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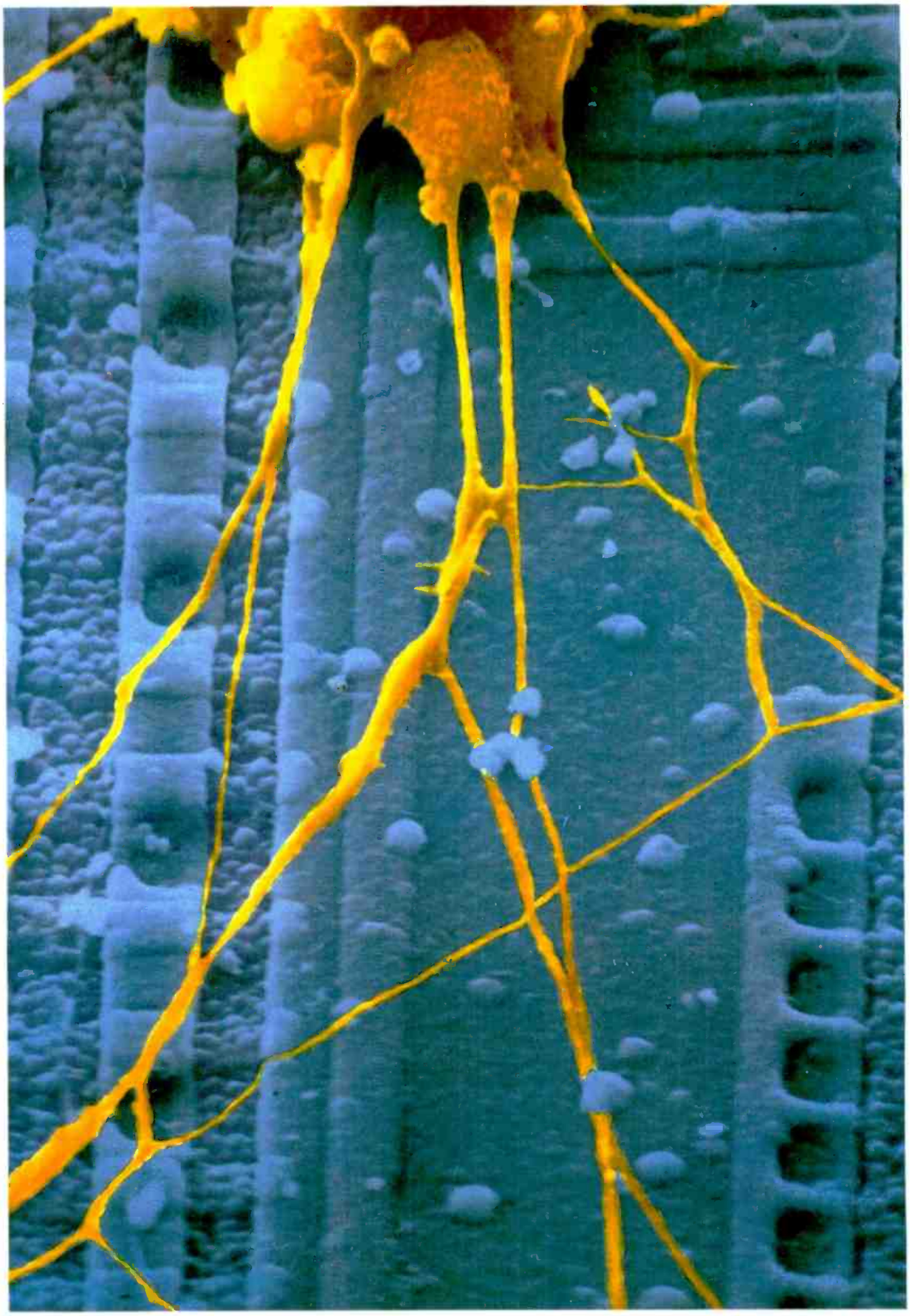

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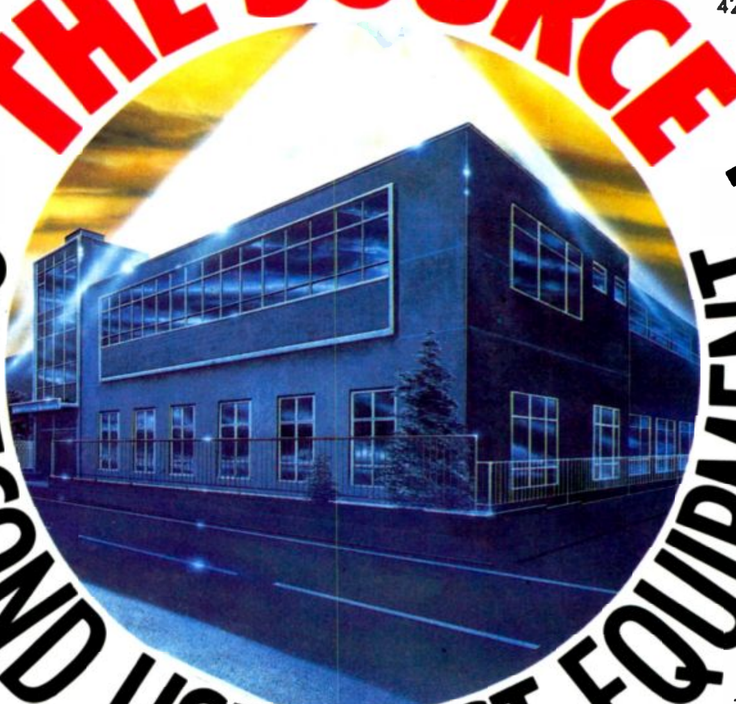

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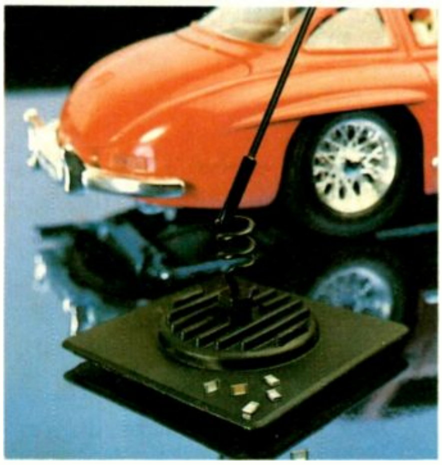

By 1990 a typical car might contain 500 capacitors, say AVX of Aldershot, leading to a very large volume of production if the estimate of 10 million new cars in Europe is realistic. See page 688 for an analysis of Europe's capacitor market.

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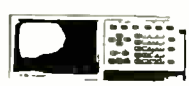

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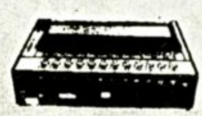

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COMMENT

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Whenever an engineering development to improve services is made possible, the broadcasting organizations are at pains to ensure that existing equipment is not rendered obsolete or, if it is made incompatible, long periods are allowed for any necessary changeover. One can cite the move to 625-line television; the introduction of f.m. radio; the start of colour; the incorporation of teletext – all these were brought about painlessly, at no cost to those users who did not want the new service, except for the 625-line change which took place over more than 20 years, and in some cases without the user even being aware of the development. These organizations have a duty to bring about change in this way and take a great deal of trouble to do so. They are concerned chiefly with providing the best possible service and the profit motive is absent.

But what of development in the rest of the consumer electronics market? It appears that no such scruples can exist alongside the need to create new markets. Each new development that emerges from the multinationals is, of course, an improvement on previous products, but at what cost to the public?

Admittedly, there are those who will acquire the newest, simply because it is available. But, if the majority have been persuaded to buy cassette recorders and black disc turntables at great expense, it is surely not unnatural for them to feel aggrieved when the next development uses optical discs and is totally incompatible with their equipment. If a music lover possesses a collection of cassettes, built up over ten years, does not the impending introduction of digital audio tape fill him with alarm and despondency?

It would be naive to expect the manufacturers of domestic electronic equipment collectively to refrain from introducing new techniques to the market until the previous generation of equipment had had a reasonable run, but there must surely be a less cynical way of progressing than to render collections of hardware and "firmware" obsolete at a stroke. The very least that can be done is to allow existing technology an extended period of obsolescence.

The consumer society is becoming, or has become, the victim of the pursuit of technology for its own sake. So far, society has been tolerant and even eager for new technology, but in the face of time scales of introduction and obsolescence which are shrinking to the point of bewilderment, it must eventually begin to react: the diminishing returns of "investment" in new methods of playing recorded music or watching television cannot escape notice for ever.

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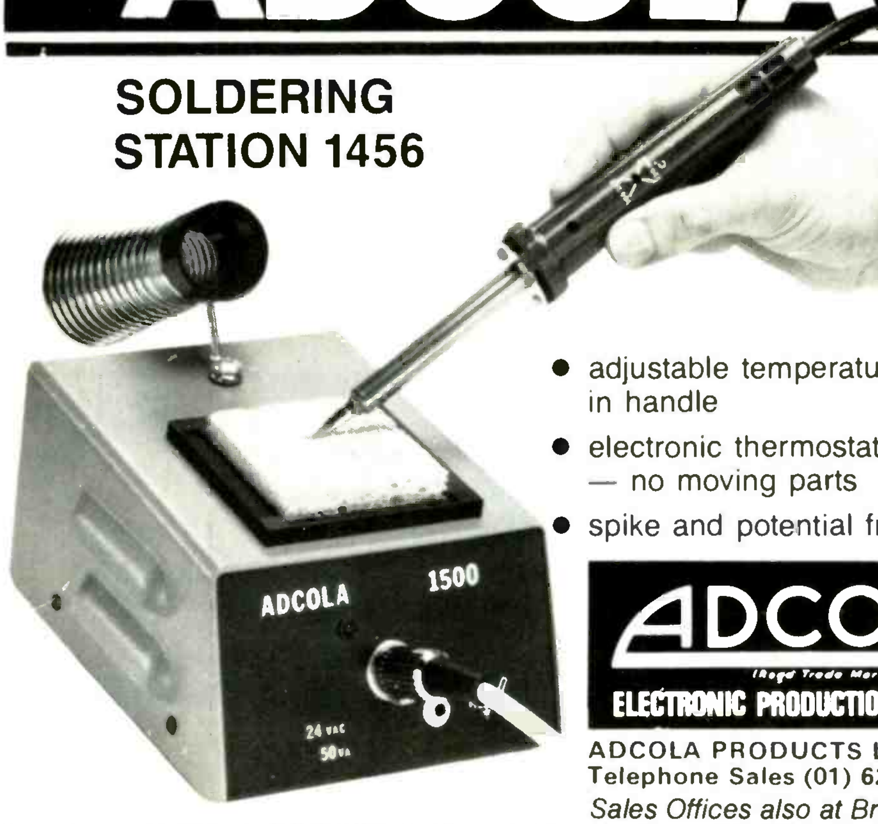

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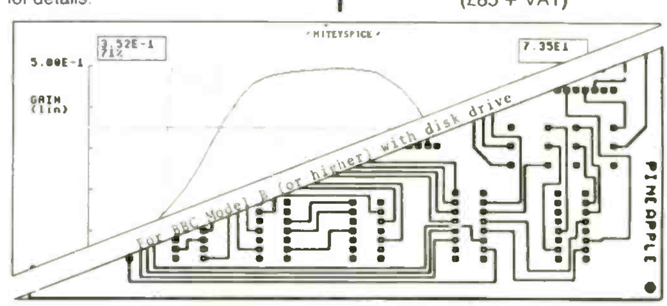

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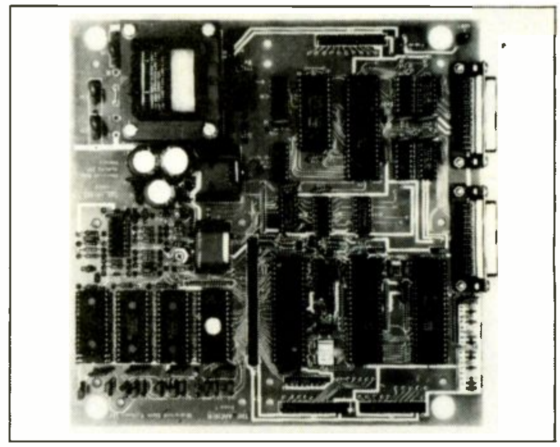

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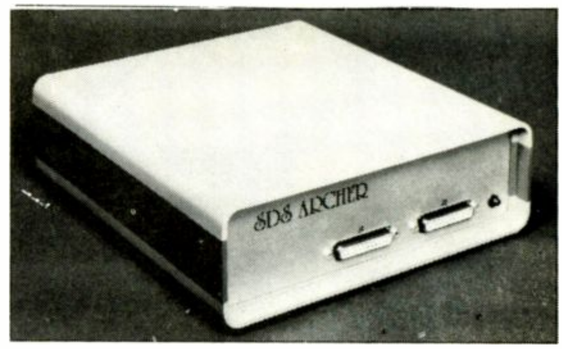

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New-wave architecture

The performance of traditional bus-based computer systems is limited by the bus itself. The new architecture makes all the devices on the bus intelligent, so that most of the activity is local to these processors and the bus is used for data transfer rather than program execution.

DAVID HUNT and KEITH HODSON

A good understanding of system architecture is important for all users and potential users of microsystems. This article describes a novel approach to the problem of how to arrange the components of a microprocessor system to maximize the performance without excessive complexity and cost.

Modular computer systems made up of a series of p.c.bs and connected via a backplane bus were originally developed by the computer manufacturers as a way of increasing the flexibility of their systems. These bus-based systems allowed a wide variety of systems to be built from a relatively small number of components, which were the computer p.c.bs themselves. A well-known example of such a bus, prominent in the 1970s, was DEC's Unibus, to which some of the current buses, namely STE and VME, bear more than a passing resemblance.

It was the advent of the microprocessor which opened up this area to a wider audience. The original four-bit c.p.us were obsolete before bus standards were created but their replacements have spawned a diverse range of buses. The eight-bit buses have endured longer than most pundits would have predicted at the time of their introduction and in fact the STE standard has only recently emerged.

The first people to bring out bus-based systems for general use were the semiconductor manufacturers, whose first designs comprised a c.p.u. card, a memory card and i/o function cards, Fig.1.

The bus was really an extension of the microprocessor pins and it ran at the same speed as the processor clock. The bus was processor-specific and used for both program execution and data movement. This type of bus was very easy to implement and in general there was no contention for the use of the bus, the single c.p.u. being always in control. The bus was limited in the sense that once the system ran out of power, that was it; there was no easy way of increasing it.

DESIGN PHILOSOPHY

Software concepts have formed an important part of the 'new wave' design philosophy. In software terms, the language runs at the top level with the hooks into the operating system below it. The operating system itself calls software modules which control the physical devices themselves. In standard VME systems, many of these modules are charged for separately or else the system engineer has to write them. In the 'new wave' approach, the hardware modules are intelligent and the software is an integral part of the module. It is as if we had a 'hardware operating system'.

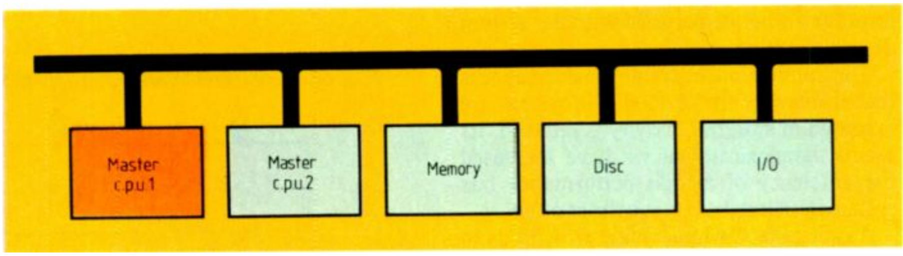


Figure 1. The old pioneer: This is a simple system in which the bus is an extension of the microprocessor pins. In some designs the microprocessor address and data lines were taken directly onto the bus without any intermediate buffering.

