25
EL509 MULLARD	7.50
EL519	6.95
EL802	3.65
EL821	6.95
EL822	12.95
ELL80	22.50
EM34	12.50
EM83	1.65
EM84	1.65
EM85	3.95
EM87	2.50
EN32	15.00
EN91	2.25
EN92	4.50
EY51	0.80
EY70	7.50
EY81	2.35
EY82	1.15
EY83	1.50
EY84	5.95
EY86/87	0.65
EY88	0.95
EY91	5.50
EY500A	2.95
EY802	0.70
EZ35	1.00
EZ40	3.50
EZ41	3.50
EZ80	0.75
EZ81	1.50
EZ90	1.50
FW4-800	4.50
G55/1K	9.00
G180/2M	6.95
G240/2D	9.00
GC10B	17.50
GC10D	17.50
GC10/4B	17.50
GC10/4E	17.50
GC12/4B	17.50
GD86W	6.00
GDT120M	5.00
GN4	8.50
GN10	15.00
GR10G	4.00
GS10C	16.50
GS10H	12.00
GS12D	12.00
GT1C	9.50
GU20	35.00
GU50	17.50
GXU1	13.50
GXU3	24.00
GXU50SS	14.50
GY501	1.50
GY802	1.50
GZ32	4.50
GZ33	4.50
GZ34	4.50
GZ37	4.50
HBC90	1.95
HL41	3.50
HL90	3.50
KT8C	7.00
KT33C	3.50
KT36	2.95
KT44	5.95
KT45	5.95
KT61	7.95
KT63	2.95
KT66 USA	11.95
KT66 GEC	25.00
KT66 TEONEX	5.00

KT67	9.00
KT77 GEC	14.95
KT81	7.00
KT88 USA	12.95
KT88 Selectron	15.00
KTW61	2.50
KTW62	2.50
KTW63	2.00
KTZ63	2.50
L87 20	95.00
LS9B	6.95
M529	65.00
M5143	155.00
M5199	295.00
M8079	6.00
M8082	7.50
M8083	3.25
M8091	7.50
M8096	3.00
M8098	5.50
M8099	5.00
M8100	5.50
M8136	7.00
M8137	7.95
M8161	6.50
M8162	5.50
M8163	5.50
M8190	4.50
M8195	6.50
M8196	5.50
M8204	5.50
M8223	4.50
M8224	2.00
M8225	3.95
ME1400	3.50
ME1401	19.50
ME1402	29.50
MHLD6	4.00
MP25	195.00
M548	5.50
MU14	3.50
N37	12.50
N78	9.85
OA2	1.50
OA2WA	2.50
OA3	2.50
OB2	1.50
OB2WA	2.50
OC3	2.50
OD3	2.50
OM4	2.50
OM5B	3.00
OM6	1.75
ORP43	2.50
ORP50	3.95
P61	2.50
P41	2.50
PABC80	0.95
PC86	0.75
PC88	0.75
PC97	1.10
PC900	1.25
PCC84	0.40
PCC85	0.55
PCC88	0.70
PCC89	0.70
PCC189	0.70
PCC805	0.70
PCC806	0.80
PCE82	0.80
PCF80	0.65
PCF82	0.60
PCF84	0.65
PCF86	1.20
PCF87	1.25
PCF200	1.80
PCF201	1.80
PCF801	1.35
PCF802	0.85
PCF805	1.25
PCF806	1.00
PCF808	1.25
PCH200	1.50
PCL82	0.85
PCL83	2.50
PCL84	0.75
PCL85	0.80
PCL86	0.85
PCL805	0.90
PD500	5.95
PEN25	2.00
PEN40D	3.00
PEN45	3.00
PEN45DD	3.00
PEN46	2.00
PFL200	0.95
PL36	1.75
PL38	1.50
PL81	1.25
PL82	0.60
PL83	0.52
PL84	0.78
PL500	1.25
PL504	1.25
PL508	1.50
PL509	4.85
PL519	4.95
PL802	6.00
PL802T	3.50
PL820	2.95
PY32	0.60
PY33	0.50
PY81	0.70
PY82	0.70
PY83	0.70
PY88	0.99
PY500A	1.95
PY800	0.85
PY801	0.85
QB3-300	72.00
QB3 1750	139.00

QB5 3500	595.00
QQE02 5	19.50
QQE03-12	7.95
QQE03-20	35.00
QQE06 40	45.00
QQV02 6	19.50
QQV03 10	5.50
QQV03 10 MULLARD	15.00
QQV03-20	25.00
QQV06 40A	27.50
QQV06 40A MULLARD	39.50
QQV07 50	55.00
QQZ03 20	42.50
QQZ06 40	45.00
QS75/20	1.50
QS95/10	4.85
QS108/45	4.00
QS150/15	6.95
QS150/30	1.15
QS150/40	7.00
QS1205	3.95
QS1213	5.00
QU37	9.50
QV03 12	6.50
QV05-25	3.50
QV06-20	29.50
QV08 100B	145.00
QY3-125	85.00
QY4-250	105.00
QY4-400	110.00
R10	4.00
R18	2.50
RG1 240A	14.50
RG3 250A	6.50
RG3 1250A	35.00
RR3-250	15.00
RR3-1250	35.00
S11E12	38.00
S104-2K	10.00
SC1/1300	6.00
SP61	3.50
STV280/40	11.95
TB2-5/300	95.00
TB2 300	195.00
TB3-750	115.00
TB3-2000	450.00
TBL2-300	395.00
TBL2 500	495.00
TD03 10/D/E/F	35.00
TT15	45.00
TT21	45.00
TT22	45.00
TT100	69.00
TY2-125A	105.00
TY8-600W	365.00
U19	9.50
U26	0.90
U35	3.50
U37	9.00
U41	6.95
U50	3.00
U82	3.00
U191	0.70
U192	1.00
U193	1.00
U251	2.50
U801	3.50
UABC80	1.00
UAF42	1.95
UBC41	3.95
UBC81	1.50
UBF80	0.95
UBF89	1.00
UBL21	2.95
UC92	2.50
UCC84	0.70
UCC85	1.00
UCF80	1.00
UCH21	2.50
UCH41	2.50
UCH42	3.95
UCH81	1.95
UCL82	1.75
UCL83	2.50
UF41	2.25
UF42	2.25
UF80	1.75
UF85	1.20
UF89	2.00
UL41	10.00
UL44	3.50
UL84	1.95
UL85	0.85
UU5	3.50
UU6	6.00
UU7	8.00
UU8	9.00
UY41	3.50
UY85	0.70
V235A/1K	250.00
V238A/1K	295.00
V246A/1K	250.00
V246A/2K	315.00
V241C/1K	195.00
V453	12.00
VLS631	10.95
VP48	9.50
VP41	4.95
VR101	2.50
VR105/30	2.50
VR150/30	2.50
VU39	2.50

W21	4.50
W61	4.50
W77	5.00
W81M	4.50
W739	1.50
X24	4.50
X41	4.50
X66/X65	4.95
X81	6.00
XC24	1.50
XC25	0.50
XFW47	1.50
XFW50	1.50
XG1-2500	75.00
XL628FT	7.50
XNP12	2.50
XR1/1600A	49.50
XR1/3200A	79.50
XR1 6400A	149.50
Y65	6.95
YD1100	75.00
YJ1060	265.00
YL1020	42.50
YL1060	195.00
YL1070	195.00
YL1071	195.00
YL1290	65.00
Z77	1.20
Z3001	6.00
Z302C	12.00
Z359	9.00
Z700U	9.50
Z759	15.00
Z803U	18.95
ZA1000	12.50
ZA1001	1.50
ZM1001	12.00
ZM1005	8.00
ZM1020	8.50
ZM1021	8.00
ZM1023	7.95
ZM1041	14.00
ZM1082	9.00
ZM1084	10.00
ZM1175	6.50
ZM1177	9.00
ZM1202	55.00
ZM1263	4.00
1A3	4.50
1AE4	3.50
1AX2	3.50
1B22	10.00
1B27	55.00
1B3GT	1.95
1B35A	45.00
1K3	2.50
1N5GT	2.50
1P28	25.00
1R5	1.50
1S5	1.50
1T4	1.50
1U4	1.75
1U5	1.50
1X25	2.50
2A3	16.50
2AS15A	11.50
2B7	4.50
2B22	69.50
2C36	70.00
3C39A	32.50
2C39BA	39.50
2C40	37.50
2C42	29.50
2C43	60.00
2C51	2.50
2CY5	1.50
2D21	2.25
2D21W	3.15
2E22	49.00
2E26	7.95
2J55	295.00
2K25	59.00
2K26	95.00
2K29	250.00
2K48	140.00
2K56	250.00
2X2A	5.00
3A/107B	12.00
3A/108A	9.00
3A/109B	11.00
3A/110B	12.00
3A/141K	11.50
3A/146J	7.50
3A/147J	7.50
3A/167M	10.00
3A3A	3.95
3A4	1.50
3A5	4.50
3AT2	3.35
3B22	25.00
3B26	24.00
3B28	15.00
3BZ6	1.50
3C45	39.50
3CX3000A7	650.00
3CY5	1.50
3D21A	29.50
3E22	49.50
3E29	39.50
3EJ7	1.95
3H	0.40
3J 170E	1450.00
3L	0.40
3Q4	2.50
4-65A	85.00
4-250A	105.00
4-400C	95.00
4-1000A	495.00