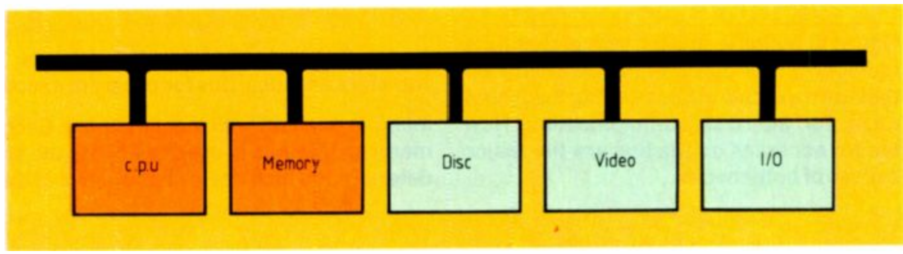


Figure 2. Multiprocessors: The performance of a system can be increased by adding a second processor to the bus. A bus arbitration unit determines which c.p.u. has access to the bus.

MULTIPROCESSOR SYSTEMS

The next major advance was to modify the bus so that more than one processor could work with the same memory and i/o. This was achieved by adding some arbitration logic to determine which device had access to the bus. If, for example, a c.p.u. needed to access bus memory, it had to gain control of the bus first. This extra delay causes what is known as a 'wait state' in the c.p.u. and slows it down by typically 10%. In fact, the ability of a c.p.u. to handle wait states is fundamental for processors in multiprocessor systems. (The alternative is to stop the c.p.u. clock temporarily). Adding a second processor to such a bus system did not result in a commensurate increase in performance. The main reason for this is that occasionally, a c.p.u. has to wait for access because the bus is already in use. In this type of system, the bus is the limiting factor in system performance, Fig.2.

The local execution bus technique uses the multiprocessor bus for data transfers but has a local bus for program execution. This goes a long way toward alleviating the problems described, Fig.3. The problem is that now, one has to be careful in the selection of card types. I have seen a recently produced system with a c.p.u. and local execution bus, except that, in this case, the disc controller was only capable of tranferring data into memory on the bus! The system was set up with an extra memory card so that accessing data in this memory was penalised by way of unwanted wait states. The local bus was reserved for the system stacks only.

This idea can be extended to include a number of masters, each with their own execution buses. The c.p.us each carry on with their own tasks and the system bus is only used for intertask communication and i/o accesses. It is now the i/o accesses which limit system performance.

To overcome the problem of i/o accesses, an i/o slave bus can be used in conjunction with the main system bus. One particular solution, discussed in a recent issue of *Electronics and Wireless World**, is to put in a bus coupler from the main bus to the i/o bus, which in this case were VME and STE respectively.

INDIVIDUAL INTELLIGENT SLAVES – THE NEW WAVE ARCHITECTURE

The ultimate solution for a fixed bus size is to assign to each i/o activity its own c.p.u. and its own local bus. It is now possible, because of the low cost of c.p.us and memory, to do this while keeping the prices of the cards about the same as those of the old, non-intelligent predecessors. Each card in the system has its own operational software and can therefore be used with any c.p.u. on the bus. In fact, these cards can be used to improve the performance of the older system described earlier.

The implication for system performance is that if many of the tasks of the system are executed in situ, bus activity is reduced. Its seems paradoxical that we have increased the efficiency of a high performance bus system by using the bus as little as often!

A crucial factor in deciding which bus to use for a given application arises here. The justification for eight-bit data buses has been that much of the i/o is in this format. This is true for serial data, ascii characters for video and printers, SCSI for disc data and indeed for GPIB protocol. If this is the case, the argument goes, most i/o operations will involve eight-bit transfers, so why go to the expense of a 16 or 32-bit bus when a less expensive bus will do? Unfortunately, we have forgotten about the local intelligence of the i/o cards. These intelligent i/o cards can preprocess the data in their local memories. For example, they can join together two bytes to form one 16-bit word prior to transmission on the bus. In this way, 16-bit bus data transfers can take place with twice the throughput of the eight-bit systems.

Our new wave architecture system would comprise the following:

- Multiprocessors each with local execution bus
- Data bus with communication memory and inter-c.p.u. interrupt facility
- Intelligent disc processor with local track buffer intelligent second management
- Intelligent video, keyboard and printer processor with a fifo buffer
- Intelligent i/o processor for analogue and digital i/o
- Intelligent serial processor with fifo buffers XXX processor

XXX means you name it: GPIB, advanced graphics, etc. This provides a loosely coupled, open architecture providing elegance and efficiency!

COMMUNICATION ON THE BUS

A master is a device which is capable of initiating a data transfer, such as a processor card or a d.m.a. device. A slave is a device which can respond to a master either receiving data from the bus or putting data on to the bus as required. Traditionally, slaves were passive, but the new wave architecture features active slave boards.

Master-master communication. If master A wishes to send a message to master B it cannot do so directly. The master address lines are normally outputs only, so there is no way to establish a destination address for the data in master B. Therefore, a global ram, which is accessible to all masters, must be used. This memory could be found on a bus memory card or perhaps dual port ram on one of the masters.

Example: master A sends the string 'Hello' to master B.

A 1. Check semaphore bit is clear
A 2. Write message string into message block
A 3. Set semaphore bit (also causes irq on master B)
B 1. Master B receives vectored interrupt
B 2. Transfer message from local ram
B 3. Clear semaphore bit

* STE as an i/o bus in VME systems, by Tim Ellsmore. February issue.

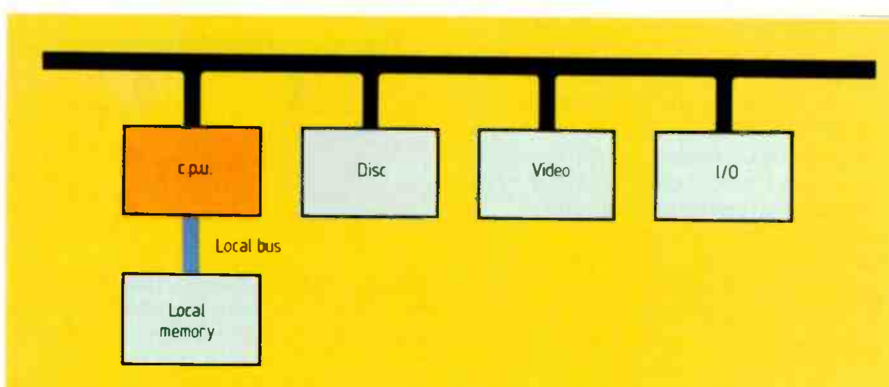


Figure 3. Local execution bus (above): Technique uses multiprocessor bus for data transfers and local bus for program execution.

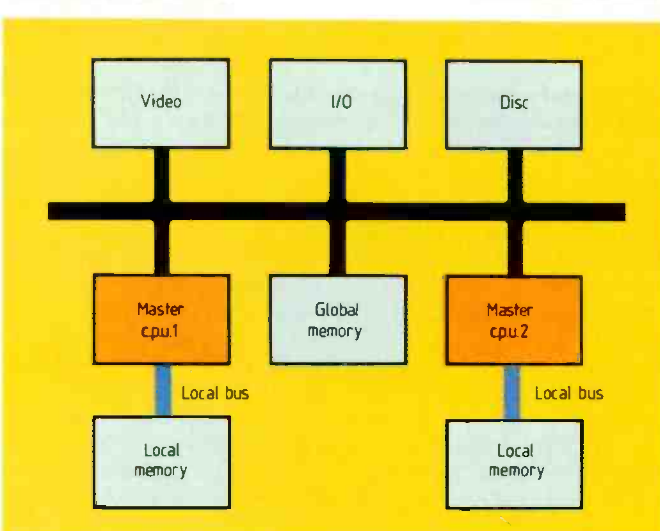
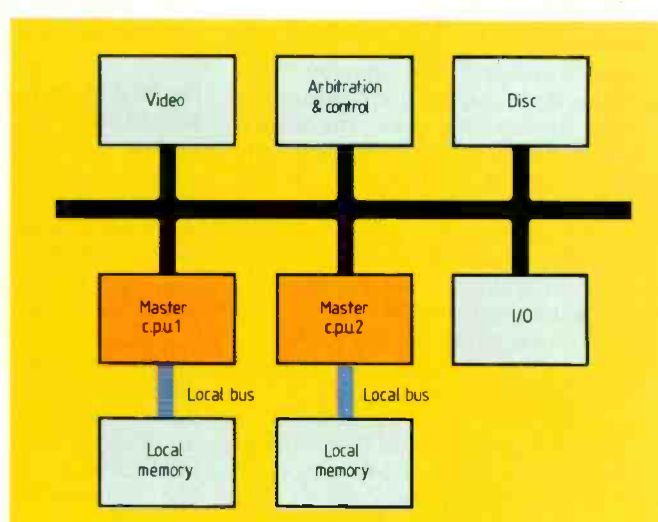
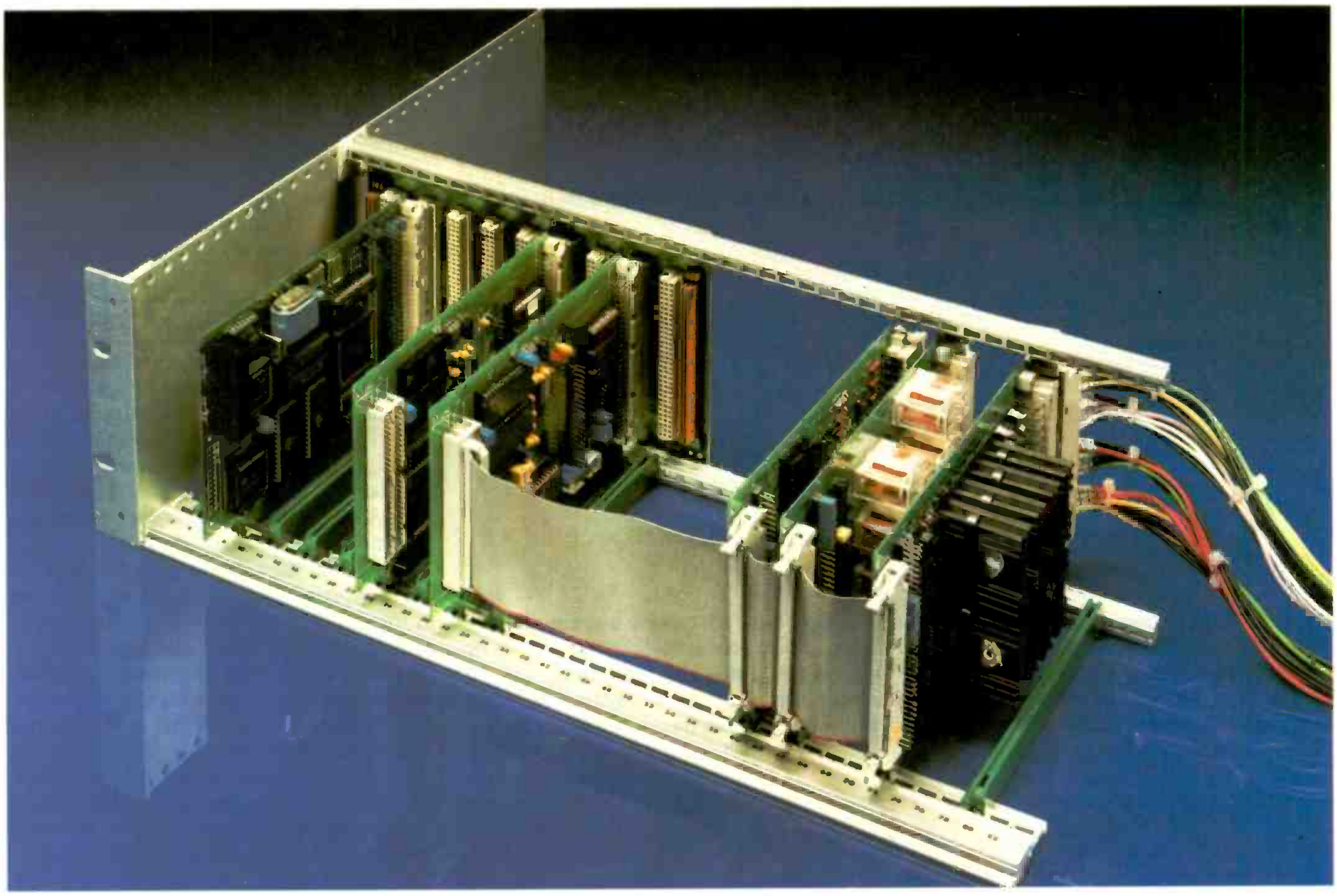


Figure 4. Multiple master with global data memory: CPUs operate independently on their own execution buses, using the global r.a.m. for intertask communication. Now the i/o accesses on the bus are the major causes of bottlenecks.



Multiple masters with local memory: Each c.p.u. card can run its own program in its own memory. The bus is used to access the slaves including i/o. Arbitration and control unit determines which device has control of the bus when more than one device requests it.



The ability to interrupt the receiving master once the message has been written to the global ram is essential for efficient operation of a multimaster system.

The communication ram is normal on the VME bus. The special feature is the interrupt semaphores. The interrupt vector could also be in the ram hence providing multiple transfer types. The standard bus arbitration deals with the problem of masters clashing and interrupt priority.

The example shown is parameter block passing. The same method can be used for any data length including single bytes.

Master-slave communication. Although slaves have no mechanism for taking control of the bus, they may be capable of causing bus interrupts. They are much simpler than masters and this is why the IO processor, described below, is very attractive solution in the new architecture.

The two commonly used data transfer methods used for slaves are basically the same as that for masters.

1. Using parameter ram: The parameter ram is local to the slave and may also appear on the bus as i/o data area. It generally does not need to be dual ported as the transfer of data is always under the control of a master.
2. Using first-in-first-out buffer: The slave can have a single byte for communication (read and write) which is effectively a window into the fifo itself. A status register is used to control the flow of data.

CASE STUDY OF NEW WAVE ARCHITECTURE

A real example of the new wave architecture has been implemented by PSI Systems of Cambridge on the VMEbus. In this system, the master is a 68000 series c.p.u. capable of running a modern multitasking language under an operating system. Its local memory can easily accommodate 2MByte of ram and 2MByte of eprom. The VMEbus active slave boards include a text processor to control video, keyboard and printer, an i/o processor to control analogue and digital i/o and a disc processor to control hard and floppy disc drives.

The components of this system are effectively asynchronous and can work independently of each other. In fact, master-slave architecture is parallel processing. The key to the efficiency is that the backplane should only be used for data transfers, and the individual program execution is done locally. The master runs the controlling program at the same time as the slaves individually handle their specific tasks.

Now see how the new wave architecture works in practice, assuming that one of the tasks on that master requires a disc sector fetch and a second task is writing to the video screen.

The PSI New Wave Architecture showing VMEbus backplane, single-system c.p.u. and the intelligent i/o processor. The i/o bus is a low-cost 50-way ribbon cable which connects the i/o processor to the signal conditioning modules such as relays and triac outputs. A second 50-way ribbon cable is used for the analogue i/o bus (not shown).

USING THE DISC PROCESSOR

The task must first gain access to the disc processor to avoid collision with another task that may already be using the disc. The processor will have a 'test and set' bit for this purpose in its status byte which is read until it becomes clear. The test and set instruction will have left the bit set so that no other task can now interfere. The read-sector command is now written to the disc processor together with any data required

<read sector>, <logical sector number>.

At this point the task suspends. All of the other tasks will be continuing as normal and can still use the VME bus to access other slave processors. The disc processor is now loading the required sector into its local data ram which can also be read from the VMEbus. When the sector is ready, the disc processor interrupts the master and the task resumes. The master then copies the sector ram into its own local memory and the job is done.

Two interesting points arise from this example. The first is the disc access was done as an eight-bit transfer but the memory access was done as a 16-bit ram-to-ram copy, the point being that the time spent on the VMEbus was very short. The second point is that it is very likely that the next sector request will follow the previous. This is already sitting in the disc processor's memory. In this case the next sector read will be extremely fast in fact at 16-bit memory speeds. What we have here is the slave doing sector management.

This may sound simple and obvious but in many systems the architectures create a

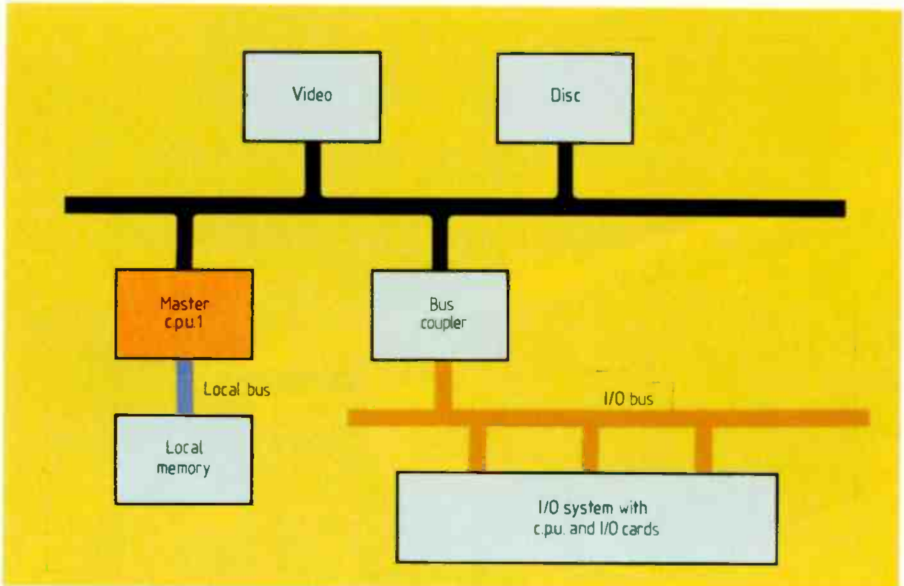


Figure 5. The i/o slave bus: The i/o is accessed via a separate i/o bus via bus coupler (eg. from VME to STE). The i/o bus (eg. STEbus) can have its own processor(s), memory and i/o cards. In other designs, the coupler may be incorporated into one (or all) of the master c.p.u.s and the secondary bus may be manufacturer specific. Unfortunately, such solutions are quite expensive, incurring the cost penalties of two backplanes and the bus coupler itself.

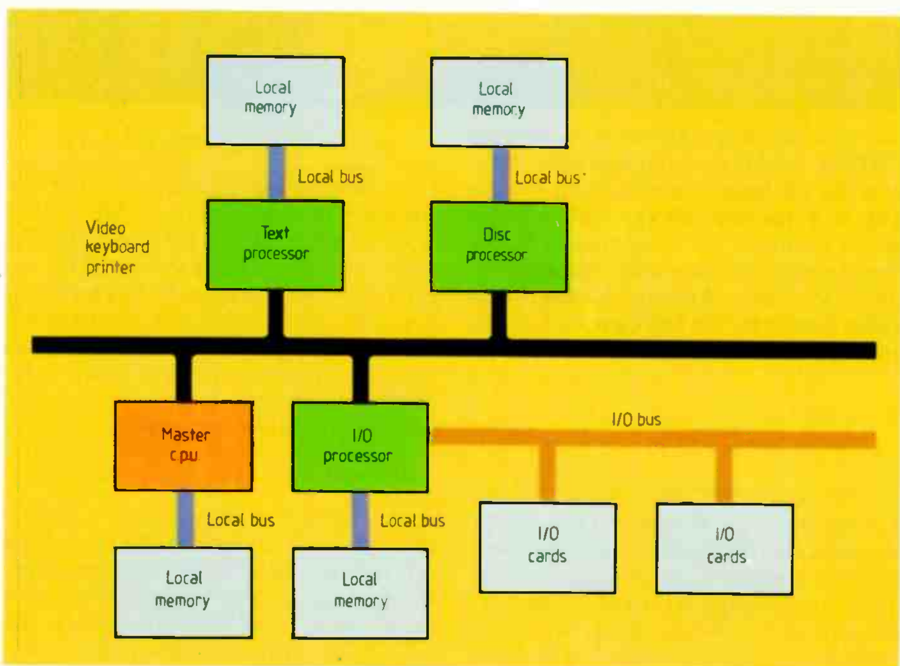


Figure 6. The New Wave Architecture: Each card on the system bus has its own local microprocessor and memory. Analogue and digitial i/o is controlled by the i/o processor so that most i/o tasks do not require the use of the system bus. The system bus is now a data bus rather than an execution bus.

MANUFACTURE OF BUS SYSTEMS IN THE UK

The first bus systems were produced by the major semiconductor manufacturers and as such they were a vehicle for the sale of their products. These products were used by system houses who found them wanting in some respects and as a result some went into design and manufacture themselves.

Another group of manufacturers grew out of the add-on market. These companies originally developed cards for specific machines by adding extra i/o to standard computer systems or PCs. A fourth group grew out of the need of some of the larger companies for large numbers of cards for in-house use, particularly in testing and plant monitoring.

severe bus bottleneck by transferring the sectors directly onto the bus, either under master control or with d.m.a. transfer. Some even cause the shut down of all other tasks during the transfer.

Probably one of the worst architectures, and yet one of the most common, is where the execution bus and the data bus are the same thing. Now the master program execution is slowed down or stopped during a disc transfer.

USING THE TEXT PROCESSOR

Another prime area for master/slave efficiency is the text processor, which uses a different technique for communication to that of the disc processor. The text processor uses a single-byte data channel with a status register to semaphore data movement. Again the activities of the slave are completely asynchronous to that of the master.

Using the example of PRINT "Hello": in conventional systems each letter would be processed in turn. With the master/slave architecture the whole statement can be transferred in one go. The master can then continue executing its program while the text processor writes "Hello" to the screen. This is analogous to a printer spooler. In fact, the text processor also has a printer spooler of 64Kbyte and a keyboard input. The keyboard processor stores the key strokes in a local buffer, so providing a type-ahead facility. The master takes the first key from the slave buffer, if the buffer is empty, the master can request that the text processor interrupt the master when a key comes in and then suspend its task. The task restarts when the next key is pressed.

USING THE INPUT/OUTPUT PROCESSOR

The simplest area of the computer is probably the most neglected. If the system c.p.u. is running the language in a control application, there are a number of operations which can be performed. The c.p.u. issues commands along the VMEbus to the i/o processor in the form

<token>, [<parameter>], [<parameter2>] . . .

Because this slave is intelligent, these i/o operations can be processed locally.

I/O OPERATIONS

A. Digital operations

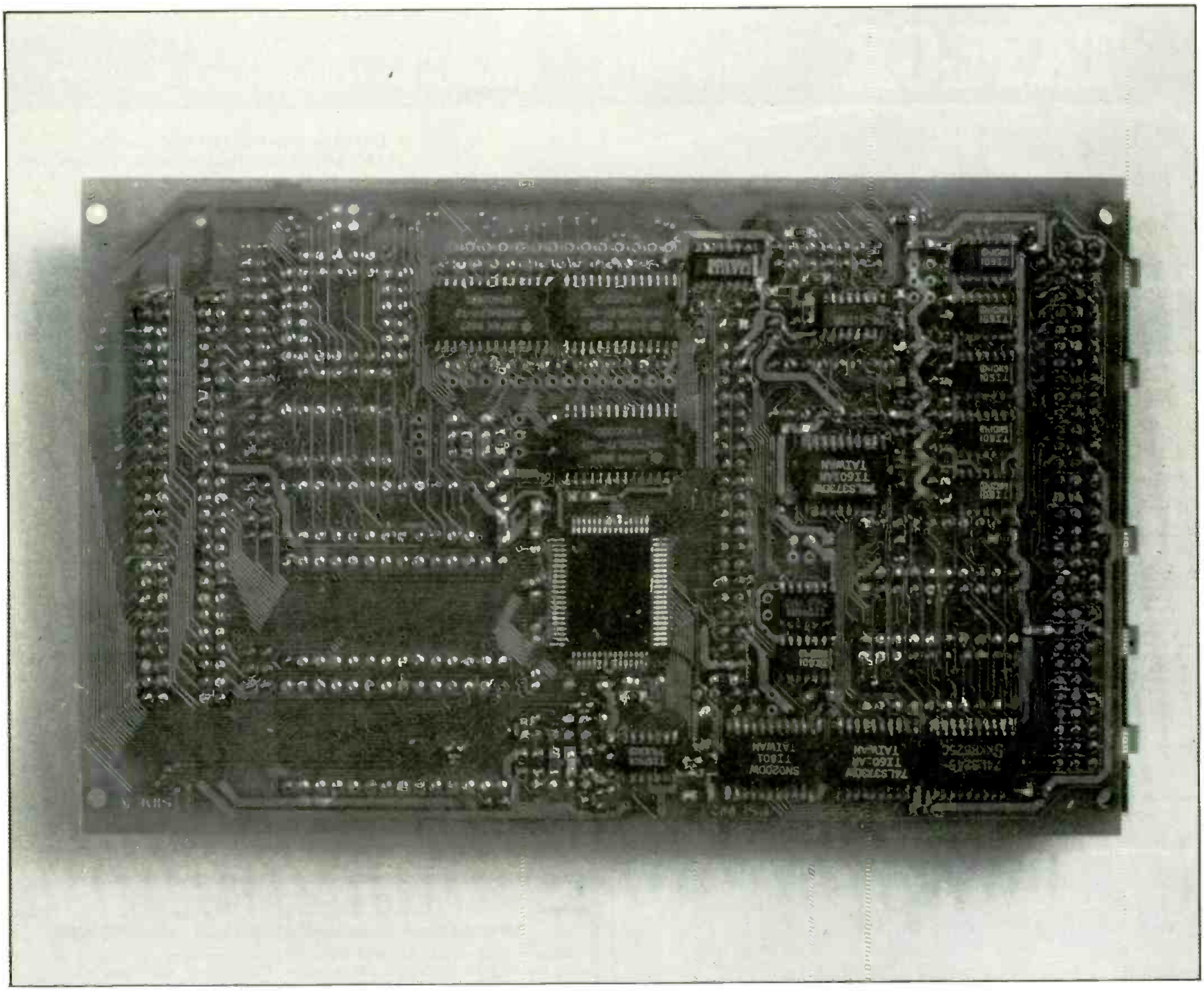
1. Bit-wise manipulation Immediate:
   - a. define bit as imput or output
   - b. turn off
   - c. turn on
   - d. invert existing output state
   - e. read external signal level

Real-time events:
- a. positive edge detect
- b. negative edge detect.

2. Byte control
Immediate:
   - a. output byte (write)
   - b. input byte (read).

B. Analogue operations

Using a 12-bit, 12μs analogue-to-digital



converter and a 12-bit digital-to-analogue converter

Immediate:
 a. read input a.d.c. channel
 b. write output d.a.c. channel
 c. read back samples.

Real-time events:
 a. analogue input greater than defined limit
 b. analogue input less than defined limit
 c. sampling inputs over time

C. Intelligent operations
 a. stepper motor control
 b. linearization of transducers
 c. three-term control loops

D. Local i/o programs
These are completely independent i/o control activities. The master can just set parameters and monitor the activity. The slave can interrupt for emergencies.

SIGNAL CONDITIONING

Returning to the architecture the final problem associated with i/o processing is connecting the physical devices in question, to the i/o cards. cards generally use t.t.l.-compatible inputs and outputs with 0–10V or ±5V analogue inputs and outputs. The devices, particularly power, tend to be physically large so that any one single height card is restricted to eight or possibly 16 channels.

The New Wave Architecture showing a 68000 c.p.u. i/o processor and signal conditioning modules.

It would be silly to put a slave processor in charge of eight relays even though processors now cost less than relays. A better solution is to construct separate i/o buses using low-cost ribbon cable. One for say 32-digital lines and a second for 32 analogue lines. These cables could then plug in up to four conditioning cards apiece. This scheme is actually bus-independent and as such it eliminates the need for couplers to provide an eight-bit i/o subsystem to the 16-bit VME. One i/o processor would then be in charge of 32 digital and 32 analogue lines and an on-board extension gives an extra 32 digital and 32 analogue channels. Extensions to the i/o capability of the system could be made by paralleling i/o processors on the bus.

At first glance these new generation cards do not look any different from their contemporaries except for the single-height or 3U form factor. (VME cards are more usually double-height or 6U.) However, another technique has been used to include the additional features. Looking at the underside of the cards, one sees all of the digital logic is surface mounted. The ability to keep the size to single-height significantly reduces the overall system cost.

Furthermore, the i/o scheme described is actually an industry standard, bus-independent scheme that has been implemented in the UK in both eight-bit STE systems as well as the PSI VME system. Taken as a whole, the new wave architecture removes the need for 'drone' cards such as VME-STE couplers, since the low-cost i/o is now accessible from the VMEbus.

FINALLY

The new wave architecture removes bus bottlenecks of its predecessors without adding much to the overall cost. There is one further important advantage to the system designer. Because the slave processors are intelligent, all of the system software relating to that card is on-board. This saves the software designer a tremendous amount of time in installing the final system. Not only that, the slaves are processor-independent working for a high level command/data structure. This on-board software satisfies 95% of all requirements, but to cater for the minority 5% a down-loader can be added to the system so that system designers can write their own slave software.

David Hunt and Keith Hodson recently founded PSI Systems of Cambridge.

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Mobile radio update

Deregulation and the prospect of spectrum auctions were among the topics aired by the Mobile Radio Users' Association at its 1987 conference in Oxford.

With delicate timing, the Department of Trade published its consultants' report on deregulating the radio spectrum just a few days before the conference began, ensuring that no-one there would run short of a topic of conversation. Copies of the fat yellow volume, the Yellow Peril as it was soon dubbed, were on sale at the conference office in Keble College and quickly became as much a part of delegates' hand-baggage as the inevitable cellular telephone.

Some of the background to the report was reviewed in the first session by Tony Nieduszynski, head of the DTI's Radiocommunications Division as it is now called. He listed steps towards deregulation already taken by his department: the UK frequency allocations table had for the first time been published (and a reprint was now on the way); non-governmental laboratories were to be appointed for type-approval testing of radio equipment, giving manufacturers and importers a choice of testing house (though approval certificates would continue to be issued by the DTI); low-power satellite tv reception had been legalized for those who had the necessary £10 licence (and indeed the DTI did not for its own regulatory purposes wish to keep any control over receive-only users).

On the fixed links side, RD had lifted its rule by which assignments were refused unless the applicant could show that his needs could not be met by the public telephone networks. For some fixed services, RD was even thinking of offering remote on-line access to its database and assignment software: this would enable prospective users to try out different scenarios to see which best suited their needs.

Looking ahead towards the concept of private-sector frequency planning organizations (FPOs) proposed by the consultants, Mr Nieduszynski spoke of moves already made in that direction. "We have increasingly sought and used opportunities to delegate management of blocks of frequencies to identifiable groups of users," he said.

For several years, frequencies for on-site pagers had been successfully managed by the Radio Paging Association. And very shortly, the BBC and the independent broadcasting contractors would be assigned jointly a pool of frequencies for their ancillary services. Day-to-day management of this would be controlled by the broadcasters themselves through what would effectively be a user-FPO. Independent programme makers could expect to benefit from similar arrangements a little later; and discussions were in progress with other user groups, including the water authorities, local government and the London courier companies.

For existing licensees, policies were being applied much more flexibly to take account of local circumstances: for example, facilities such as talk-through and reverse-frequency working were being granted.

A major piece of deregulation soon to take effect would be the exemption from licensing of a wide range of low-power devices, including radio microphones, garage door openers, toys, security alarms, baby alarms, and alarms for the elderly. Some 25 000 existing licences would be swept away by the measure, which was to cover the induction bands, telemetry and telecommand bands, including 49MHz. Also exempt would be wideband alarms on 48MHz: the DTI hoped that this deregulated slot would provide an opportunity for British industry to flourish.

WHAT THE CONSULTANTS PROPOSE . . .

Deregulation of the Radio Spectrum in the UK is the title of the report commissioned by the Department of Trade and Industry in 1985 from the consultancy firm CSP International. This document examines the potential for relaxing the rules governing the radio spectrum, for transferring spectrum management to the private sector and for using market forces to ensure the economically efficient use of radio frequencies.

All civil uses of radio in the UK are covered by the report, but the authors have concentrated on the commercially valuable ranges between 30MHz and 30GHz.