4B32	35.00
4BQ7A	1.75
4BZ6	1.95
4C28	25.00
4C35	145.00
4CS250R	285.00
4XC125C EIMAC	150.00
4CX250B	45.00
4CX250BM	65.00
4CX250K EIMAC	115.00
4CX250R AMPEREX	125.00
4CX350A	100.00
4CX1000A	425.00
4CX1500B	475.00
4CX5000A	1000.00
4D21/4 125A	85.00
4D32	125.00
4E27A	125.00
4GS7	2.25
4GV7	2.25
4J6A	2.95
4KT6	1.50
4TB5P	150.00
4X150A	35.00
4X150D	55.00
4X500A	350.00
5A/102D	9.50
5A152M	9.00
5A163K	10.00
5A170K	6.25
5A-180M	9.00
5A 206K	10.00
5B 110M	10.00
5B-254M	11.50
5B-255M	14.50
5B 256M	15.00
5B 257M	15.00
5B258M	14.50
5C22	125.00
5CL8A	2.50
5J180E	1250.00
5JL8	2.95
5R4GB	5.50
5R4GY	4.95
5R4WGY	5.95
5T4	5.95
5T8A	1.95
5U4G	4.50
5U4GB	4.50
5V4G	2.50
5W4	4.95
5X4	4.95
5Y3GT	3.50
5Z3	4.50
5Z4G	2.50
6/30L2	0.70
6A/203K	9.00
6A7	4.95
6A8	2.50
6AB7	4.50
6AC7WA	2.00
6AG5	2.50
6AG7	2.50
6AH6	3.50
6AJ4	3.50
6AJ7	2.00
6AK5	1.95
6AK6	2.50
6AL5	0.85
6AM4	3.25
6AM5	4.50
6AM6	1.95
6AN5	4.50
6AN8A	4.50
6AQ5	1.75
6AQ8	1.50
6AR5	8.95
6AS5	1.50
6AS6	2.50
6AS7G	4.50
6AT6	1.95
6AT8	1.75
6AU4GT	2.95
6AU5GT	4.50
6AU6	1.50
6AV6	1.95
6AW8A	3.50
6AX4GT	1.95
6AY3B	1.95
6AZ8	4.50
6B8G	2.50
6B10	1.95
6BA6	1.50
6BA7	4.50
6BA8A	3.50
6BC8	1.50
6BR3	2.95
6BE6	1.50
6BG6G	3.00
6BH6	1.95
6BH8	1.50
6BJ6	1.50
6BK4	6.50
6BL6	85.00
6BL8	1.15
6BM6	115.00
6BN6	1.65
6BN8	3.95
6BQ5	1.35
6BQ7A	1.50
6BR7	4.95
6BS7	5.50
6BW6	5.35

6BW7	1.50
6BZ6	2.50
6BZ7	2.95
6C4	1.95
6C5	2.50
6C6	3.50
6CBG	2.50
6C9	4.95
6CA4	4.95
6CA7	3.50
6CB5	3.95
6CB6	2.50
6CD6GA	4.50
6CF6	1.95
6CG7	4.50
6CH6	6.95
6CL6	3.25
6CL8A	2.95
6CM7	2.95
6CS6	0.75
6CS7	0.95
6CW4	8.00
6CX8	3.95
6DC6	2.35
6DJ8	1.35
6DJ8 SPECIAL	3.50
6DK6	1.50
6DQ5	8.50
6DQ6B	2.50
6DT6A	1.50
6DW4B	3.50
6E5	3.95
6EA7	2.50
6EAB	2.50
6EB8	3.50
6EJ7	0.85
6EM5	2.50
6EM7	2.50
6EU8	1.75
6EV7	2.95
6EW6	1.50
6F1	2.00
6F5	5.50
6F7	5.50
6F13	3.00
6F14	1.00
6F17	2.75
6F23	0.60
6F24	1.25
6F25	1.25
6F28	1.25
6F32	1.25
6F33	10.50
6FH5	8.50
6FH8	15.00
6FL2	4.50
6FQ7	4.50
6GE5	3.95
6GH8A	2.50
6GJ7	0.85
6GK6	3.95
6GM6	2.65
6GS7	21.5
6GV8	0.95
6GW8	2.50
6GY5	4.95
6GY6	2.50
6H1	9.50
6H6GT	2.50
6HB7	1.95
6HF8	3.50
6HM5	2.50
6HQ5	3.50
6HS6	4.95
6HS8	2.95
6HZ6	3.50
6J4	2.15
6J5G1	2.50
6J6	2.00
6J7	4.15
6J7G	4.15
6JB6A	10.95
6JE6C	10.95
6JM6	10.95
6JU8A	2.50
6JS6C	10.95
6K7G	2.00
6K8G	3.00
6KD6	12.50
6KG6A	6.95
6L1	2.50
6L6GC	3.50
6L6GC USA	9.50
6L6GT	3.50
6L7	3.50
6L15	3.15
6L19	3.95
6LJ8	2.50
6LD20	1.15
6LF6	11.50
6LQ6	9.50
6P28	2.00
6Q7GT	1.50
6R7	3.15
6RHH8	10.00
6S4A	1.95
6SA7	1.95
6SC7	1.95
6SH7	1.95
6SJ7GT	1.95
6SK7	1.95
6SL7GT	1.95
6SN7GT	4.50
6SQ7GT	4.50
6SS7	1.95
6T8	1.50
6U6GT	3.50
6U7G	3.50
6U8A	1.50
6V6G	1.95
6V6GT	2.50

6W4GT	1.95
6Y6G	3.95
6X2N	1.00
6X4	1.50
6X5GT	1.00
6XBA	2.25
6Y6G	4.50
7AU7	1.50
7B6	3.50
7B7	2.50
7D8	4.50
7J7	5.50
7K7	7.50
7L	1.50
7Q7	4.50
7Y4	2.50
8B8	2.50
8B10	2.50
8BQ5	1.95
8CW5	1.50
8EBB8	1.50
8FQ7	1.95
10O2	1.25
10DE7	2.50
10DX8	2.50
10EB8	1.95
10EW7	2.95
10F1	1.95
10GK6	1.95
10IP4	2.50
11E3	55.00
11R3	5.50
12A6	3.95
12AD6	2.50
12AE6	5.50
12AH7GT	4.95
12AL5	1.00
12AT6	1.75
12AT7	1.50
12AT7WA	2.50
12AU6	1.50
12AU7	0.85
12AV6	1.95
12AV7	2.50
12AX4GTB	2.50
12AX7	0.95
12AX7WA	2.50
12AX7S	7.95
12AY7	3.95
12B4A	4.50
12BA6	2.50
12BE6	1.95
12BH7A	4.95
12BL6	1.75
12BR3	1.95
12BY7A	3.50
12CB	2.50
12CA5	1.95
12CX6	1.95
12DQ6B	3.50
12DW4A	3.50
12DZ6	3.95
12E1	19.50
12E14	38.00
12FX5	1.95
12GN7	5.50
12GH7	3.95
12J5GT	3.95
12J7GT	3.50
12JZ8	2.95
12KGT	1.50
12K8Y	1.95
12KU7	1.95
12S7GT	1.50
12SA7GT	1.95
12SG7	4.75
12SK7	1.95
12SJ7	1.50
12SN7GT	1.85
12SW7	3.50
12SY7	4.50
12X4	1.95
13D7	3.20
13DE7	2.50
13DR7	2.95
13E1	145.00
13EM7	3.50
14B6	4.50
14R7	3.50
15E	5.50
16AQ3	1.95
16GY5	2.95
16H	0.40
16L	0.40
17AB	3.50
17AX4GTA	1.95
17BE3	2.50
17DW4A	2.95
17EW8	1.50
17JZ8	4.50
18D3	6.00
18GB5	3.50
19AQ5	3.50
19AU4GT	2.50
19BG6	3.50
19G3	19.50
19G6	9.00
19H4	35.00
19H5	33.50
20CV	9.50
20D1	1.50
20LF6	7.95
20L1	0.95
20P1	0.55
20P4	1.95
20P5	1.15
21JZ6	6.50
21KQ6	4.95
21LU8	3.75
24B1	39.50
24B9	39.50
25BQ6	1.75