Among the report's main recommendations are the following:

- **For substantial portions of the spectrum, the present licences should be replaced by a Spectrum Management Licence. Under this system, private-sector Frequency Planning Organizations would sublicense spectrum to those who required it (other than to broadcast or telecommunications operators, who would need separate government authorization). British Telecom and Mercury Communications would be given the status of Major Users and would act as their own FPOs. Any potential user should have a choice of at least two FPOs to approach.**
- **Bands should be considered for early transfer to the new system where the number of individual licensees is very large, where the band is vacant or soon to become so (e.g. Band III), or where the present occupants have spare frequencies which they could usefully sublicense on commercial terms.**
- **FPOs and Major Users should be free to determine their range of services and charging structure.**
- **Spectrum Management Licensees might propose new technical specifications or alterations of existing ones. The DTI would refuse these only if they would cause international difficulties or unacceptable interference to other users' allotments.**
- **Fixed services bands between 1GHz and 30GHz should be managed by two FPOs and the two public telecommunications operators, BT and Mercury.**
- **Private mobile radio bands should be managed by four FPOs plus the Joint Radio Committee (which accounts for some 43 000 mobile units in the gas, electricity and coal industry) as a Major User. Each would have both v.h.f. and u.h.f. allocations.**
- **SMLs should be licensed in the sound broadcasting area, in accordance with the recent Green Paper.**
- **Bands for exclusive satellite use should continue to be managed by the DTI. The development of small-dish business satellite services in these bands should be encouraged.**
- **Responsibility for monitoring and enforcement should be divided between the SMLs and the DTI's Radiocommunication Division.**
- **Amateur radio allocations should continue to enjoy a degree of protection, but the UK government should apply pressure in international discussions to avoid increasing these allocations or even to reduce them.**

The consultants estimate the annual economic benefit of a 1MHz portion of u.h.f. spectrum at £75 000 for fixed services, £1M to 4.6M for mobile services and £4M for television broadcasting. Radio paging, with its capacity for extensive re-use of frequencies, rates much higher. These figures, they believe, indicate the advantages to the economy of a re-allocation of spectrum.

Deregulation of the Radio Spectrum in the UK is published by Her Majesty's Stationery Office at £9.50. The body of the report consists of 182 pages and there are six appendices covering cost analyses, capacity requirements, a summary of spectrum allocation procedures in the United States, and a review of literature.

Comments on the report should be sent to the Spectrum Pricing Secretariat, Room 305, Waterloo Bridge House, Waterloo Road, London SE1 8UA.

OPPORTUNITIES

Several times Mr Nieduszynski returned to the theme of creating opportunities. It was this principle, he said, which lay behind his department's thinking in looking at deregulation and market forces: if the aim was to raise revenue for the Treasury or to cast off the Department's own responsibilities, he had not been made aware of it.

The question was how to increase opportunities substantially without doubling RD's staff. And he reviewed some of the ways in which the current licensing system fell short of perfection.

One failing centres on the operator who is inefficiently using spectrum which is in high demand by others. He has no incentive at present to do other than use the cheapest and possibly most spectrum-inefficient equipment, since he gains nothing by relinquishing frequencies. He cannot sell or sub-license unwanted spectrum. And if he lets Waterloo Bridge House hear of his position, he risks forfeiting the frequencies without compensation. The licensing authority could require him to buy more efficient equipment: but it had no means of judging how much extra cost the scarcity of spectrum warranted.

Other problems for RD included difficulty it had in judging which of its queue of applicants offer the schemes with the best chance of economic or commercial success; and the lack of incentive at present for seeking new ways of exploiting the spectrum. Most people expected to be told that no spectrum was available. And the user who had been given frequencies for one purpose but wanted to use them for something different risked losing them to someone else.

Mr Nieduszynski outlined possible ways of reducing this rigidity, many of which were discussed in CSP International's report.

One approach designed to increase exploitation of the spectrum was to license two or more franchisees to exploit the same piece of spectrum, as is the case in the USA with fixed links. The user would then have the choice of organizations able to provide him with his assignment.

Another approach, requiring the use of new technology, was the currently-proposed Private Advanced Radio System (PARS). With this, many users could have access to the same spectrum without interference: the equipment itself would select a free channel, and no user would have a pre-emptive right to any particular frequency.

Later on, it might be possible to do away with all controls on certain bands (60GHz, for example) where it was unlikely that users would cause interference to each other.

But Mr Niedusynski reminded delegates that the report did not necessarily anticipate future policy: the Government had an open mind on these issues. It had asked to receive views and comments by 30 June.

A DEREGULATING ENVIRONMENT

To start off the debate, the conference organizers had arranged three presentations to set out the pros and cons of deregulation.

First came Michael Kennedy from Motorola Inc. of the USA, to give a picture of life in a deregulating environment. A series of Federal decisions since the 1970s had brought a considerable degree of private sector control to mobile radio and had proved very successful, he said.

Frequency co-ordinators designated for each service handled most of the administrative routine in issuing licences. They processed each application, dealt with technical and other issues and were allowed to charge reasonable fees. Since co-ordinators were responsible for post-licensing problems such as interference, they had an incentive to get things right first time.

Matters of overall policy were still dealt with by the Federal Communications Commission, which continued to represent the US's international obligations to the ITU.

There were now some 9M private transmitters in the US, said Mr Kennedy, and deregulation had created a very healthy climate. It had brought more services for business, especially in the fields of data and paging, lower costs, technical innovation and many direct and indirect public benefits.

A controversial proposal now before Congress was for frequency auctions. Radio users would file their licence applications in the normal way, but the fees would be determined by the auction. An annual revenue for the government of some £350M was though possible, and Congress was naturally interested. Public safety services, radio amateurs and mass media were excluded from the proposal, though some felt that tv stations ought not to be.

Motorola's fear was that auctions could inhibit the introduction of new technology; if frequencies began changing hands very rapidly, future planning would become very uncertain.

. . . OR CENTRAL CONTROL?

Arguing the case for central control of the spectrum was Jorma Karjalainen of the Finnish PTT's radio department; though he admitted (to laughter) that some of the areas now being deregulated in the US had never been subject to regulation in Finland, through lack of regulatory manpower.

The spectrum was a limited natural resource, he said. Central control offered the advantages of consistency of policy, economies of scale important to a small country, concentration of scarce expert resources, and the ability to maintain up-to-date knowledge of spectrum usage for forecasting future trends.

Summing up the arguments, John Carrington of British Telecom Mobile Communications said he believed the regulation issue was a bit of a red herring. The proponents of both viewpoints were moving towards flexibility and the accommodation of new technologies.

Under the proposed system, he said, the idea was that RD would withdraw to a role of representing the UK at international fora and ensuring that FPOs' allocations complied with international regulations.

But it would presumably be necessary to give each FPO an allocation in each band; and for two FPOs, the inefficiencies this would create might be an acceptable overhead. However, as the number of FPOs increased, this overhead would quickly become dominant. "By opting for spectrum pricing as well as deregulation", he said, "one is not so much throwing out the baby with the bathwater as selling the bath with the baby in it." A flexible approach that encouraged redeployment of frequencies, rather than a free-for-all, was what he wanted.

British Telecom, as a major spectrum user, is an obvious FPO candidate; and a questioner afterwards asked Mr Carrington whether his company could be sufficiently disinterested to act as an FPO on behalf of others. If there were two FPOs of equal stature, Carrington replied, effective competition would arise. Pressed by another speaker who wanted to know whether BT might turn away applications which might harm its own business, Carrington said that such worries could be ignored: colleagues in BT saw it as against their own interests to act in such a way. Another voice commented that spectrum pricing would not encourage better use because BT could afford to pay high rates. John Carrington replied that if pockets were deep enough the spectrum could be sterilized, and this was one of the pitfalls of deregulation. But BT had already discussed certain areas of spectrum which it could release for others to use.

In a later open-forum discussion, Mike Coolican of RD was asked about the reduction in strength of the Radio Investigation Service proposed by the report, since many users might expect interference to grow rather than diminish. Coolican said the report envisaged that each FPO would look after its own patch of ground. Unless Parliament gave FPOs policing powers, decisions would be enforced by contract law as in the US; though this, he added, could become a lawyers' charter. Otherwise, RIS would have to get whatever strength was needed.

The impression given during coffee-breaks was that many delegates thought CSPI's package of proposals unpractical in their present form: the report might be strong on philosophy but the technical issues affecting mobile radio had not been thought through. A worry expressed by one radio network operator concerned how interference problems might be resolved. At present, frequency conflicts can be dealt with quite simply by moving a channel or two following discussions with RD. But if rival FPOs were involved, each might blame the other and nothing would be done.

BAND III

Mobile radio's other hot topic of the moment is Band III radio, for which spectrum released by the closure of the v.h.f. television services is being reallocated. Martin Cain of RD's frequency planning unit outlined some of the difficulties with this band, which certainly sounds a nightmare. Since tv broadcasting continues to occupy Band III both in Ireland and in continental Europe, interference must be strictly controlled. Protection criteria have been agreed with the administration in France, Belgium and the Netherlands and RD must observe them to the letter.

So far, the planners' activities have concentrated on the middle sub-band, with base transmitters in the range 200–208MHz and mobiles on 192–200MHz.

A formula drawn up by the CCIR is used for calculating the total nuisance field due to the proposed UK stations; and it is possible to reach the agreed limit on a given channel with a single well-sited station in southern England. Because of the need to minimize interference around the vision carrier frequencies of the continental tv channels, some frequencies are no-go areas; others near the sound and colour subcarriers are virtually so.

With regard to Ireland, the difficulties are almost worse. Mr Cain said that the broadcasting authority there had regarded the UK's intentions with deep suspicion. It had been talking of co-ordination radii of 700km, which would impose severe restrictions on those areas of the UK not already subject to the agreements with France and the Low Countries.

A further worry is the prospect of second-harmonic interference from Band II broadcasting. There is little reason to suppose that the many unlicensed stations lose much sleep over this aspect of their operations.

One man who will have to cope with all these difficulties is Alan Sheward, who presented an update on GEC's national Band III p.m.r. network[1], due to open for business in August. The system – now named GEC National One – would offer a wide range of voice and data services, including dispatcher-controlled or two-party calls, public telephone and p.a.b.x link-ups, voice messaging, store-and-forward messaging and vehicle tracking. With its simplified licensing formalities, the network would be responsive to users; and the common signalling standard for all Band III systems would mean a wide range of off-the-shelf equipment. Dealings with individual customers would be through third-party service providers, except in a very few cases which would require special permission from Oftel.

Some of the practical features of trunked Band III systems were discussed by Michael Vadon, formerly of BT and now a director of RT Radiotelephones, the regional Band III licensee for north-east England. From the user's point of view, he explained, the ready availability of Band III systems would be a big advantage. There would be no searching for base station sites, no waiting for equipment or for licences to come through – and so customers would buy before the whim passed. But a drawback would be higher equipment prices than for ordinary p.m.r.: the sets were more complicated and no world market existed for them.

MOBILE DATA

Most present-day mobile radio networks are voice-only systems; but with the inexorable growth of the computer the need for data transmission is growing rapidly. Systems incorporating data links are welcomed by planners because they can usually make a more efficient use of scarce radio channels.

Sweden's new Mobitex system offers efficient communication between data systems and mobile terminals (Ericsson).

One such system is Sweden's new Mobitex network, a trunked voice and data dispatch system operating in the 80MHz region. Following a two-year trial, Mobitex entered public service last October. The system is to be marketed worldwide under the name MRS6000.

The network is co-ordinated via a single control channel, the same all over Sweden: by exchanging data over this channel, stations may set up a speech call on one of the associated traffic channels or transfer a data packet. If system loading is light, packets can be exchanged on the control channel. A minimum system would thus consist of just two channels: the control channel and one other.

Some of the trial Mobitex systems were described by Göran Berntson of Ericsson Radio Systems. One is at Gothenburg harbour, where it has apparently been used to good effect in speeding up cargo handling. When a ship is being unloaded, crane operators key in the number of each container as it emerges. A central computer responds with details of where the container should be placed. Also linked in to the network are lorry drivers approaching the port, who give early warning of their arrival. The dispatch centre can now plan their loading and departure automatically.

Also using Mobitex are the Swedish post office, whose vans now bring on-line postal and banking services to rural areas; and the regional alarm centres, which act as dispatchers for Sweden's emergency services. Print-outs from the mobile terminals ensure that personnel can work fast, without mistakes and in secrecy.

By 1990, the system will be fully expanded with 150 base stations, 60 area exchanges and 20 interlinked main exchanges.

A large data communications system now under development in Britain is that of the Automobile Association, the country's largest handler of motoring breakdowns. The AA's new operations centre at Stanmore is the focus of its activities in the London area and has been in use since May, 1986.

Graham Warner of the AA described the new system, which makes use of data terminals carried by the area's 500 mobile patrols. The AA's workload was increasing by 10% per year, he said; and if the change to data transmission had not been introduced, the breakdown service would have become unable to cope by 1990. With the superseded radiotelephone system, London patrols often took as long as 15 minutes to contact the base station. Only five radio channels were available and each radio operator handled 35–40 mobiles.

Today, breakdown calls from AA members are received at Stanmore by an operator who can quickly locate each incident with the help of a computer-based gazetteer. This stores not only street names but names of buildings and other places of interest – including public houses, together with their nicknames. Such information makes it possible to cut out time-wasting 'no trace' jobs. The system now estimates how long it will take help to reach the stranded motorist and co-ordinates the rescue operation.

Control positions are manned by two operators, each with an interactive screen capable of displaying job details and status information in 50 different screen formats.

Data communication at 1200 baud has proved reliable in London, even where there has been difficulty with voice. The system uses just four of the AA's radio channels.

A second control centre at Thatcham is to become operational in October; and by 1990 a network of 10 centres will extend coverage to the whole of the UK. The AA is now looking for terminals with improved facilities and price-performance for the remainder of its 3000-vehicle fleet.

RADIO TELESWITCHING

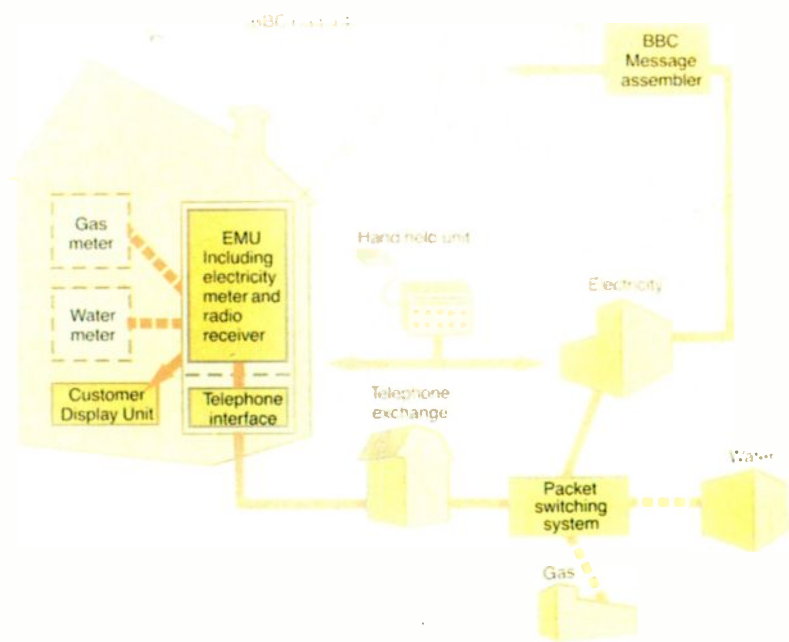
Alan Dick of the Electricity Council provided an update on the teleswitching system[2] by which a data signal on the BBC's long-wave transmissions is used to help trim electricity demand to match the generated output. The system, which since the meeting has brought the Electricity Council and the BBC a joint Queen's Award for Industry, is now being used by most area electricity boards to replace clockwork switches for off-peak supply meters. A new application is in 'budget warmth' schemes, by which domestic customers can buy electric storage heating in return for a fixed weekly payment. The operating board uses weather forecasts to decide how much charge to provide and broadcasts teleswitching messages daily.

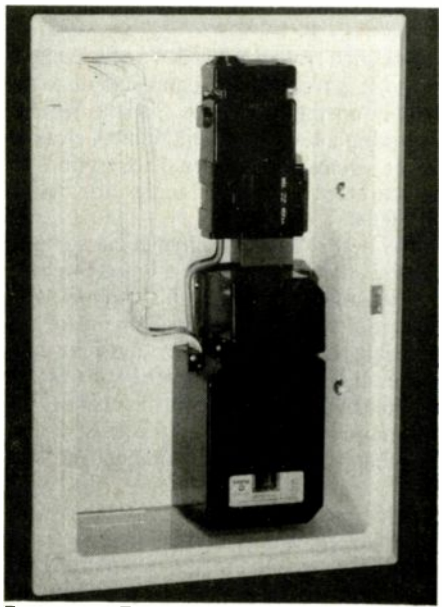
Now being developed in co-operation with Mullard Ltd is a new metering device with communications facilities – the Energy Management Unit or Emu. This can be read or re-programmed via a hand-held unit or remotely over telephone lines. Tariff and switching information can also be broadcast to it by one-way radio. Emus can handle up to six charging rates, allowing time-of-day and seasonal multi-rate tariffs. Security codes are used to prevent tampering. For the forthcoming trials, the system will be controlled from the area board's office by a desk-top PC, which will also act as an interface to the accounting computer.