25DQ6B	2.95
25L6G1	1.75
29C1	19.50
29KQ6	6.50
30C15	0.50
30C17	0.40
30C18	1.48
30FL2	1.35
30FL12	0.95
30FL13	1.10
30FL14	1.25
30L1	0.45
30L15	0.60
30L17	0.60
30P4MR	1.00
30P12	1.00
30P18	0.60
30P19	1.00
30P1	2.50
30PL13	0.60
30PL14	1.75
31JS6C	5.50
33A/158M	19.50
35A3	3.95
35A5	4.50
35C5	4.50
35L6GT	2.00
35Z3	1.95
35Z5GT	3.50
38HE7	5.95
40KD6	5.50
42	6.95
47	6.00
50A5	1.50
50B5	1.95
50C5	0.95
50CD6G	1.95
50EH5	1.50
50JY6	2.95
53KU	4.50
75B1	3.50
75C1	4.50
80	4.50
83	8.50
83A1	7.50
85A1	6.50
85A2	2.95
90AV	17.50
90C1	3.50
90CG	17.50
90CV	17.50
91AG	9.00
92AG	25.00
92AV	25.00
95A1	6.50
100E1	50.00
108C1	2.50
150B2	6.50
150C1K	9.00
150D2	2.50
150C4	2.50
185BT	1.50
211	25.00
2300	15.00
2310	15.00
250TH	150.00
307	5.00
328A	15.00
5728	49.00
705A	12.50
713A	25.00
723A/B	75.00
724A	275.00
725A	275.00
726A	75.00
801A	15.00
803	14.95
805	59.00
807	3.50
811	15.00
812A	24.00
813 Philips	35.00
813	27.50
8298	22.50
833A	95.00
845	40.00
866A	8.50
872A	20.00
873	60.00
954	1.00
955	1.00

[illegible]	315.00
[illegible]	25.00
2040	25.00
2050A	5.95
2050W	6.50
4212H	250.00
4471	35.00
4687A	9.50
5544	79.50
5559	55.00
5636	5.50
5642	9.50
5643	9.50
5651	2.50
5654	1.95
5670	3.25
5672	4.50
5675	28.00
5678	7.50
5687	4.50
5696	4.50
5702	3.50
5704	3.50
5718	6.15
5725	2.50
5726	2.50
5727	2.50
5749	2.50
5750	1.85
5751	2.95
5763	6.50
5814A	3.25
5823	9.50
5829WA	6.50
5840	3.50
5842	11.00
5847	10.95
5863	95.00
5879	9.50
5886	13.95
5894	39.50
5899	4.50
5963	1.75
5965	2.15
6057	3.75
6058	2.50
6060	2.25
6072	6.95
6080	8.50
6080WA	9.50
6132	10.50
6136	2.50
6146B	9.50
6146W	12.50
6155	22.00
6156	125.00
6157	2.50
6158	3.20
6189	4.50
6201	6.45
6350	3.50
6360	4.50
6386	14.50
6442	75.00
6463	7.50
6550	8.95
6550A GE	13.95
6870	11.50
6883B	9.95
6973	8.95
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7119	9.00
7189	5.50
7199	7.50
7247	8.50
7475	5.00
7486	155.00
7527	125.00
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7586	15.00
7587	19.50
7591A	8.95
7815	59.50
7868	8.50
7895	17.50
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CIRCLE NO. 142 ON REPLY CARD

number of 8 + 16-bit micros up to a 32-bit micro coded bit-slice monster. Its 6 mips in 1975 wasn't bad.

My motto is "a little bit of hardware can beat an awful lot of software". Putting some multipliers or correlators or string searchers in a system can make a huge improvement to a cheap pedestrian model.

The baseline model Mac is doing all the work normally done in hardware chips with (poorly written?) software and suffers as a result.

So hate it or not the 8088 and its issue will survive and flourish. This of course wouldn't be the first time some architectural freak has made it to the top of the heap and stayed there, much to the dismay of some of us pre-1970 relics.

Leonard Spyker
Karrinyup,
Australia

Licence to make money

I heartily agree with the sentiments of your editorial in the September *EW + WW* but, rather than hairdressers, I think the better-educated will become accountants and solicitors.

For over 50 years the professional institutions have been preaching that we must improve the prestige of engineers. In the 15 years of the existence of the Council of Engineering Institutions, many millions of pounds were wasted in the attempt to boost the image of the engineer: and now the Engineering Council has taken up the challenge.

The fact is that engineers do not have the same prestige as other professionals simply because they have no legislative support. In theory, an unqualified engineer can build a skyscraper, a missile or a bridge, but only a qualified person can cut a carbuncle off the nether regions of the body – because the law says so.

A glance at the job ads in any of the week-end papers will give the reason why people don't want to go into engineering. A newly-qualified chartered accountant is much sought after at £22/23 000 p.a. plus benefits. On the other hand, we regularly receive job specifications from leading electronics companies expecting five years' specific experience in a particular discipline in electronics, with salaries of between £13 000 and £16 000 a year.

When national and international legislation specifies that a chartered engineer must be used on projects above a certain value, then we shall see more people becoming interested in joining the engineering industries, and not before.

T. Jeffrey Burton
Electronics People
Tunbridge Wells

Phasor limitations

Joules Watt in his August article makes too much of phasors *per se*. Mathematically a vector quantity is simply one which obeys the vector rules for addition and subtraction and for multiplication by a constant. Thus phasors do qualify as two-dimensional vectors, and compare with such classical vectors as the reaction forces on a rod at the points where it is pinned to other rods forming part of a planar linkage.

Vector diagrams show the relationship between the phasors representing, say, the currents at a particular mesh point in a network of impedances just as well as the relationship between the set of reactions on a particular rod when the linkage is stressed.

The vector approach has the advantage that it allows the impendances (which reflect the way in which the network components contribute to the differential equation) to be modelled in terms of frequency dependent 'vector operators', which rotate and re-scale the vectors.

The modelling exploits the fact that the *multiplication* law for the operators follows that for complex numbers (see my November 1988 letter). In Joules Watt's presentation, starring phasor voltages and currents, the impedances are left only with bit parts.

The notion of a 'vector field', applied for example to the electrostatic field generated by a point charge, deals with the forces that would be exerted on a hypothetical test charge if it were placed at various points in the neighbourhood of the original charge.

Evidently this notion involves an extension of the basic concept of a vector. A clear distinction must be made between the abstract spaces in which vector diagrams are drawn on the one hand, and on the other the physical space over which a vector field is defined.

The frequency domain approach to a network builds up from its reponse to a sinusoidal signal (i.e.a signal with a delta function spectrum). This response involves only a particular integral from the general solution to the differential equation.

The time domain approach starts from the response of the network to a delta function voltage signal (which still sets up finite charges on the capacitors and finite currents in the inductors!). In determining the response to this signal only the complementary function part of the solution is involved.

In the first approach the signal has 'zero' bandwidth, and in the second 'zero' duration, so that neither permits the product of duration and bandwidth to be determined.

By using true Fourier transforms, which link the waveforms and spectra of arbitrary signals of finite duration, one can show that the product of the RMS width of a waveform with the RMS width of its spectrum is a number which must exceed unity.

Phasor treatments fail to bring out this property because they correspond to the initial frequency domain approach.

C.F.Coleman
Grove,
Oxon.

Rotten audio by design

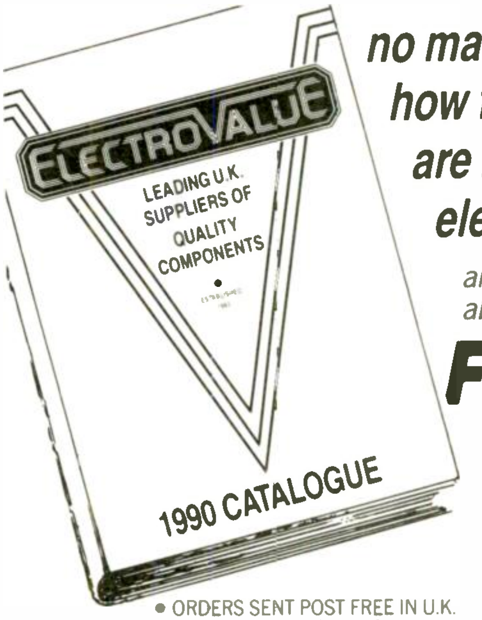
"On reading Mr Steckel's letter in September *EW + WW*, my first reaction was a resigned sigh that he had seized upon my first paragraph, which dealt unremarkably with slew-rates and compensation, and ignored the original work that made up the remaining 90%. Nonetheless, I decided that a couple of interesting points might emerge.

I concur that there are far better ways of measuring subjective audio impairment than by using THD methods, and that pseudo-random IMD test signals are very effective for this. Indeed I dealt with the Belcher technique in my article "Science v. Subjectivism" in *EWW & WW* (July 1988).

I also do not dispute that intermodulation products play a greater role in perceived degradation than harmonics do, when average musical signals suffer non-linearity. I also made this point in the article.

The real point here is that this kind of assessment of audible impairment should have nothing to do with hi-fi. The intermodulation tests are designed for use on channels of marginal or questionable acceptability, such as AM radio, while with modern technology the acceptability of a relatively simple system such as a pre or power amplifier should really be beyond question, providing one

continued on p. 1212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eschews subjectivism, and pays attention to the engineering.

It is, or at any rate should be, routine to build an electronic signal path that exhibits less than 0.003% THD across the audio band, and it is unlikely that anyone would contend that such non-linearity could ever be audible.

Applying subjective-impairment tests to this sort of system is pretty pointless, but a 20Hz-20kHz THD sweep allows a quick and cheap check that it is working properly. An intermodulation test may generate a raw number, but if something is wrong it gives no clue as to what.