The trials form part of a European project aimed, among other things, at showing whether customers can be coaxed by special tariffs into modifying their pattern of consumption and so reducing overall energy costs. Besides the 850 Emus to be installed in Britain, a further 150 will be in Brussels where they will be controlled over a cable tv network.

Another remote-metering idea under investigation was to fit electricity meters with a radio device which would enable them to be interrogated and read by equipment in a nearby van. The customer's wiring and service cable would act as the device's antenna. Trials have already been conducted in the US on a 900MHz version, by the Long Island Light and Power Company; though Mr Dick believed that a frequency in the range 1–3MHz would be more practical. But would the DTI be willing to allocate one? A single 8kHz channel would be sufficient for the whole industry.

The cost of reading meters worked out at 80p–£2 per year, and any electronic system would have to match this target.





Prototype Energy Management Unit, or Emu. The customer's installation can be linked to an extensive communications system controlled by the area board.

CELLULAR – THE FUTURE

Steve Temple, another member of the RD's team, turned the spotlight on the future of mobile radio, where international developments may bring big changes over the next decade.

Planners, he said, had to think of the industry's needs ten years ahead, since experience showed that it took this time for new schemes (such as cellular radio) to reach fruition. Users should get together now with the DTI to ensure that preparations were made. Another mobile radio WARC would be needed around 1992.

Cellular radio in Britain had been a spectacular success, with more mobiles in service than anywhere else in Europe: 90 000 new users were joining each year, compared with 22 000 in Germany.

For the future, European heads of state had agreed in December that there should be a common standard for a future cellular system and there had been a directive from Brussels to keep channels available.

There was complete unanimity in Europe that a narrow-band t.d.m.a. system was the best technical solution. Thirteen administrations felt able to go forward with this system for 1991 implementation date, with only two (France and West Germany) holding back. [Since the meeting, those countries have agreed to support a modified specification containing features of their own proposals.] At least three large European markets would have to be available in 1991 for the system to be a success; but UK manufacturers would have a chance to become world-class contributors to it.

SATELLITES

Other centres of activity for planners included a new European radiopaging system for the mid-1990s and a so-called aeronautical public correspondence service. This last would give businessmen global communications by portable telephone wherever they went. Satellites like those of Inmarsat would handle in-flight calls, though direct ground links for the heavily-populated European area might be cheaper. Mr Temple, whose hotel in Brussels had just charged him £70 for putting through a brief call to Florida, evidently felt strongly about this.

The introduction of satellite systems for global mobile radio is not as far off as it may sound, as delegates heard in a presentation by John Norbury, head of the radio communications research unit at the Rutherford Appleton Laboratory. Interest in the idea, he said, had been stimulated by the ATS-6 project of 1974, with its 860MHz communication transponder.

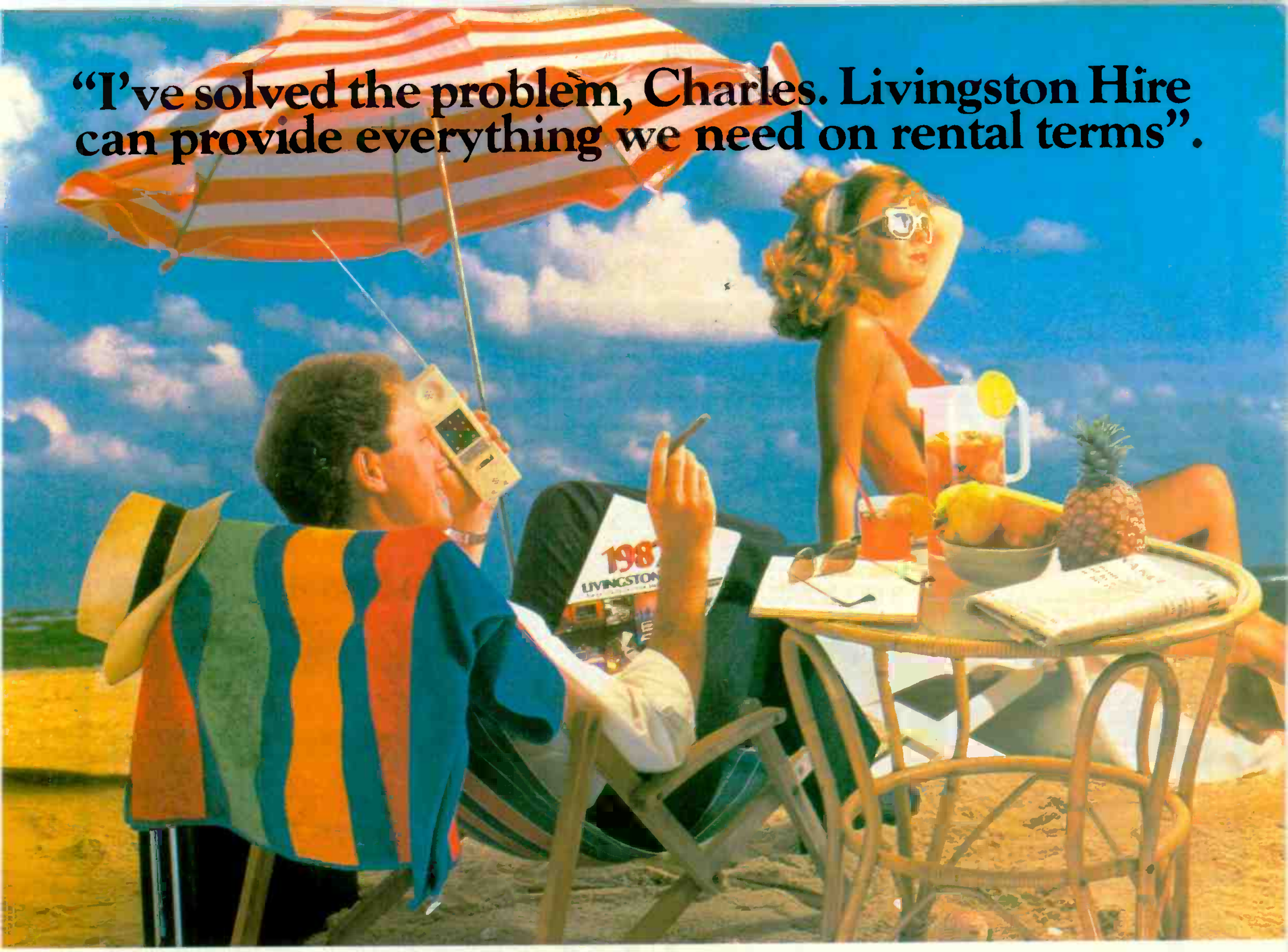
Later experiments with geostationary satellites – such as the Canadian M-Sat project – had been encouraging, but this class of orbit brought a considerable cost penalty for countries at moderate latitudes. To avoid the need for a tracking system, mobiles had to use omnidirectional antennas; and in North America a 15dB margin over the free-space signal loss had been found necessary because of the satellite's low elevation. A much greater margin would be needed in cities. Link margin for satellite systems was expensive: one rule of thumb reckoned it at £1M per dB.

An alternative scheme, with which the speaker had been involved, was for a system using an inclined Molniya-type elliptical orbit: such a satellite would appear to hang overhead for perhaps 8–12 hours at a time, avoiding the problem of blockage by buildings. With a constellation of three satellites a 24-hour service could be provided.

References

1. Trunked mobile radio in Band III, by P. J. Delow: *Electronics & Wireless World* December 1986, page 51.
2. Broadcast radio-data, by D. T. Wright and S. M. Edwardson: *Electronics & Wireless World* November 1986, page 63.

Conference papers are available from the Mobile Radio Users' Association at £25 a set. The association's new address is 28 Nottingham Place, London W1M 3FD. Tel. 01-400 1518.



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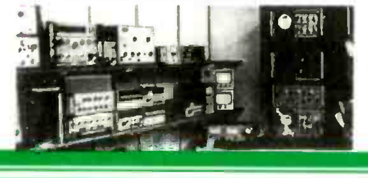

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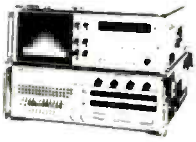

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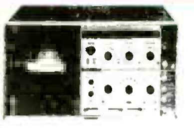

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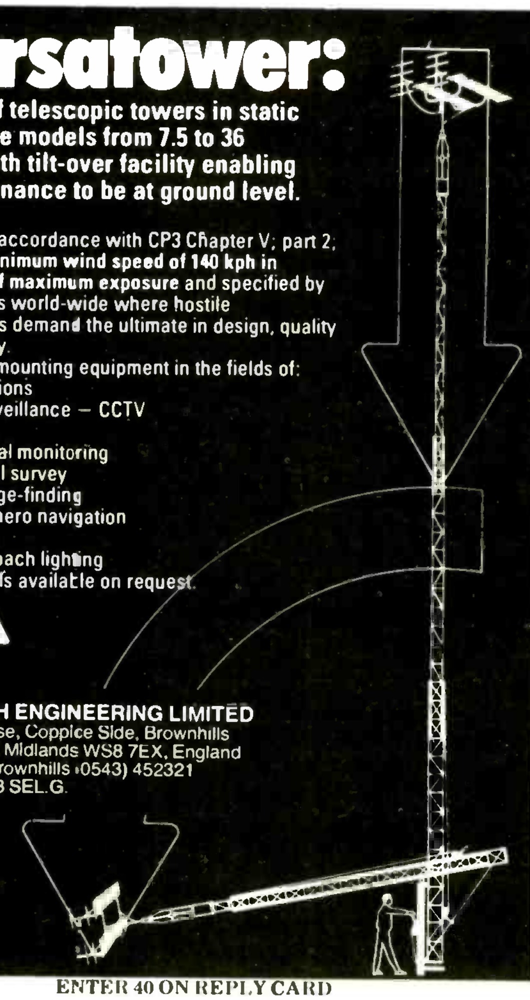

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ICF7600D test signals for v.h.f. receivers

Sony's ICF7600D is a handheld broadcast receiver with synthesized shortwave tuning under the control of a dedicated microcomputer. Here's how the local oscillator signal and its harmonic can be used as an accurate calibration source for two and four-metre receivers without any direct connection.

The ICF7600D uses a variable first local oscillator operating above the selected frequency and this is provided by the synthesizer with considerable precision. Suppose that you wish to confirm that a two-metre receiver is tuned to channel S20 (145.5MHz). Switch on the ICF7600D receiver and select 16.905MHz. Hold the ICF7600D close to the antenna. The squelch should lift and a strong c.w. signal should be indicated.

This is because the second harmonic of the l.o. falls within S20. Table one shows some of the S channels and their corresponding settings.

Two-metre channel	AM setting
S14	16.830
S15	16.840
S16	16.855
S17	16.865
S18	16.880
S19	16.890
S20	16.905
S21	16.915
S22	16.930
S23	16.940

Formula one enables a frequency and its setting on the ICF7600D to be calculated. Errors can occur since the test signals varies in 10kHz steps whereas the S channels are in 25kHz steps. However any variation in the ICF7600D will cause the test signal to favour either the odd-numbered S channels or the even-numbered S channels. This may in turn be checked against a two-metre repeater output.

The five-line program enables a microcomputer to calculate the corresponding a.m. settings between 112 and 171MHz. This allows marine band and air-band receivers to be checked.

```
10 DEF FN F(X) = X/2 - 55.845
20 PRINT " Frequency ",
   " ICF7600D " : PRINT
30 INPUT " Enter Frequency
   MHz " ; f
40 PRINT f , FN F (f)
50 GOTO 30
```

$$\text{a.m. setting} = f/2 - 55.845 \quad (1)$$

In the case of four-metre receivers the fundamental l.o. is used. This enables 5kHz steps to be made and the formula for obtaining the a.m. setting becomes

$$\text{a.m. setting} = f - 55.845. \quad (2)$$

The procedure for four-metre tests is otherwise indentical, for example, the ICF7600D would be set to 14.415MHz a.m. to calibrate 70.26MHz.

Other settings corresponding to frequencies from 56 to 76 MHz can be obtained.

This unusual application of the ICF7600D has been of great help for setting up receivers and converters in the absence of transmissions. The reader is left to work out how a 70cm receiver test signal can be generated.

Mike Mucklow
Stony Stratford
Bucks

Betrayal of science by 'modern physics'

We can classify discipline as ranging from hard to soft: from physics, engineering, chemistry, biology; through sociology, psychology; to geography, history, literature, religion. The hard disciplines are described as 'science'.

In a soft discipline, a model, theory or fact is still of value even if it is imperfect, flawed.

The definition of a hard science could be that it is capable of sustaining a perfect, true, model, theory or fact.

For prestige reasons, the soft sciences – sociology and psychology – try to take on the mantle of the hard sciences by using 'scientific method'; a method of arriving at rigid, 'true', facts, models and theories. They do this in order to gain access to the prestige and funding (NASA-type) that the hard sciences command. So we see subjects trying to move to the left, from soft to hard.

Unknown to the soft science careerists, struggling towards the left, the position of their colleagues at the hard, physics end is uncomfortable. This is because if a theory can be exactly true, it is also brittle; more vulnerable to complete overturn by new developments than is a softer, imperfect theory. Now career advancement is, if anything, a soft subject, not a hard one. So for career reasons, a traitor group in physics has developed a soft discipline called 'modern physics'. These careerists betray science by softening their discipline and so stablizing the theoretical status quo and with it their career status quo.

An individual's career in hard science is brittle, because it is based on more absolute, therefore more brittle, theories and models. He then makes his position more pliable, and his status and career more secure, by softening the brittleness of his discipline. In doing this he betrays his discipline in order to protect and further his career.

'Modern physics', a bastard pseudo-physics, is a soft discipline which has been developed by career physicists unwilling to risk a brittle career in hard science.

Meanwhile, the soft sciences (sociology and psychology) trying to obtain the prestige and funding of the hard sciences are not fearful of this brittleness. In any case 'modern physicists' are telling them that physics is soft.

The sign posts on the road from physics to modern physics – from hard science to soft – are: uncertainty; (wave-particle) dualism; confusion of observer with observed; relativity; and the use of statistics and probability. Paradoxically, one of these, statistics, also signposts the opposite march of the soft sciences towards the hard.

Ivor Catt
St Albans

Oscillator amplitude stabilization

In the good old days a filament bulb or an n.t.c. resistor was used for amplitude stabilization in Wien Bridge and phase shift oscillators. However, the output amplitude, though stable, was often unpredictable and tended to change with ambient temperature. These days, active control circuits using fets, o.t.as or other analogue control circuits are generally employed. The major source of distortion in these type of oscillators is the non-linearity in the gain-control element (be it filament or fet).

This is well-known, but there is another factor that is generally overlooked. The output of the sinewave generator is rectified and smoothed by a low-pass filter before being fed to the active control element. Now even if the gain control element was perfectly linear, there would be a secondary source of non-linearity since the a.g.c. bias voltage is not purely d.c. as it should be but contains traces of the oscillation frequency itself. The conventional remedy is to make the a.g.c. time constant as large as possible, but this is not the best solution.

Theoretically, it seemed, there was no way in which the control voltage could be made purely d.c. without an excessively long time constant. I was pondering over this problem for a long time when the identity $\sin^2 x + \cos^2 x = 1$ occurred to me.

If we take the two outputs of a phase-shift oscillator that are 90° out of phase, full-wave rectify them, feed them independently into voltage squarers, and add the resultant waveforms, we get a direct voltage proportional to the amplitude of the sinewaves but having no a.c. components in it.

Of course, this method isn't very elegant as analogue squaring chips are not exactly cheap, but it is certainly worth trying. I am not aware whether any of your readers have thought of this idea which I feel is the solution to this problem.

R. Shankar
Madras
India

New markets

I read with interest the editorial in the April edition discussing new markets for the UK electronics industry. I would like to suggest another region where UK and Japanese companies may be able to find new markets.

The countries of Latin Amer-

FEEDBACK

ica have historically traded with the United States, but in many of these countries governments are emerging which seek greater independence from the USA and are trying to reduce their technological dependence on the USA. Nowhere is this more true than in the Central American country of Nicaragua, which finds itself embargoed by the US and has turned to European countries, the EEC and the Comecon nations for new trading partners.

I am about to go as a British volunteer to Nicaraga, to teach digital electronics and microprocessors at the National University of Engineering. I will be responsible for establishing an electronics laboratory at the university and advising local industry. I have over 10 years experience in industry: currently I am the manager of an electronics laboratory within Lucas CAV Ltd.

I would like to invite readers to consider donating equipment to this university laboratory. The primary benefit to companies would be that Nicaragua's new generation of electronics engineers would be trained using their equipment. What may be less obvious is that the university has some 21 different nationalities amongst its staff, a large proportion of whom are from other Latin American countries. The university also has visitors from all over the world: particularly Western Europe, the Comecon area, the United States and Latin America. Thus equipment given would be seen and used by an unprecedented variety of potential customers.

Any help offered will be a significant contribution to a poor third world country and will be genuinely appreciated. I can supply a detailed list of the equipment and components required on request (01-743 3111 till the end of June, 01-993 5631 after).

Donald Power
34A Cowper Road
London W3 6PZ

Transistor sound

Having followed with amazement the debate about 'capacitor sound' (which can be practically nullified by using, where unavoidable, high quality electrolytics correctly biased and suitably bypassed) I should like to recall attention to the subject of 'transistor sound,' which is more noticeable, less controversial, and perhaps a more rewarding subject for investigation.

Most of the pundits will have read M. Hawksford's paper on charge quantization in bipolar devices, and the recommendations for minimizing the problem. This prompted a closer look at the extent of the effect; How it could be calculated for a given amplifier and, hopefully, reduced to negligible levels.

A few calculations showed that charge quantization is a property of small alternating currents and that it would present problems even to a perfect current-driven amplifier. Given that the charge on the electron is 1.6×10^{-19} coulomb, it is immediately obvious that no bipolar amplifier can resolve a signal smaller than 3.2×10^{-19}A per Hz (i.e. one electron per half cycle). At 10kHz the smallest a.c. that can flow is 3.2×10^{-15}A, the only conceivable waveform of this current being rectangular. This current represents the threshold of fuzz from both the logical and aural points of view.

For any current-driven amplifier (i.e. bipolar input) the signal-to-fuzz ratio at the input will be $20\log[I_{in}/3.2\times10^{-15}]$ dB or a little more conveniently $20\log[3.12\times10^{14}\ I_{in}]$ dB. Alternatively the ultimate signal resolution (u.s.r.) is equal to $3.32\log[3.12\times10^{14}I_{in}]$ bits at 10kHz referred to a given input level, I_{in} (A r.m.s.).

For any amplifier it is only necessary to calculate the actual current (ignoring external load resistors etc) flowing into the amplifier at, say, 5cm/s recorded velocity for phono inputs or 1V output for power amplifiers.

For example consider a typical op-amp phono preamp:

Open-loop gain (10kHz)	6000
Open-loop input resistance	100kΩ
Closed loop gain	10
Cartridge output (5cm/s)	5mV
Preamp output ,,	50mV
Differential input (50mV/6000)	8.33μV
Input current (8.33μV/100kΩ)	8.33×10^{-11}A

(This is the net current flowing into the amplifier itself, not the cartridge load resistor.) Thus

$$\text{s.f.r.} = 20\log[3.12\times10^{14} \times 8.33\times10^{-11}]$$
i.e. 88.3dB

$$\text{u.s.r.} = 3.32\log[3.12\times10^{14} \times 8.33\times10^{-11}]$$
i.e. 14.7 bits at 10kHz ref. 5cm/s.

Until bipolar input stages are redesigned to allow higher input currents it seems that it will be necessary to use valve or f.e.t. input stages for good signal resolution.

Roger C Lowry
Christchurch
New Zealand

Relativity

Professor Michael Butterfield (Feedback February 87) believes "that without space which permits geometrical shape and movement, our very existence would have no meaning". This is rather a strong philosophical point of view which implies that as a priority we must have "space" to begin with so that things can happen! Moreover, we have also assigned to this strange space many properties so that Dr H. Aspden is, therefore, more than justified to fill it with an ether if by doing so the explanation of physical phenomena becomes easier as well as more interesting and palatable!

It is not my intention in this brief letter to comment on the "Relativity Simplified" article but to emphasize that one of the manifestations of matter in the universe implies (create) the "idea" of space. Without the presence of matter there is not such a thing as "void" or "space" and consequently geometrical shape and movement is unthinkable. These aspects can only be directly associated with the energy and forces belonging to material objects. Equally, we cannot go beyond the world of material objects to look for an abyss of an infinite space. We can only consider the existence of a "medium" between any two objects that are acting upon each other (be it electromagnetically or gravitationally). We must, therefore, be concerned with the study of this limited and finite medium with respect to these objects and avoid at all cost extending our system to involve what is logically inconvceivable and in the process get lost in a forest which neither God nor Nature had ever created.

Finally, universal time is far from being an outdated Newtonian concept that had to be thrown out of the window like a dead corpse before the arrival of the respectful Einsteinian world system at the front door. Granted that, for the sake of practical necessity, we are forced into accepting, for example, our own earth frame of reference to be stationary in the universe (i.e. zero energy level with respect to absolute motion), this only leaves us with a clock that can read local but not universal time (for the simple reason that so far we are unable to detect, and therefore correct for, our motion with respect to that point from which everything had started). If it is possible to arrive at this "common time" in a future theory, then we shall be in a position to do without measuring rods, forget about the concept of simultaneity as well as the bedside story of the paradox involving the far space travelling twins. I expect many so-called Relativists would then be only too happy to throw some of their own cherished and over-protected hypotheses of Einsteins's Special Relativity out of the window as well!

M. Zaman Akil
Al-Thubaeya
Kuwait

'Computers, language and logic'

I read the article entitled 'Computers, language and logic' by A. Medes but could not understand the purpose. I was unsure while reading it so when I got to the end, applied the objective test – see if I could summarize what it was about. I couldn't really write down anything concrete. Alluding to something? Mathematics of higher degree circuitry? This is the sort of thing that I have been arguing for to reinstate causality.

Other than this there were occasional patches of comprehensibility but no overall coherence. The logical problem "I am a liar" was dealt with as a feedback process in a logic inverter to simulate the sequential process in our conscious awareness.

FEEDBACK

accepting one idea then the other, then back again.

Is the concept of causality still treated with contempt or are you becoming educated to understand your own mental processes: not to have double values, in engineering practice (causality rules the machine, intuitive knowledge) and in theoretical modelling (causality *appears* to vanish in asymptotic equilibrium formulae).

In the example here, it is presumed there is a propagation delay to explain oscillation, the logic unable to 'decide' on a consistent certainty.

How would you explain the theoretical inconsistency if you rephrase the problem, replacing the logic gate with an analogue amplifier and used the 'op-amp' formula for negative feedback?

The op-amp formula does not predict oscillation simply because this intuitive information is not programmed into its derivation which assumes, falsely, that stable equilibrium can exist for the feedback currents.

If causality is assumed with propagation delay, we use iterative analysis, the feedback process generates a power series of terms (voltages) which IF it converges produces the op amp formula as its asymptotic form.

The instability between 0 and 1 states does not appear in the op-amp formula which passes through the *logic* value of ½ (see maths textbook 'Divergent Series' by G. H. Hardy).

The author A. Medes seems to be struggling for an idea: "The calculus of logic can be used to describe some simple circuits, (no feedback)...but it is totally inadequate if we require rigorous mathematical description of other types of circuit". *Logic* says nothing about physical reality. Logic is merely a low-noise information storage medium – a medium for storing information or physical intuition derived from experience.

The required idea is causality, modelled by discrete element analysis. Interactions are described by iterative processes which might converge to an asymptotic limit under certain conditions of the feedback interaction. The asymptotic limit is called, inappropriately, the 'generating function' for the power series of the iterative process.

Justification for the use of the surd $\sqrt{-1}$ is: logical self-consistency. It needs no more 'meaning' than its definition: when multiplied by itself it gives -1. In all complex formulae the real and surd elements remain linearly independent of one another because they cannot be combined in arithmetical calculations until all surds are transformed back to reals again (in some 'real' invarient).

In modelling physical situations $j = \sqrt{-1}$ arises in asymptotic formulae (of circular functions) when we *assume* equilibrium can exist for the amplitudes of sinusoidally varying responses.

The mathematics of complex number algebra is neat but hides a lot of physical assumptions that may not necessarily be valid. So don't be fooled by superficialities of appearance.

P J Ratcliffe
Stevenage
Herts

Time and space

I enjoyed reading Scott Murray's article "If you want to know the time..." but searched in vain for the rider "ask a relativistic policeman". Can it really be that clocks at the pole and at the equator can cooperate to prove that Einstein was wrong?

Such a proposition is outrageous and I have it on good authority. The editor of *Physical Review Letters* has drawn my attention to an experiment* reported by NASA. It appears that in 1976 the NASA-SAO rocket-borne redshift experiment proved that the theory of relativity was correct and that over a 10,000km range from the Earth light speed was the same in opposite directions within 3 parts in a billion. If this is true, then, as an antirelativist, I am defeated and Scott Murray should hoist the white flag as well. No longer can *Wireless World* entertain us by encouraging debate in this exciting arena of 'relativity'.

It wold indeed be sad if *Wireless World* followed the example of *Applied Optics*. The editor of this journal, published by the American Institute of Physics, had occasion to write at page 544 of the March 1977 issue: '*It was probably unwise for Applied Optics ever to have ventured into the controversial area of relativity theory (and the various optical tests for it). In that area even the experts carry long swords and enjoy duelling to the death. Unarmed editors of applied journals would be well advised to avoid that battlefield*'.

It appears that NASA did send a stable maser oscillator into space to test relativity. As a clock, it behaved as expected in slowing down as it returned to the stronger gravitational potential in its descent. This is just as Scott Murray would predict. But what about the time dilation effect due to motion? Well, since relativity references motion on the observer, the speed of the rocket was referenced on the Earth frame and the time dilation terms were small enough to be ignored. The experiment performed by NASA has such small residual error that it could be said with confidence that the radio signals sent to the rocket travelled at the same speed as those sent back from the rocket. No evidence of motion through the preferred frame was found, and the range was 10,000km.

Now, what is fascinating about this experiment is that it was a major NASA project involving numerous scientists and aimed at testing relativity. It was seen as an experiment to detect motion through the ether, besides testing the effects of gravity. Yet, in the analysis the time dilation was calculated as referenced on the Earth frame, whilst the resulting equation was used to estimate motion relative to the preferred frame. Could one really credit such an error? When the time dilation formula is referenced on the preferred frame the resulting equation contains no terms which would allow the anisotropy to be tested. The effects cancel out completely, making the test completely inconsequential so far as detecting our motion through space is concerned.

Such is the arena of debate on this question of relativity. The Establishment scientist wants to believe in relativity and no one seems to question results which support relativity. All the venom is directed at those who seek the truth and need convincing.

In conclusion, it is relevant to mention that the so-called time dilation formula has only been tested for atoms and particles moving at very high speeds, speeds far in excess of any expected motion relative to the preferred frame. The privileged role of the relativistic observer has not been tested in this context.

H. Aspden
Department of Electrical Engineering
University of Southampton

*Vessot and Levine, *Gen. Rel. and Grav.*, vol 10 1979 p.181.

Sibilant distortion

Your issue of March has just arrived here. In it John de Rivaz says (Circuit ideas) that sibilants are made unpleasant due to overmodulation . That they are often unpleasant or exaggerated is true, but since Wrotham f.m. opened in 1951, I have been led to believe that this is due to an imbalance in the frequency response of the total overall audio system being used. Judicial use of audio equalizers (and not tone controls) seems to take care of most cases.

Your Dolby-inspired article on digital audio equipment for broadcasting in the same issue, with its variable but closely controlled variable pre-emphasis, ought to provide the tools to check this problem which so worries purists.

By the way, the BBC World Service broadcasts, although a.m. with limited audio top end, seem to have their audio so processed that voices sound natural and without undue emphasis of the sibilants. Maybe a BBC spokesman would care to explain how they do this.

Peter Hirschmann
Haifa
Israel

Unfortunately the BBC's response did not arrive in time for inclusion in this issue.

ILP

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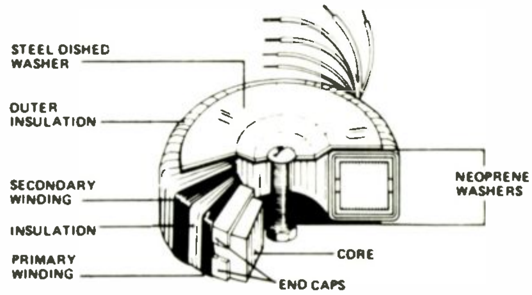

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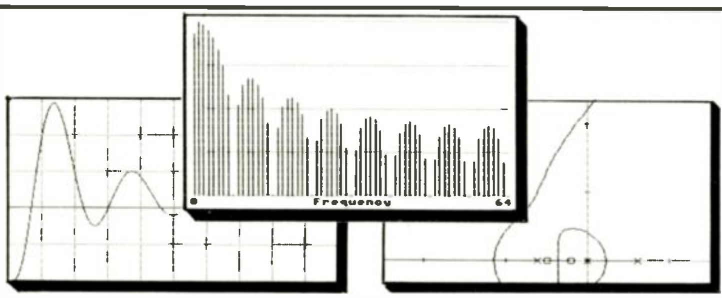

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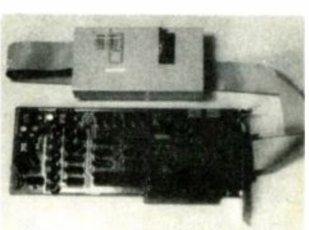

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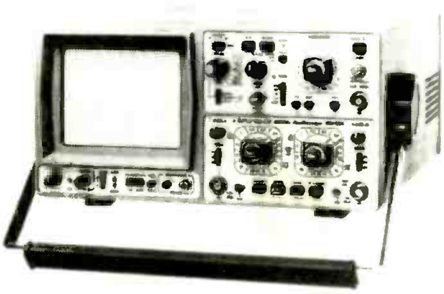

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Europe's capacitor market

For many years the somewhat slow moving and mature capacitor industry has been overlooked by investment interest and PR pizzaz. But there are changes afoot, in both market and industry.

KEITH THOMAS

Whilst the semiconductor industry worries itself about the cost of R&D and strategic mergers to breech the $1bn billings 'critical mass,' the capacitor industry worldwide is facing similar issues of profitability and technological and business change. Over the last two or so years, many household names in capacitors have declared the desire for a merger with a stronger group. Some have openly declared unprofitability followed by rapid posting of 'For Sale' notices. Only in France is there evidence of bullish investment being made to increase manufacturing capacity of technologies that have much less than average growth. Elsewhere, it is exclusively the ceramics houses that have been spending money.

The shake up of the industry has followed a radical shift in the technology used by circuit designers, as shown in Fig.1. From this illustration it is evident that the dielectric flavour of the month is ceramic – and multilayer ceramic at that. The tantalum, aluminium and film industries have lost market share to cera-

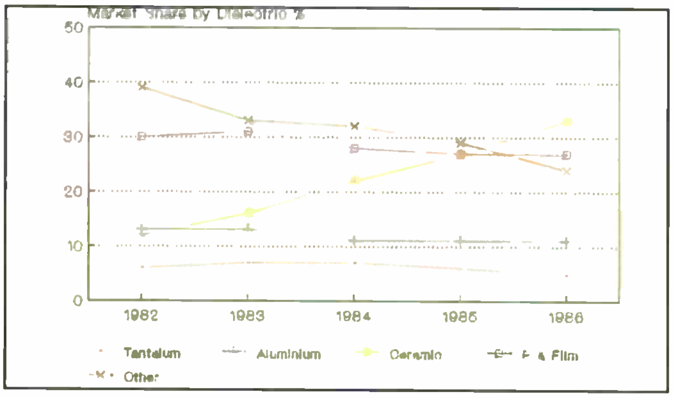


Fig.1. Percentage share of the total capacitor market enjoyed by the major dielectric families from 1982 to 1986.