Naturally I agree with Mr Steckel that loop gain is important and slew-limiting is bad, but these are hardly original sentiments. If "many high-feedback… designs have inadequate loop gain at high frequencies" then I would hope to be told which manufacturers have failed to appreciate basic electronics, though I suppose this might turn elementary technical problems into intractable legal ones.

It is not really enough to say that given poor design, such-and-such will blight one's music. Given sufficiently poor design anything could be a problem, from slew-limiting to decapitation by exploding electrolytics.

Douglas Self,
Forest Gate,
London

Small talk

In your July editorial, 'No business in show business', you make a number of derogatory comments about British Electronics Week, concluding with a 'small is beautiful' message and extolling the virtues of journals such as your own.

You are, of course, entitled to your personal view in such matters (which rather parallels the oft-expressed view among our exhibitors that there are too many journals serving the electronics market!).

However, it is important to emphasise that this is just a personal view, and it is far removed from the response we have received from surveys of both exhibitors and visitors after this year's event.

And, of course, reflecting your 'small is beautiful' theme, the British Electronics week does incorporate a number of small, specialist events, each of which has its own particular audience. Again, our surveys show that exhibitors and visitors at such events appreciate the synergy and cross-fertilisation that results from being alongside technology-focused shows and conferences.

Moreover, contrary to your comments, people attend from all over the country – not just the South-East; and, incidentally, there is a significant European attendance which we hope to see increased as the event adopts a pan-European posture in the run-up to 1992.

Neil Slaughter
Evan Steadman
Communications Group
Saffron Walden

Whither the OTA?

I found the article on current-feedback op-amps (*E&WW*, August 1989) interesting for more than one reason. Apart from the improved performance these devices offer, I was reminded of the operational-transconductance amplifier (OTA), which was developed in the late 1970s. It was hailed as a breakthrough in analogue engineering but, curiously, nothing further was heard of it after a time.

I would be interested to know of its fate. Perhaps one of your readers could enlighten me.

B.D. Runagle
Burton on Trent
Staffordshire

Gyroscopes

As a relatively new regular reader of your magazine I have been impressed by the breadth and depth of coverage of topics. Therefore it is to be expected that aspects of mechanics will enter into articles and correspondence.

I was, however, surprised to read that some readers still believe that gyroscopic phenomena fall outside the jurisdiction of Newtonian mechanics. Whilst appreciating that any physical law is only an approximation and is only valid until proven incorrect, all observed gyroscopic phenomena are quite adequately explained by Newtonian mechanics.

The basic equation of motion for rigid body motion in thre dimensions were established by L. Euler (1758) and gyroscopic motion in particular was discussed in some detail by E.J. Routh (1905). An excellent contemporary text is Gyrodynamics by Arnold and Maunder (1961). In the seventies I published an article to help dispel some of the misconceptions that were being perpetrated at that time. Also at the same time other dynamicists and myself took part in a meeting with the same objective. I thought the matter now was just history, but apparently this is not so.

As a direct result of these 'close encounters' we constructed some simple experiments to show how rotating objects and oscillating bodies apparently 'levitate' when using simple beam balances and spring balances. The gyroscopic 'levitation' demonstration is easily repeated but with a simple Newtonian explanation. I use these demonstrations to indicate that care is needed in making dynamic measurements and further that the senses can easily be confused when applied to three dimensional phenomena.

If anyone still believes that gyroscopes are non-Newtonian then I shall be pleased to arrange a short demonstration at The City University, London.

As an example of apparent anti-gravity effects in electronics consider the case of a charged particle moving in a plane normal to a uniform magnetic field. It is well known that the particle will move in a circular path. If now we take into account a gravitational field acting in the plane of motion, i.e. at right angles to the magnetic field, the path does not sink downwards but drifts sideways; apparently defying the law of gravity. The problem described is also readily solved by classical mechanics.

In all the above examples it is assumed that speeds do not approach that of light so that the theory of relativity does not need to be considered.

H.R. Harrison
Dept. of Mechanical
Engineering & Aeronautics
The City University
London EC1

Unkind cut

With reference to your September editorial comment, "A nation of hairdressers"; as a hairdresser of over 45 years standing, I think this is an offensive attack upon my profession.

To hide this attack in a technical magazine, where most hairdressers would be unable to reply to it, was despicable. The professional hairdresser has more skill, knowledge and ability than you will ever understand.

They are craftsmen and artists, caring and hardworking, psychologist and therapist, teachers and businessmen, diplomat and good listener. They have many other desirable attributes which they carry forward into public life. You will find them involved in local councils, charitable institutions, school management etc., all for the benefit of the community.

To succeed in hairdressing requires a good all round education, an ability to create, to interpret fashion and an agile mind to accept a continuous learning process throughout the working life. Not for them the narrow confines of factory or laboratory.

The country would be a better place if it were "a nation of hairdressers".

P.L. Peach
Axminster
Devon

Doubt and faith

It is an old problem with the scientific method that the validity of all scientific laws is dependent on them being open to theoretical and empirical refutation. This status should not change with the passing of time. After all, Newton's laws had been established for 200 years before Einstein came along! At the same time, it is helpful for the pragmatic scientist to be able to have faith in certain "fundamental" laws of science. It is inevitable that the scientific community is sceptical whenever someone claims to have found violations to them.

Both doubt and faith in well established principles are healthy attitudes for science to adopt. But they are in conflict with each other and a proper balance must be struck. It is my belief that in recent years the emphasis has been too much in the direction of faith.

The trouble is this: it is almost impossible for a single mind to simultaneously have doubt and faith in anything. Consequently when a discussion about the absolute truth of a law arises, it tends to be between two factions of scientists (usually in the pages of a journal with the subscribers as onlookers). Scientists being only human, this debate can degenerate into personal attacks. Even if it doesn't, there are those who believe that this sort of discussion can only be damaging for the image of science (which the general public has come to regard as the fount of all indisputable knowledge). They would rather there was never any public dissent. I maintain that these people are wrong. As in politics, dissent is a sign of a healthy system. It is only damaging to a false image of science. Although many scientific doubts can be resolved in private by appropriate research, there will always be some which can only be resolved by discussion amongst a wider audience.

But who are these dissenters? Why do they always sound so paranoid? Why have so many original ideas originated from outside the universities? My own experience when I started to doubt the universal validity of the second law of thermodynamics have given me an insight into these questions.

I thought (and still do think) I could see a flaw in the reasoning behind this law. Furthermore I thought I could see a way that the law might be circumvented to build what is known as a *perpetuum mobile* of the second kind. At first, I thought that it was likely I might be wrong and that some friendly colleague or consultant might point out the error. This did not happen. The next step was research in public and university libraries. This showed me some mistakes I had made that the people I consulted could have shown me but nothing that destroyed the idea. In fact this research enabled me to refine my theories and encouraged me to think that I might be on to something.

Writing to academics who had been recommended to be as knowledgeable in the field was unsuccessful. Usually I received no reply at all (although one lecturer wrote back and told me he was not interested in discussing ideas which defined "Common Sense"). Trying to get my ideas published also failed (even in *Wireless World*). Could it have been the style rather than the content? I never knew because I always received my manuscript back without comment. The only practical experiments I have been able to afford have proved to be encouraging but equivocal. Even the avenue of patenting my device is denied to me because I am advised that the law forbids it. There seems no avenue left open to me to find the truth of the matter. I am sure that these experiences are not unique to me.

The next time you read an article in these pages by someone challenging a scientific orthodoxy, remember these things. He has probably had to refute many spurious objections from people who ought to know better. He has probably been ignored my many academics to whom the fear of ridicule damaging their career prospects is far greater than their lust for knowledge. He may even have been laughed at by people who have not the wit to understand one tenth of what he is trying to say. A little suppressed aggression discernible between the lines is appropriate in these circumstances.

I congratulate and encourage those few journals such as yours who are prepared to challenge scientific orthodoxy. But please do not call it "Lunatic Fringe" science. Without dissent your journal might be known as "Semaphore World". We can take a joke but the situation is bad enough as it is without one of our few outlets taking the mick. If anyone is interested in discussing my revised theory of the second law and its applications, I would be happy to hear from them.

R. Lerwill
Castle Mills
Chirk Clwyd

Pseudo science

The article Science v. subjectivism in audio engineering (July 1988) by D.R.G. Self was excellent. It could also be applied to FM tuners, at least in the USA and I suspect Great Britain as well. Mr Self did an outstanding job in disputing the claims of "electrolytic capacitor sound" or the effect of 100 dollar per foot cables, and the argument is equally applicable to FM tuners which have only a 17kHz audio response at best because of the requirement to filter out the 19 kHz FM stereo pilot. The claim that an NE5534 operational amplifier modifies the sound of the low-pass filter is ridiculous. In one tuner, the manufacturer provides a low-level audio output before the NE5534 for those who want purer sound; the real result is that the capacitance of the cable connecting the tuner to the audio amplifier messes up the resistive termination of the low-pass filter and causes a peak at 16 kHz. This, of course, sounds a little brighter.