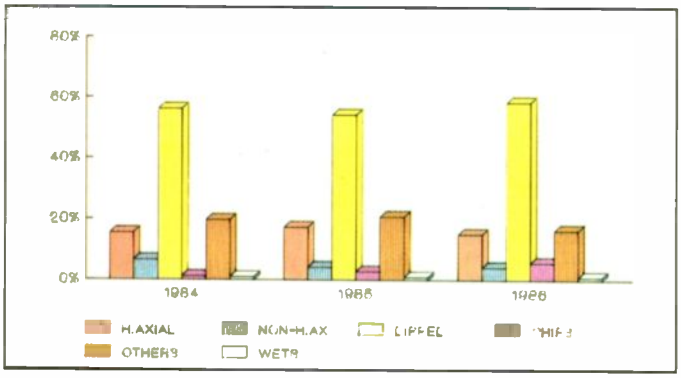


Fig.2. Change in packaging of the tantalum capacitor elements: note the rise in popularity of the chip packaging style.

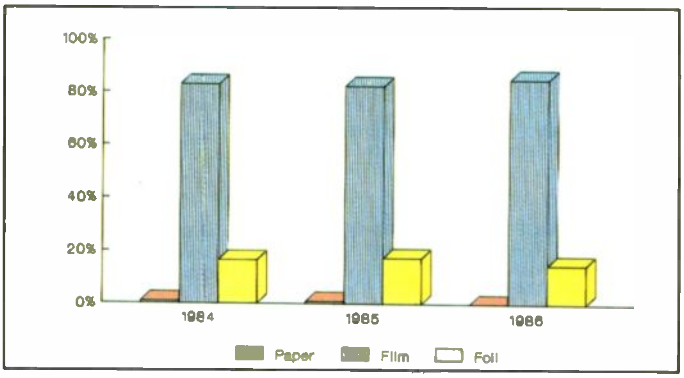


Fig.3. During the last three years consumer preference between paper and film capacitors has been almost static.

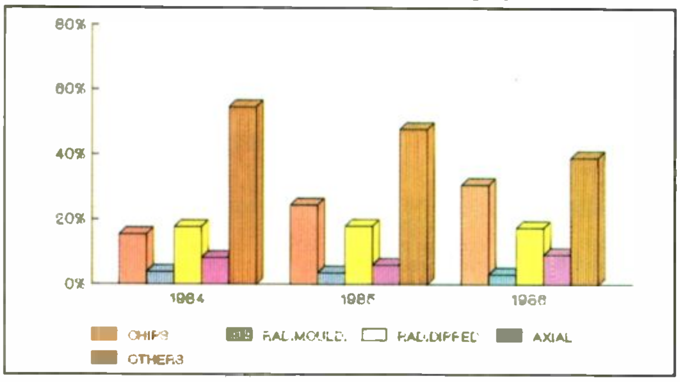


Fig.4. Emerging popularity of the chip packaging style in the ceramic dielectric is largely at the expense of discs.

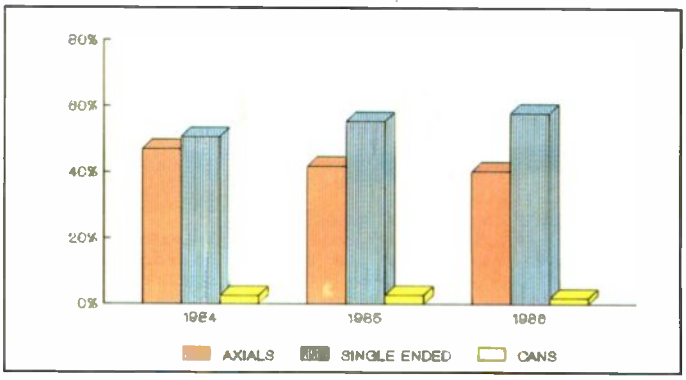
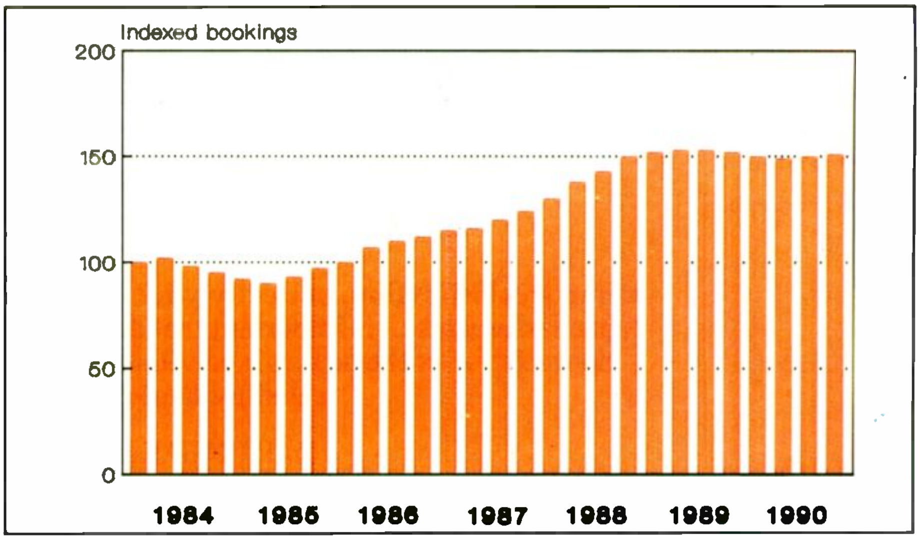


Fig.5. Since 1984 the package styles of aluminium capacitors have moved slightly away from the large cans and axials to small cans.

Fig.6. Smoothed forecast of the likely growth of capacitors in Europe to the end of the decade.



mic, which has trebled its share of the European market since 1982. Comparison with the US market will show an even stronger move towards ceramic, since the US does not have the installed and somewhat protected film dielectric manufacturing base that is characteristic of Europe.

Figures 2 to 5 show the movements within each dielectric of the packaging of the dielectric. It should come as no surprise that the chip package is becoming popular at the expense of the traditional parts. The trend to surface mounting is of course playing havoc with the relative market shares of each dielectric, since the ceramic capacitor is ideally suited to the surface mount assembly process – manufacture of a leaded part starts with a stand-alone chip. The other technologies must add extra manufacturing process steps to their capacitor element to protect it from the harsh soldering environment, shrugged off by the ceramic dielectric, thereby increasing cost. The most at risk from the move to SMT is the small aluminium and film dielectrics that shy from the soldering processes used.

Interestingly, the tantalum capacitor is forecast to fare well in this trend to SMT since no other dielectric can offer the volumetric efficiency at the cost, so the role of 'replenisher' or topper up of on-board capacitors will remain the domain of tantalum, whether leaded or chip. However, the move to SMD in all dielectrics is most pronounced in ceramic, in particular for consumer applications.

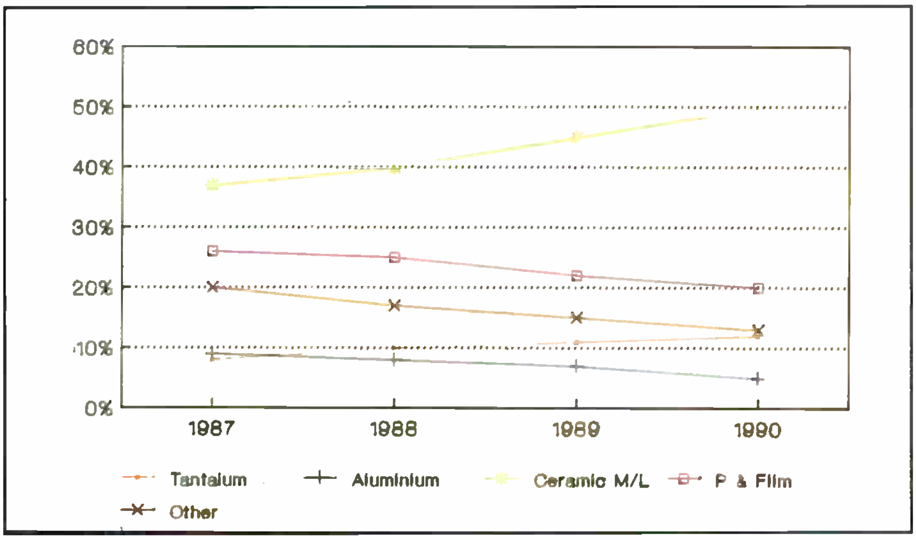


Fig.7. Expected movement of designer preference for each dielectric as the market grows in the coming years. Notice the enormous growth forecast for ceramics.

FOR THE FUTURE

The capacitor market is forecast to keep on growing. The relentless pace of the electronics industry is utilising electronics technology for more applications in all sectors. The computers, consumer, communications, instrumentation and control industries have depended absolutely upon utilisation of electronics, and now newcomers, the car industry, are starting to exhibit strong demand as they embrace electronics technology. The defence industry hit, with cutbacks worldwide, are utilising their somewhat reduced disbursement in a different manner. Gone are the projects for bigger guns – they are replaced with more sophisticated projects that improve control of weapons, and improve communications and intelligence, which all need electronics. So defence budgets are favouring a very strong swing to more electronic equipment. The communications industry too is lifting off with strong demand for mobile communications: cellular radio is the driving force.

The capacitor element of this growth is forecast to grow about 9-10% in 1987 and a little more in 1988 – 12-14%. Beyond that pundits are already speaking of the next slowing down of demand that hits the electronics industry from time to time as supply, stocks and demand move out of line. During that time, SMD is forecast to grow rapidly by as much as 50% a year and it is clear that the winners are going to be ceramic and tantalum dielectrics. The others will find their niche which will keep some of the machines rolling – in many applications the traditional through hole technology remains the optimum choice – but it is clear that there are a galaxy of companies, large and small, that plan to move into surface mount in the coming year.

In terms of numbers of units, the general-use on-board capacitors dominate total demand. They are the most affected by the change in assembly technology and so massively influence the global numbers. For off-board capacitors, the large power correction capacitors, or the large aluminium cans, the growth pattern is individualistic and it is misleading to offer a global growth figure since these capacitors tend to be end-use, application-specific. However, it is clear that in medium power applications, incumbent energy storage capacitors will be eventually replaced with smaller devices working at high frequency. The dielectric chosen for this application is most likely to be ceramic in the medium to long term although aluminium will continue to find favour in the short term. This is because the ESR of ceramic at 1MHz is much lower than aluminium or wet tantalum, and at these frequencies the consequential capacitance required falls dramatically to a few microfarads. Savings can be made not only in terms of microfarads, but also in the size and cost of the magnetics which at 1MHz are a fraction of those at 50Hz or 40kHz.

We may then refer to Fig 6 & 7 to forecast the likely future for capacitor demand by dielectric and numbers of units sold. It looks sound for ceramic and not too bad for tantalum, but we trust the manufacturers of other dielectrics have already selected their niches.

Keith Thomas is vice-president of sales and marketing, Europe, for AVX of New York.

Capacitor technologies compared

Ceramic, plastics film, or electrolytic? With significant overlaps in capacitance value, it is important that design engineers have a good appreciation of the factors involved – especially in todays cost-sensitive markets.

MARTIN BAKER

Every year, as capacitor technologies improve and are stretched to new limits, the complexities and the economics of the enormous variety of styles, materials and performance characteristics become more difficult to understand.

Miniaturization, new materials and new production techniques have resulted in some radical, and many subtle changes in the range of capacitors available today.

The majority of capacitors used in electronic engineering fall within the spectrum of one picofarad (1pF) to 220,000 microfarad (0.22F) and are grouped into a number of main technologies. They include ceramic-based capacitors, film or plastics types and aluminium/solid aluminium/tantalum capacitors.

Each of these technologies cover typical capacitance values as shown in Fig. 1.

Perhaps the most complex area is the overlap of ceramic and film technologies for which the following comparisons and observations can be made.

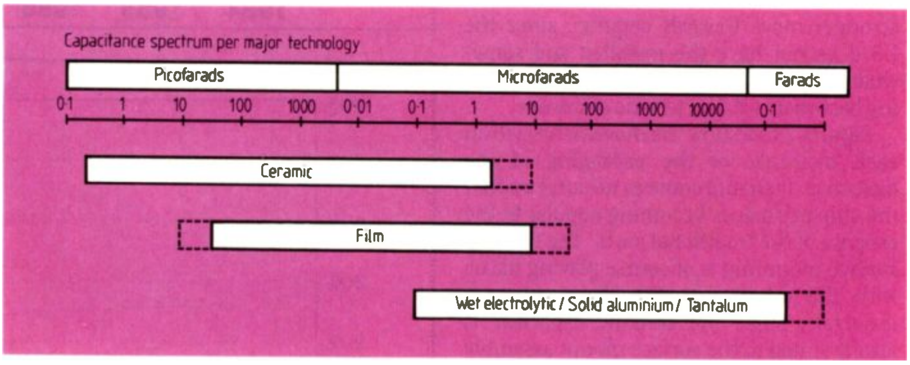


Fig.1. The most cost-effective technology will vary depending on basic capacitance value and on a multitude of other interactive parameters.

FILM CAPACITORS

Plastics-film capacitors utilise one of four main plastics films for their dielectric material; each has advantages and disadvantages on performance, stability, dielectric strength, environmental resistance and cost.

The film dielectric is either stacked, or more commonly wound with electrode layers to form a capacitor cell. The electrode layers may be metal foil or the cell may be an integral winding of metallized film (the electrode layer being vacuum deposited onto the film). This metallized film construction realises a very size and cost efficient capacitor; it does, however, have a limited pulse load capability (see Table 1). A film/foil construction by comparison has significantly better power handling (pulse load) capacity but will be larger and more expensive.

Four main plastics films are used as dielectric material: polyester (PETP) polycarbonate, polystyrene and polypropylene. Each has its own unique features.

Polyester is by far the most commonly used material due to its low cost and reasonable performance characteristics. Moderate voltage ratings, pulse load characteristics, temperature and frequency stability all combine to produce the ideal purpose capacitor. The cell is almost always of metallized film construction and frequently in a 5mm lead pitch module for which capacitance values up to 1μF can be produced reliably and economically.

Polycarbonate is a higher performance alternative to polyester for general purpose applications. Capacitors in this material command a price premium (typically +15 to +30%) and offer improved stability of capacitance (△C) with changes in temperature and frequency. Maximum voltage ratings and pulse load characteristics are also better than those of polyester. The use of polycarbonate capacitors in modern circuitry is declining and hence this dielectric is only offered by a few major manufacturers (eg Philips).

Polystyrene is probably the most commonly used material for precision 1% tolerance capacitors. Usually in a film/foil construction, polystyrene provides optimum stability of capacitance with temperature change. The capacitance/temperature relationship is linear with a –125ppm tempera-

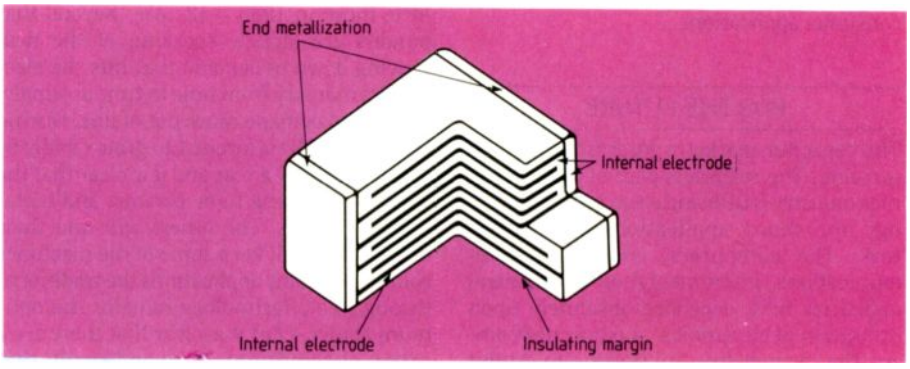


Fig.2. Sintered ceramic electrode multilayer construction creates a size-efficient and reliable capacitor.