The other situation which continually causes problems is the desire for more selectivity. No non-technical person and very few engineers understand that filter selectivity and distortion produced on FM signals are related. Furthermore, the IEEE/IHF specifications on FM tuner measurements allow for "slight retuning" of a tuner when measuring THD. Digital synthesized tuners cannot usually be slightly tuned, but the generator can, so this is usually done. Unfortunately, the user is not able to ask the station to slightly alter its frequency. There are some very expensive tuners on the market today with a narrow bandwidth selection for those difficult reception conditions, and the filter is often not exactly centred on the correct frequency. The result is that they often have 2% or more distortion on the narrow position, but the magazine reviewer will never say that he had to offset his generator to get the less than 1% claimed.

I will continue to apply the best engineering practice to my designs, and if the manufacturer want to add five dollars worth of polypropylene coupling capacitors to the audio output of his tuner, and the purchaser wishes to pay 50 dollars more for the satisfaction of knowing that no electrolytic capacitor is corrupting his sound, that is his business. An electrolytic capacitor still couples the FM detector output to the stereo decoder, however.

S. Woodstock
Connecticut
USA

MININEC antenna modelling on a PC

Computer modelling of antennas has been the province of mainframe computers. Ian White explains how this inexpensive program makes it accessible to PC users.

Mininec is a personal computer program for modelling antennas. By adapting the main features of the well established Numerical Electromagnetics Code (NEC) from the mainframe computer to the PC, the creators of Mininec have placed a powerful development tool on the desk tops of antenna engineers.

For small businesses involved in antenna engineering, the development of new designs has often relied on a tedious and expensive cycle of fabrication, performance testing and modification, backed up where necessary by equally tedious and expensive computing on a remote mainframe. In contrast, Mininec allows the initial development of many types of antenna to be carried out entirely on a PC. As a result, the first physical prototype can be well on the way towards its finished form.

If Mininec cost thousands of pounds, it would still be a bargain. But in fact the basic program is free, a spin-off from the United States defence budget, and even the commercial enhanced versions are available at low cost.

How Mininec works

The program models wire antennas by a technique called the Method of Moments. To understand how this works, you first need to recall the performance of an antenna is almost entirely determined by its size, shape and surroundings – all of which can be scaled in relation to wavelength. These characteristics determine the magnitude and phases of the RF currents that flow on different parts of the antenna, and also flow in the ground plane if there is one nearby. In turn, the RF current distribution determines the practical performance of the antenna – its near-field and far-field radiation patterns, directive gain, efficiency and feedpoint impedance. Starting from the size, shape and surroundings of an antenna, the main problem is thus to calculate the RF current distribution.

In a real antenna, the RF current flowing in each portion of each wire depends on two factors: the currents flowing in other parts of that wire, and the currents induced in it by currents flowing everywhere else in the antenna and in the ground. When RF power is fed into the antenna, the overall current distribution adjusts itself to meet all those physical requirements. **Figure 1(a)**, for example, shows the simple current distribution of a half-wave dipole in free space.

Mininec models the antenna as a series of straight wires, joined where necessary, and each wire is subdivided into segments. As in a real wire antenna, the current in each segment depends on its connections with adjacent segments and on its electromagnetic coupling with all the other segments of the antenna, including the ground plane if present. Taken together, all of these interactions provide enough information for Mininec to calculate the current distribution using the Method of Moments.

It makes the approximation that the current in each segment is uniform along its length, that is, the current distribution is built up as a series of small steps as in **Fig. 1(b)**. In real life this would not be true, of course; the current distribution would vary smoothly along the conductor and the current at one end of a segment would generally not be the same as the current at the other end. Within the software, the boundary conditions at the ends of segments are rewritten to accommodate the step transitions, with further adjustments for open-circuit ends and joints between wires.

The main limitation on accuracy is the pattern of segmentation chosen by the user. Sections of the antenna where the current distribution is changing rapidly require smaller segments than areas of virtually constant current. Choosing a segmentation scheme therefore requires a good understanding both of the way that antennas work and of the limitations of the computer model. With a little care, Mininec can provide surprisingly accurate results for a wide variety of real-life antennas.

Applications

Mininec can model an enormous variety of wire and rod antennas. As a simple example, **Fig. 2** shows the well known pattern of a half-wave dipole in free space; the feedpoint impedance and directivity of 2.15dBi are also predicted with good accuracy. But unlike many simple programs, it can deal equally well with a dipole that is longer, shorter, horizontal, vertical, sloping, close to ground – or any combination of the above – and with the feedpoint anywhere along its length. Impedance loading can be introduced at any point, and loop antennas can be modelled as a series of interconnected straight wires. The only limitations are that the wires should be reasonably "thin" – see later – and that the antenna is divided into segments in an appropriate manner.

Figure 3 shows the pattern of a 21-element UHF long Yagi modelled by Mininec. In spite of the restricted number of segments available in this particular implementation of the program, very few practical antenna test ranges could achieve the same accuracy at such frequencies. The program has been used extensively in optimization of long Yagis for terrestrial and space communication.

HF antennas present a different set of problems: sheer physical scale makes development and evaluation extremely difficult and they must always operate relatively close to imperfectly conducting ground. Apart from computation, the only useful development techniques in the past have been measurements on VHF scale models, or post-construction field strength surveys – by which time it

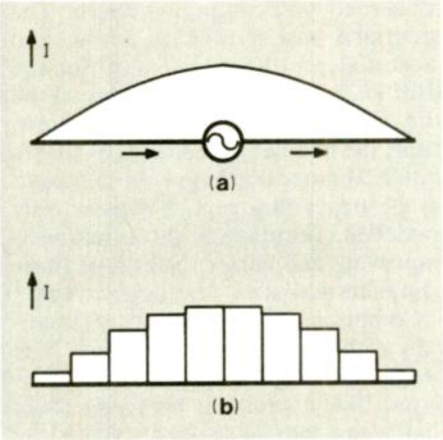


Fig. 1. Shows current distribution on a half-wave dipole (a) and the same current distribution modelled in ten segments by Mininec.

OPERATING ENVIRONMENT

Mininec will run on any PC or compatible computer, but the faster, the better; best results have been obtained using an 8C386 type with maths coprocessor. Any PC will possess enough ram for this purpose. The operating system is MS-DOS.

Any type of display will suffice, although the reviewer used EGA, and a Hercules graphics card will produce output.

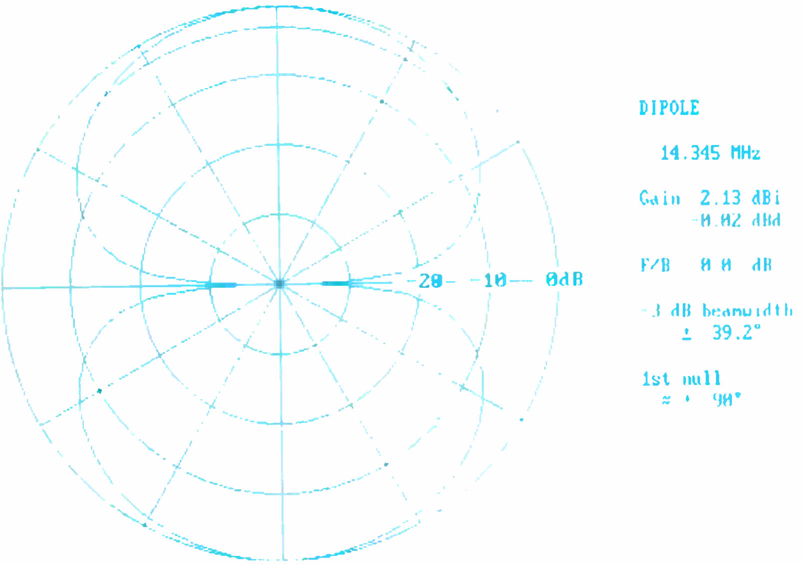


Fig. 2. E-plane radiation pattern of a half-wave dipole, modelled by Mininec in ten segments.

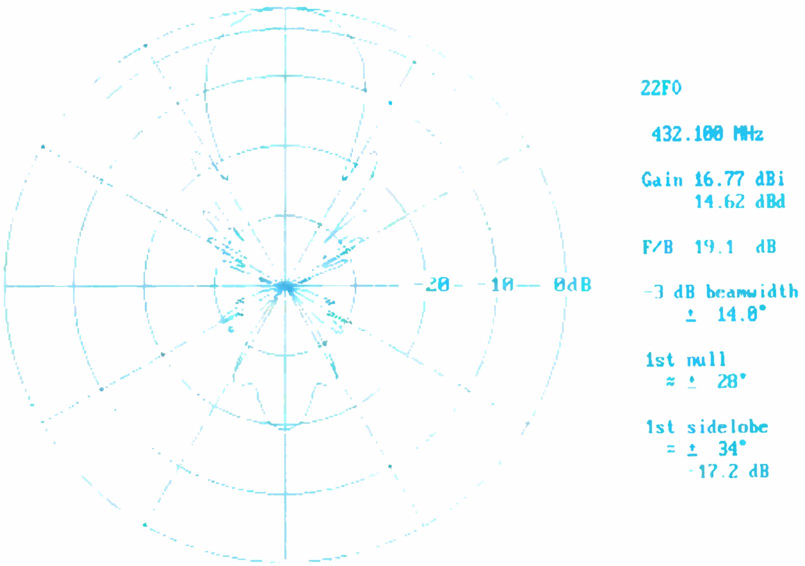


Fig. 3. E-plane radiation pattern of a 21-element UHF Yagi antenna, modelled by Mininec in 100 segments.

is rather too late! This program offers a number of facilities to simulate either perfectly conducting ground, radial ground wires, or simple geometric zones of defined ground conductivity and dielectric constant. While it would be inadequate for a major HF antenna project that relies extensively upon the ground beneath it, the program can be used for approximate work, and to show whether an HF antenna is unduly sensitive to ground effects.

Other applications include analysis of the sensitivity of the performance of an antenna to its physical dimensions and surroundings, including other antennas, of course. Even simple simulations can pinpoint areas of potential difficulty *before* the antenna is delivered and installed, with potentially enormous savings in cost. A further problem with transmitting antennas, which arises increasingly often, is the need for an RF hazard assessment. Once again, Mininec has an answer: as well as calculating the far radiation field for communication purposes, the program can calculate the separate electric and magnetic components at any point in the near field. This information can be of great value in demonstrating compliance with exposure standards.

Limitations

The main limitation is the restriction to "thin wires", which obviously rules out surface-reflector, waveguide and dielectric antennas, and restricts the practical range of application to UHF and below. Mininec will attempt to allow for the effects of wire thickness and indeed is very successful for UHF rod Yagis; but to model shapes which are far removed from a thin wire, one must turn to a program such as NEC.

The other major limitations are all concerned with computing power. The programe was written in Basic, and most dialects of that language for the IBM PC have severe restrictions on the size of matrix arrays. This, in turn, limits the number of segments available within Mininec and hence the complexity of arrays that can be satisfactorily modelled. Fortunately the situation is improving and newer releases of Basic compilers now allow very large arrays.

MININEC SUPPLIERS

The public domain version is free, but is difficult to obtain outside the USA and is not very user-friendly. The written report is J.C. Logan and J.W. Rockway, the new Mininec (Version 3): A Mini-Numerical Electromagnetics Code. NOSC Technical Document **938, September 1986.**

The definitive enhanced version of Mininec by the original authors is available as a package of a book plus disks at a cost of about £100. However, the program is still not very user-friendly.

John W. Rockway, James C. Logan, Daniel W.S. Tam, Shing Ted Li, The Mininec System: Microcomputer Analysis of Yagi Antennas. **Artech House (1988). ISBN 0-89006-264-1.**

An enhanced, user-friendly version of Mininec 3 is available for $80, and is the best buy for general use. Details are available from Brian Beezley, 507½ Taylor Street, Vista, California 92084, USA.

Computing time increases dramatically with the number of segments. The program's original developers considered that a problem involving more than a few tens of segments should be solved using NEC – but that was back in the days of the Apple II. Today, even a 10MHz PC XT with a maths co-processor can solve a 100-segment problem in about five minutes and a fast 80386 machine can cut the calculation time to just a few seconds. It is now possible to use Mininec for optimization, which often requires intensive iteration. With a multi-tasking operating system, calculations can run in the background while the PC remains available for less CPU-intensive work.

Mininec in perspective

The program does not relieve its user from the need to understand how real antennas work. In particular, the choice of a segmentation scheme must be based on sound engineering principles and common sense. The user must appreciate the strengths and weaknesses of the mathematical model and intepret the results accordingly. Often, the results are as good as could be obtained by practical measurement, and even semi-quantitative results can be used for sensitivity analysis and design guidance. A more powerful mainframe code such as NEC may still be useful for checking the reliability of results; an experienced Mininec user will easily learn to use the larger program.

Mininec and powerful modern PCs have, together, made computer modelling accessible to antenna engineers in small companies, as well as to the users of large mainframe computers. In the right hands, the program can often give results comparable with good-quality measurements on an antenna range. The professionally up-to-date antenna engineer will be increasingly required to integrate the two techniques, but one thing will not change: there will always be a premium on engineers who *really* understand how antennas work. ■

Dr Ian F. White is a freelance technical author and consultant.

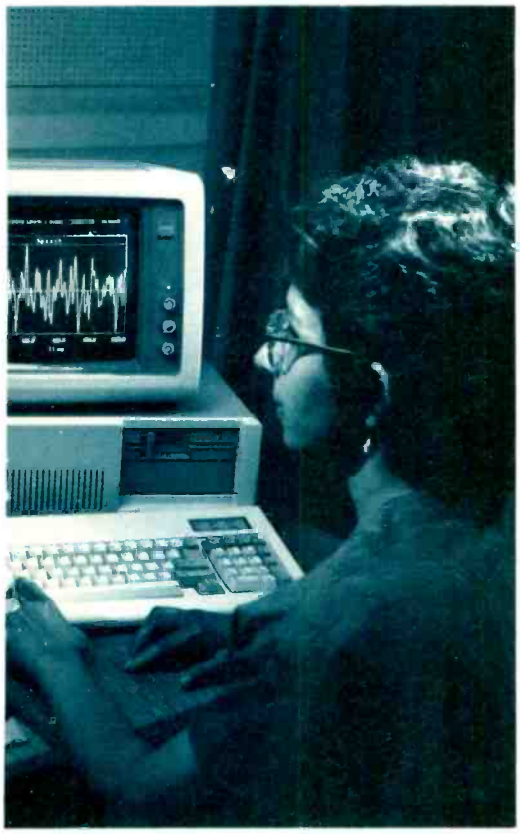
Restoring quality

The official start of service in some terrestrial TV areas of the Nicam 728 digital stereo sound system is welcome, although past experience suggests that it will be many years before a majority of viewers will have suitably equipped receivers. Among the marketing problems facing manufacturers and retailers will be that of having to continue to sell top-of-the-line receivers with analogue mono sound in many areas for several years to come.

Then again, the quality of analogue FM mono transmissions is often excellent and well suited to relatively small screens, provided that the set has a good loudspeaker in a well-designed enclosure, a requirement that has been met in some models in recent years.

Personally what I would wish to see most is an improvement in the transmitted sound quality of the older films, including virtually all those made before about 1955. Considerable interest has been shown in the restoration of the 50-year-old *Gone with the Wind*, with a new print from the original negatives, at the original aspect ratio.

film sound



Restoring sound: Cedar is a three-stage process based on digital signal processing techniques, which deals first with deep gouges or scratches on a recording, then tackles the effects of wear and finally the hiss. The first commercially-available recording processed by Cedar was a 1953 version of Holst's The Planets, by the London Philharmonic Orchestra under Sir Adrian Boult, released on a Nixa CD in March. This has since been deleted from the catalogue, but should be available again shortly from a different company. Details of Cedar are available from Cambridge Sound Restoration, Botolph House, Botolph Lane, Cambridge CB2 3RE.

Similarly, old disc recordings are beginning to reach the market which have been restored by means of the Cedar computer system originally developed by Dr Peter Rayner and commercially by Simon Godsill, working in conjunction with the National Sound Archive. This system is proving excellent at virtually eliminating hiss and crackles from disc recordings; however, these are not the only problems with old optical film sound tracks, which seem to generate a variety of distortions.

Broadcasters have established reasonably effective means of cleaning and restoring film damaged by repeated showings with the result that often even very old black-and-white pictures are acceptable while the sound (particularly some played out on Channel 4) is often appalling – just try recording the sound on a good audio tape recorder and then listening to it without pictures.

Careful restoration of sound quality, particularly of some of the classic musicals of the 1930s and 1940s, would seem to be more worthwhile than the computer colouring of black-and-white films. Certainly more worthwhile than the curious print of Jacques Tati's classic *Jour de Fête* (1949) played out recently on Channel 4 with what appeared to be an occasional hand-painted daub of colour. It is possible that this was done for the original cinema release, though, if so, it escaped my memory, I am glad to say.

It is thus welcome news that Cambridge Sound Restoration, with NSA support and Cable & Wireless funding, is reported to be negotiating with several film companies for the Cedar restoration of film sound tracks and has found it possible greatly to speed up the process while retaining its effectiveness. Let us hope that film sound on TV will benefit, though it will be a small miracle if some of the earliest optical tracks can be made to yield reasonable sound quality.

Multipath defeats FMX?

According to the publishers of a 45-page report, the FMX system, originally developed by CBS Technology Center in co-operation with the US National Association of Broadcasters to extend the range of pilot-tone FM stereo transmissions, "actually degrades reception and does not increase the stereo broadcast range".

The report, written by Dr Amar Bose, professor of electrical engineering and computer science, and Dr William R. Short (Bose Corporation), is based on a research programme on the effects of multipath on FM broadcasting, specifically focusing on the FMX system in which a compressed stereo-difference signal is transmitted in quadrature with the regular stereo-difference signal on the 38kHz suppressed carrier (see RF Commentary, *E&WW*, May 1989, pages 528-9). FMX is currently being promoted by Broadcast Technology Partners, in which CBS and NAB retain an interest.

The new report* is published by the MIT Research Laboratory of Electronics and includes mathematical models, analysis, computer simulations and the results of field tests conducted at MIT's radio station WMBR. The writers say the researchers have demonstrated that the multipath effects on current FM equipment are greater with FMX then with current stereo transmissions; a finding that appears to confirm the European fears noted in the May 1989 *E&WW*.

It remains to be seen whether those US broadcasters proposing to use FMX (for which decoder chips are already available, see Applications Summary, *E&WW*, September 1989, p.854-855) will be influenced by the MIT report. In two articles I wrote on the problem of multipath distortion on FM radio (How serious is multipath distortion? *WW*, April 1980; Multipath distortion – does polarization matter? *WW*, April 1981) I noted that this form of distortion had become the "unmentionable" topic of "the great hi-fi con", until re-opened by NHK engineers who found that it is "one of the major factors which deteriorate the received sound quality". I suggested that the problems of multipath distortion on domestic reception of VHF/FM stereo had been largely ignored and seemed to play little part in engineering planning.

In doing so I upset the BBC which by then was committed to changing its main FM transmitting antennas to circular polarization, by drawing attention to German research that indicated that this was certain to increase multipath distortion in some locations and even questioned its value for reception on car radios. Subsequently, the BBC has admitted, if only unofficially, that adding a vertical component does indeed result in an increase in multipath distortion, although in its opinion this is outweighed by the improvement to reception in moving vehicles and portable sets operated out-of-doors.

Today, digital transmission, heavily protected against multipath by 1:2 forward error correction, is seen as the panacea despite the hi-fi pundits who are already beginning to snipe at the distortion on very low-level sounds and are suggesting that levels be raised by the addition of random noise!

* A theoretical and experimental study of noise and distortion in the reception of FM signals – available from the Communications Group, room 36-412, Massachusetts Institute of Technology, Cambridge, MA02139, USA, at $11 by foreign air mail or $7.50 by surface mail, payable to MIT-RLE.

Broadcasting is compiled by Pat Hawker.

UHF propagation in factories

Although, at one time, the advocates of short-range digital radio communications systems in the UHF spectrum tended to emphasize the rugged nature of digital techniques and their go/no-go performance, recent years have seen the recognition that such systems are all too vulnerable to multipath propagation delays, unless the digits are heavily protected by error correction.

One result has been the investigation of UHF propagation within and between office buildings. Now, Theodore S. Rappaport of the Virginia Polytechnic Institute and State University points out in 'Characterization of UHF multipath radio channels in factory buildings' (*IEEE Trans Ant & Prop*, August 1989, pp1058-69) that only a limited number of the investigations have been concerned with the wide-band impulse response measurements necessary to determine the maximum data rates imposed by intersymbol interference. Those investigations that have considered this problem relate to office-type buildings. Rappaport stresses that there are gross physical differences between office buildings and factory buildings, where it is envisaged that high data-rate radio links will increasingly be used.

The result is that scattering of radio waves within factories differs considerably from that experienced within office buildings: "Building construction techniques, floor arrangements, building contents and placement of walls and other partitions are all factors which greatly affect propagation."

During this investigation, wideband propagation measurements of 1.3 GHz were made in five operational factories. Multipath power delay profiles were measured in 50 locations across four general topographies common in all factories. It was found that over local areas, individual multipath components do not fade significantly when a line-of-sight path exists between transmitter and receiver, although some rapid path fading and shadowing occurs over obstructed paths. Path loss is a function of distance to the power of 2.2. Multipath spreads ranged from 40 to 800 nanoseconds. Mean excess delay and RMS-delay-spread values ranged from 40 to 400ns. A factory making frozen and dry dessert had values consistently half those observed in metal-working factories. A worst case RMS-delay-spread value of 300ns was recorded in the aisle of a modern metal-working factory.

It would seem that these results underline the difficulty of designing systems that would work equally satisfactorily in any type of factory.

Broadband mm-wave tapered wire antenna

Back in 1931, RCA Communications engineers described several types of directional HF antennas, one of which was the long-wire terminated vee antenna that became widely used for the lower HF spectrum, though superseded at higher frequencies by the related rhombic antenna – in effect, two back-to-back vee antennas. The legs of the vee antenna were virtually always erected in the form of two long straight wires at an angle related to their length in wavelengths at the design frequency. It was recognized from the start that increased bandwidth could be achieved with this form of travelling-wave antenna by using shaped, tapered sides; but such shaping was difficult to implement without the use of many high poles.

In a recent paper entitled 'Synthesis methods for broad-band tapered-wire antennas', Eckhard Vollmer and Johann Hinken of the Technische Universität Braunschweig, West Germany (*IEEE Trans Ant & Prop*, August 1989, pp959-64) describe a new method to synthesize the geometry of extremely broadband tapered-wire antennas designed to have nearly constant gain and low voltage standing-wave ratio over a bandwidth of at least 20:1. Although the

50dB c-mos variable gain amplifier

It is widely accepted that one reason why the early solid-state receivers had such poor strong signal-handling capabilities was the absence from the semiconductor family of any device akin to the variable-mu valve, with bipolar transistors more akin to sharp cut-off pentodes. A wide-range variable-gain amplifier that remains reasonably linear throughout its range is an essential requirement for the front-end of communications receivers whether they use AGC loops or manual RF gain control.

In recent years, variable-gain amplifiers have been implemented – usually in the IF stages – for some telecommunications applications using binary weighted arrays of capacitors or resistors that are digitally selected as feedback elements round a VLSI op-amp.

After work carried out at the University of California, Los Angeles, Tzu-Wang Pan and Asad A. Abidi have described an alternative, potentially more attractive form of VGA. In 'a 50dB variable gain amplifier using parasitic bipolar transistors in cmos' (*IEEE Journal of Solid-State Circuits*, August 1989, pp951-961) they suggest that the op-amp technique is conceptually straightforward and attractive for c-mos implementation because of the ready availability of analogue switches and accurately ratioed capacitors. "However, it has some limitations", they say. "When a large decibel range of controllable gain is sought, the ratio of maximum to minimum, or spread, of feedback element values grows exponentially and may consume a substantial chip area. Further, the frequency of operation is usually limited because the operational amplifier must be compensated for stable operation in feedback." To overcome such limitations it may be necessary to cascade several VGAs, each spanning a fraction of the desired gain range.

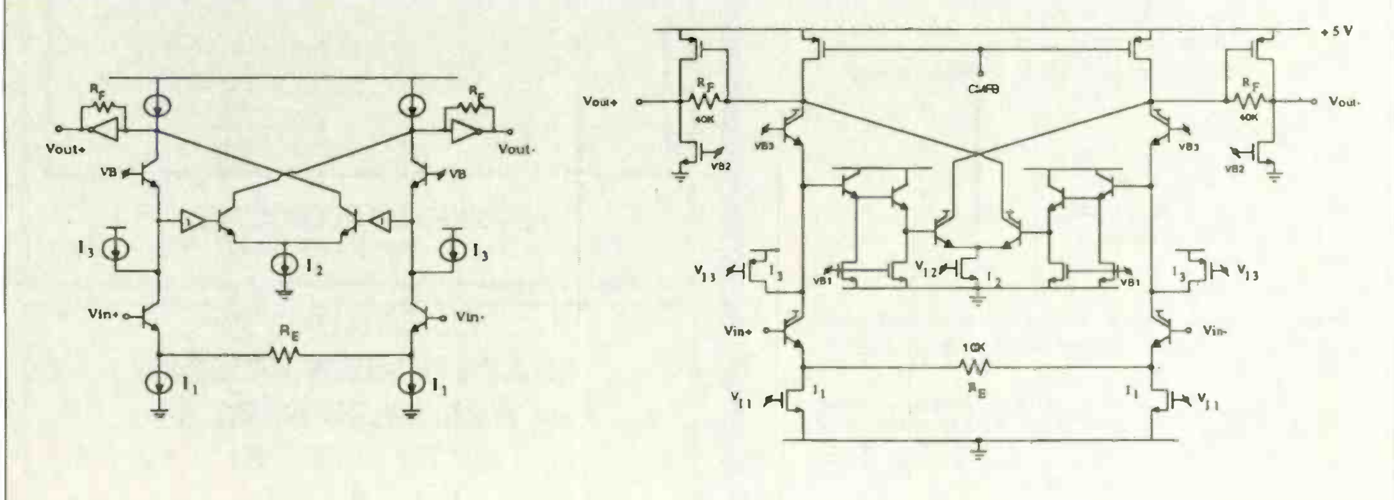
The new work, supported by Rockwell International, Western Digital Corporation and California's MICRO programme, has led to an implementation of a VGA with a gain range of 50dB based on the Gilbert gain-cell configuration, and whose gain is accurately controlled by the ratio of bias currents. As the circuit function is determined by the interplay of transistors in a loop, no overall feedback and no compensation are required.

For the bipolar transistors it would be possible to use bicmos technology in which bipolar transistors co-exist on the same substrate as c-mos, although this process would increase costs. Where only limited use of bipolar transistors is sought, as in this case, the parasitic bipolar that is inherent in the c-mos can be exploited without modification of the IC fabrication process.

The device described is thus fabricated in standard c-mos technology using the lateral and vertical parasitic bipolars to implement a Gilbert gain cell as the core circuit. The authors conclude that notable features are a bandwidth of almost 10MHz, high linearity and compact size.

prime purpose of their work was in connection with broadband spectrometers using superconductive Josephson junctions for 30 to 600GHz, with the antenna realised in thin-film form, experimental verification has been achieved by means of a scaled-up model covering 1 to 18GHz (geometry synthesized for two legs at 1.2GHz) made of 0.5mm dia. silver wire glued in the synthesized profile on a thin plate of polyurethane foam (dialectric constant about 1.05). The input impedance of the antenna, about 330 ohms, is transformed to match 50-ohm microstripline by a broadband taper.

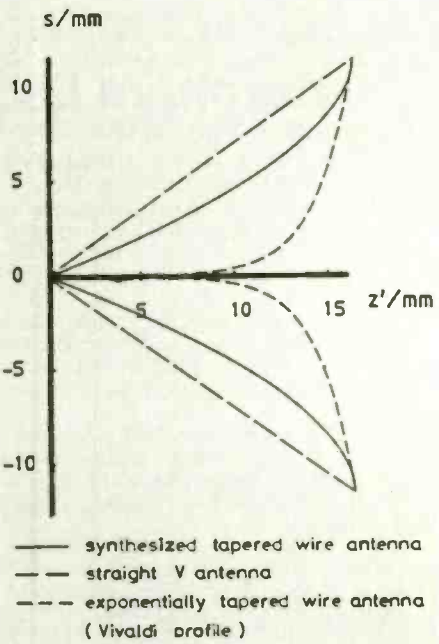
The German engineers made gain measurements at some 1200 frequencies regularly distributed over the range 1 to 18GHz. By resistively loading the antenna at the ends of the wires (as for a conventional straight-leg vee antenna), the radiation characteristics of the synthesized, tapered-wire antenna are improved. They report a mean gain of 5.7dBi, a gain variation of ±1.25dB, and a nearly constant VSWR of 1.7 (peaking at 2.6 at the lowest frequency) reached over a bandwidth of 20:1. Theoretically, the highest usable frequency is not limited. Gain can be increased by increasing the number of wavelengths of each leg at the design frequency: for example about 9.8dBi with six-wavelength sides (measured in a straight line rather than the synthesized curve); 7.6 ± 2dBi with 3 λ legs.



Parasitic bipolar transistors implement a Gilbert gain cell (left) and combine with c-mos to implement an accurate and high-speed variable gain amplifier (right).

Superconductive, superdirective antennas

Although there seems little prospect of instant, easy commercialisation of the ever-increasing family of high-temperature superconductivity, as John Wilson has noted (Superconductivity: a fading star, *Electronics World*, October 1989, p941), the significant advantages that would follow if zero-resistance conductors could be used to form electrically-short antenna elements is not to be dismissed lightly. Ronald W.P. King, in 'Supergain antennas and the yagi and circular arrays' (*IEEE Trans Ant & Prop*, February 1989, pp178-86) notes that antennas with very narrow beams have many important applications, not least for satellite communications. "If a closed-loop array with resonant superdirective properties can be designed," he says "the amplitudes of the radiating currents will be limited by ohmic losses in the conductors. By taking advantage of superconductivity a supergain superconducting array could be developed for use in space where temperatures are nearly as low as that of liquid nitrogen. This may lead to a realization of the Einstein needlepoint radiation, which was known to be theoretically possible well over half a century ago, but for which no successful design has yet been developed."



Gain measurements on synthesized tapered wire antenna by Vollmer & Hinken in IEEE Trans AP show a mean gain of 5.7dBi over the band 1 to 18GHz.

Dr King also writes: "A review of available data from numerous experimental and theoretical researches – many carried out over 25 years ago – combined with a very recent quantum-mechanical investigation, has led to new insights into the possibilities of closed loops of dipoles as highly directional arrays. The critical newly emphasized feature is the remarkable high-Q property of a correctly designed closed loop of coplanar dipoles when only one element is driven and all dimensions – length of elements, cross-sectional size and shape, number of elements, and circumference of the closed loop – are correctly chosen. Extensive, highly precise theoretical and experimental research is indicated to translate a challenging possibility into a useful highly directive radiating system."

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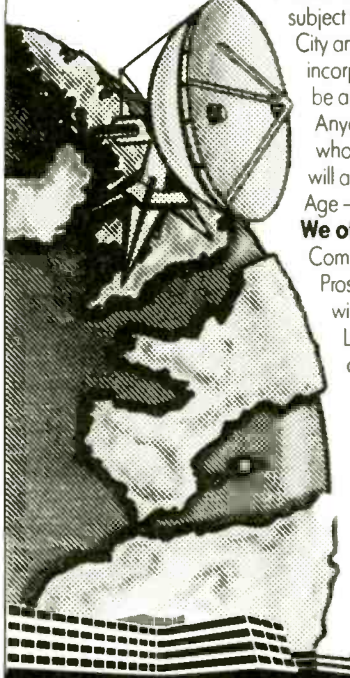

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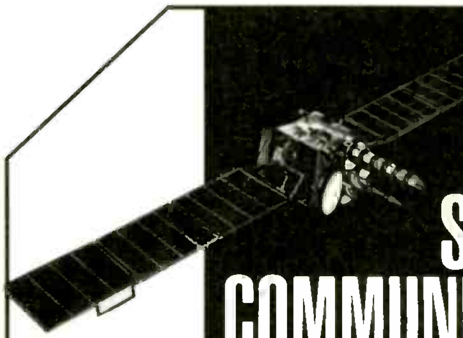

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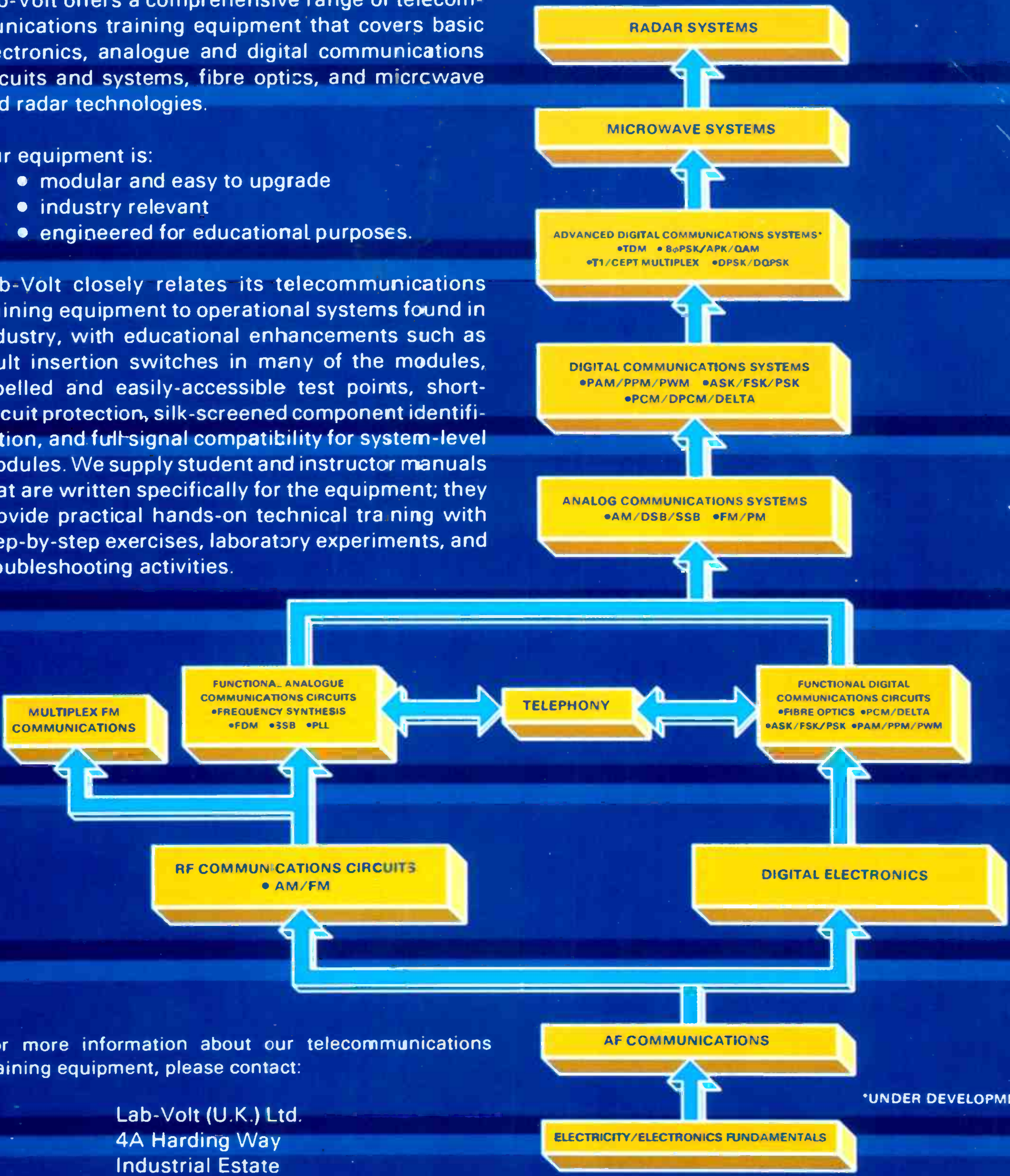
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