Table 1. Typical pulse load limits in V/μs for metallized film capacitors (based on pulse voltages equal to the rated dc voltage)

Rated d.c. voltage	Lead pitch: dielectric:	5mm MkT	7.5mm MkT	10mm MkT	10mm MkC	15mm MkT	15mm MkC	22.5mm MkT	22.5mm MkC	27.5mm MkT	27.5mm MkC
63		55	17	15	–	6	–	3	–	2	–
100		90	30	24	30	10	13	4	6	3.5	4.5
250		–	60	35	45	14	18	6	8	5	7
400		–	95	55	70	22	30	10	13	8	1

MkT: metallized polyester. MkC: metallized polycarbonate.

Table 2. Main plastics film dielectrics – typical parameters.

	Capacitance range (pF,nF,μF)	Tolerance	Max. dc voltage	Temperature characteristic	Pulse load limit* V/μs	Temperature range °C	Relative cost
Polyester (MkT)	1000pF–10μF	± 10% ± 20%	630	Non-linear $\triangle$C – 3% to + 7%	Typically 25 – 50	–55/+100°	Low
Polycarbonate (MkC)	1000pF–10μF	± 5% ± 10%	1000	Non linear $\triangle$C < ±2%	Typically 30–70	–55/+100°	
Polypropylene (precision) KP	47pF–62nF	±1%	1000	–125 to –250ppm	High	–40/+100°	
Polypropylene (power) (Kp/mmkp)	1000pF–1μF	± 5%	>2000	–125 to –250ppm	Very high eg 2000	–55/+85°	
Polystyrene (kS)	10pF–0.22μF	± 1% ±2.5%	630	– 125pm	High	– 40/+85°	High

* Pulse load limits based on 10mm pitch capacitor for MkT/MkC across 100–400V dc rated devices.

ture coefficient (t.c.) ie – 0.0125% reduction in capacitance per degree of temperature increase above 22°C, with capacitance values covering typically 10pF to 100,000 pF at ±1% tolerance and with the stable and linear-t.c. polystyrene capacitors are most frequently used in applications requiring temperature compensation, also tuned circuits and filter networks.

Polystyrene is however relatively expensive and is significantly limited by its maximum operating temperature of around 85°C. As a result polypropylene film/foil is becoming increasingly important for precision film capacitors. While still offering ±1% tolerance on capacitance, a relatively stable t.c. (–125 to –250 ppm), and capacitance values approaching 0.1 μF; polypropylene meets –40/+100°C environmental requirements and is less prone to thermal shock during soldering.

Polypropylene also performs well with high voltage and is consequently used in high pulse/small power capacitors. Metallised or double metallized polypropylene wound with foil can achieve voltage ratings in excess of 2000V dc and is often an ideal choice for a.c. applications. Polypropylene capacitors have traditionally been used in deflection circuitry and as flyback capacitors in tv applications and are now being commonly used in switch-mode power supplies.

Table 2 summarises some of the characteristics of the principle film dielectrics.

CERAMIC CAPACITORS

Two construction methods are used for the manufacture of ceramic capacitors.

Single-layer types consist of a single rectangular or discoidal layer of ceramic material with a silver or (for higher reliability) copper electrode on each side of the ceramic. Leads are soldered to the electrode layers and the capacitor is protected by a moulded body or cost effective lacquered coating.

With multilayer devices very thin (20–25 μm) layers of ceramic interleaved with offset precious metal electrode layers are pressed and then sintered at high temperature to form a very compact and volumetrically efficient monolithic capacitor 'building block'. Leads are soldered to this block or surface-mounted-type terminations are applied (Fig 2).

Ceramic capacitors are spilt into two main

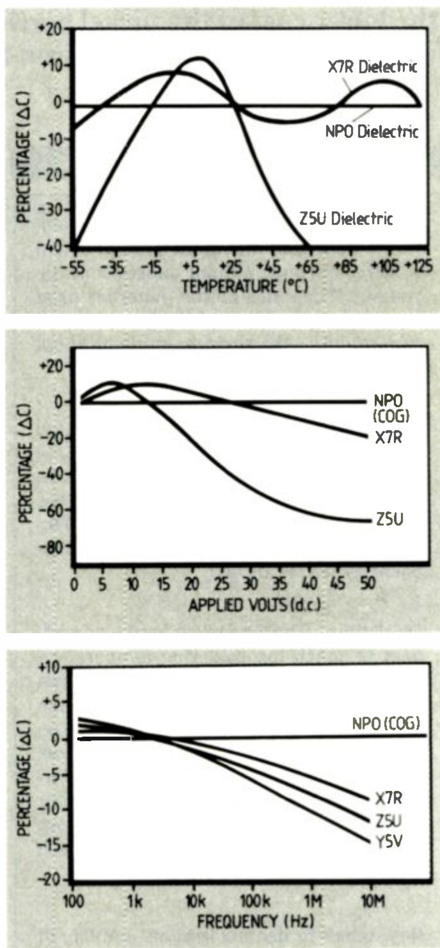


Fig.3. NPO dielectric outperform X7R, Z5U and Y5V but has a limited capacitance range and is expensive when measuring cost per picrofarad.

classes depending on the type of ceramic material used.

Class I types utilise low κ materials which result in low losses and stable linear temperature dependance.

Class II types have higher losses and non-linear temperature characteristics; they are often subdivided into medium κ and high κ materials.

The three most common 'industry classifications' for ceramics are NPO (or COG), X7R and Y5V/Z5U. Cost per microfarad and the performance characteristics of these materials are proportional

Table 3: The relative cost a performance of a film capacitor varies depending on which dielectric material is incorporated.

Type	Cost	Performance (stability of capacitance with changes in temperature, frequency and voltage)
NPO (COG)	Most expensive	Best
X7R	↑	↑
Y5V/Z5U	Least expensive	Worst

NPO devices, and capacitors with a similar t.c. (always linear and usually between zero (NPO) and – 750 ppm (N750)), fall into the class I category. Capacitance values range from 1 pF to around 1,000 pF for single layer devices and up to 10,000 pF for multilayer types, are typically specified with ± 2% or ± 5% tolerance. Class II devices show little or no capacitance change with increases in frequency or voltage and are therefore used in 'precision' applications in tuning and timing circuitry.

Class II devices include X7R (medium κ) and Y5V/Z5U (high κ) types. Both show non-linear relationships between capacitance change with temperature, voltage and frequency increase, see graphs 1-3. They are subsequently used in general purpose applications Y5V/Z5U material is most commonly used for decoupling capacitors while X7R is frequently interchangeable with polyester film.

CAPACITOR ECONOMICS

A simple cost comparison of the many different types of capacitor is impossible. In the precision area, polystyrene, polypropylene and class I ceramic, it is clear that the latter is most cost-effective for low values up to 1000pF. Between 1000pF and 4700pF prices of ceramic and film are similar while for higher capacitance values film capacitors become more cost effective.

In the general purpose area, ceramics again are the most economic choice for lower capacitance values (100pF to 10nF). Between 10nF (0.01μF) and 0.47μF ceramic and film prices are comparable. For higher values metallized polyester then becomes cost effective with metallized polycarbonate providing a higher performance but more expensive alternative.

Terminations for surface-mounted multilayer chip capacitors

The choice for terminations for ceramic chip capacitor is between the lower cost of the nickel barrier and the greater reliability of silver-palladium type

The spread of surface-mount technology beyond the realms of the thick-film hybrid has promoted component manufacturers to re-assess the materials and techniques involved in the design and construction of surface mounted components. Much of this research is being concentrated on the metallized terminations of ceramic multilayer chip capacitors.

Unlike leaded, through-hole components, where the mechanical strength of the soldered joint is reinforced by the component lead, the s.m.d. must rely on the quality of the soldered joint alone for both electrical and mechanical integrity.

The advent of high-speed placement machines and improved mass-soldering methods mean that zero-defect soldering is the ultimate goal of the equipment manufacturer who is to capitalise on the cost-effectiveness of surface-mount technology. It is essential that both the solderability and reliability of the component end-terminations are at the highest possible level prior to assembly.

This article discusses the advantages and disadvantages of the two methods currently used in the manufacture of multilayer ceramic capacitor terminations. Comparisons are made between silver-palladium terminations and those using a nickel barrier between the internal electrode structure and the outer solderable layer of termination. Each type is evaluated for wettability during soldering, ability to withstand the temperatures and dwell-times involved in both wave and reflow soldering, resistance to demetallization at soldering temperatures, ability to maintain a solderable surface during handling and storage under varying conditions, and cost-effectiveness.

Prior to end-metallization, prefabricated ceramic capacitors are cut to length, fired, and subjected to a tumbling process under precisely determined conditions. This tumbling action rounds off the edges and corners of the ceramic to enable a subsequent layer of either silver/palladium alloy or pure silver and nickel to be applied evenly over the surfaces, necessary to help prevent dissollution of the termination by molten solder.

TERMINOLOGY

Wettability – Ability of the metal termination to be wetted with molten solder within a specified time without subsequent de-wetting. It depends on the materials used for the termination and the level of contamination of the surfaces brought about by ageing, storage and handling.

Soldering temperatures – The soldering temperature will depend on the melting point of the solder used in the process, usually between 215 and 235°C for the majority of solders used in the manufacture of electrical circuits, but in some cases as high as 260°C.

Dwell time – The time taken for the component to reach the soldering temperature and for the solder to flow in the joint area depends on the thermal demand of the component, which depends on the size, construction, and the materials used. Dwell time varies according to the soldering method used, typically five seconds for wave soldering, eight seconds for reflow, and up to 30 seconds for vapour-phase reflow.

Resistance to demetallization – Ability of the termination to withstand soldering temperatures without dissolving. Demetallization usually increases with extended dwell times.

Maintenance of solderability – Wettability of the termination surfaces is affected by ageing storage, transit, and handling. Materials used for the terminations and the manufacturing process can also effect ageing, and hence solderability.

SILVER-PALLADIUM TERMINATION

The composition of the silver-palladium alloy is very important and research has shown that the correct percentage of palladium is vital for the control of both demetallization and silver migration. Demetallization can cause a build-up of silver contamination in the solder bath, giving rise to the formation of solder bridges on the finished substrate. This can entail expensive and time consuming re-work. The migration of silver across the surface of the capacitor is an on-going problem during its whole lifetime, and can cause the degredation, breakdown, and ultimate failure of the capacitor in the field. Mullard ceramic chip capacitor terminations contain 35% palladium, more than in any other brand, which experiments have shown to be sufficient to prevent silver migration under all but the most severe conditions (see Table).

Termination content Pd	Ag	Time for first signs of migration (min)	Time to short-circuit (min)
0	1.00	0.5	2.0
0.11	0.89	0.5	4.5
0.22	0.78	2.0	8.0
0.33	0.67	15.0	–
0.35	0.65	–	–

The silver/palladium alloy, in the form of a paste to which powdered glass is added, is manufactured 'in-house' under controlled conditions to ensure optimum composition and rheological properties, and quality control tests are carried out on each batch of paste. The paste is applied to the ends of the capacitor, usually by a controlled dipping method, to provide a uniform layer. This layer is approximately 35 μm thick on the top and bottom faces, and 100 μm on the end face after the capacitor has been fired a second time to form the alloy.

Wettability of silver and silver alloys is high, and well-proven in the electronics industry, and under normal conditions of storage and handling, less prone to oxidation than tin: lead.

Resistance to demetallisation. Glass is included in the alloy to improve adhesion of the metallization to the end faces, and also to reduce the rate of dissolution of the termination by molten solder. Exhaustive tests have shown that Mullard ceramic multilayer chip capacitors with silver-palladium terminations can withstand the temperatures and dwell times encountered during either wave, reflow or vapour phase soldering without any significant demetallization of the terminations. However, a small amount of silver dissolved into the solder joint beneath the component is advantageous when the finished substrate is likely to be subjected to thermal cycling; it renders the joint more compliant and enables it to compensate for thermal mismatch between the component and the substrate.

Maintenance of solderability. Regular quality checks, including accelerated ageing tests to determine the effects of air pollution (HS), oxidation in air, and corrosion on the silver-palladium terminations show that under normal storage conditions a high level of solderability is maintained for up to two years. However, under harsh conditions with a high level of air pollution, storage in a controlled environment is recommended.

NICKEL BARRIER TERMINATIONS

The manufacturing process for the body of a capacitor is the same as that for the silver-palladium type, but after tumbling to round off the corners and edges, the end connections are first formed by applying a controlled amount of pure silver paste. This provides a uniform termination approximately 35 μm thick on the top and bottom faces and 100 μm on the end faces after the second firing.

Because silver dissolves rapidly into molten solder, a 2 to 3 μm layer of nickel is plated onto the silver to prevent dissolution. Unfortunately, nickel is difficult to solder at the comparatively low temperatures and low flux activity necessary in the manufacture of electronic circuits. To overcome this, a further 10 to 12 μm layer of either tin or tin/lead is plated onto the nickel to improve its solderability.

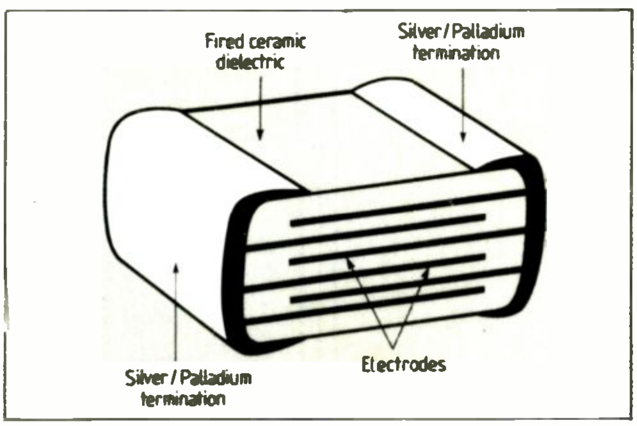
Unlike silver-palladium terminations, where the composition of the termination and that of the capacitor electrodes are similar, the nickel barrier types may be subject to 'material transport' whereby pure silver from the base termination may diffuse into the silver-palladium of the electrodes. However, this can be overcome by careful control of the process parameters during the second firing.

Unless particular care is taken during the plating processes, conditions may arise that could lead to defects during assembly or in the field: If the chips adhere to one another in the plating container, or are not evenly distributed, the plated layer may not be of uniform thickness of may even be missing altogether. If the nickel layer is missing or intermittent, the underlying silver will be dissolved rapidly into the molten solder, so destroying the termination. A missing or intermittant layer of tin-lead, exposing the nickel barrier will adversely affect the solderability of the termination.

In practice, a layer of tin, to which a very small amount of lead may be added to inhibit the growth of tin 'whiskers', is preferred to eutectic tin-lead. This is because particles of the comparatively soft tin-lead may be produced by abrasion during handling, which under humid conditions, can cause tracking between terminations or between conductors on the substrate.

During firing, microcracks may develop in the ceramic body of the capacitor. Ionic contaminants, inherent in the plating process, may become trapped in these microtracks. These contaminants are very difficult to detect and remove, and because they dissociate into free ions which are good conductors in humid conditions, may cause circuit failures in the field. They are also highly reactive with metals and produce corrosive ractions.

Fig.1. The silver/palladium terminations of ceramic multilayer chip capacitors contain 35% palladium and are approximately 35 μm thick on the top and bottom faces, and 100μm on the end faces. The rounded corners help prevent dissolution during soldering.



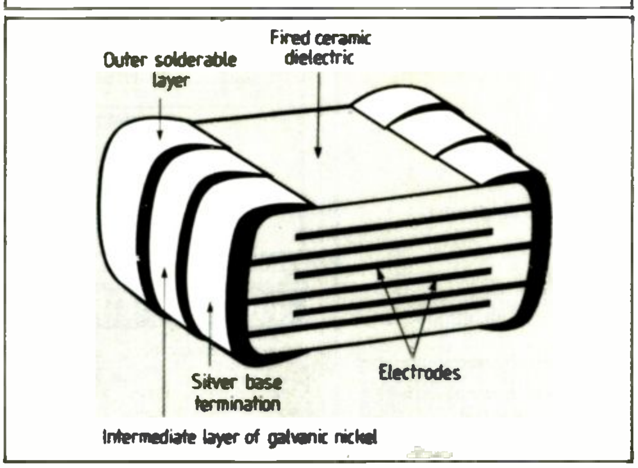


Fig.2. The 2 to 3μm intermediate layer of nickel prevents dissolution of the base termination during soldering.

Wettability. With effective plating, the wettability of the tin or tin-lead surface is good, better perhaps than silver-palladium, but any thin or void areas, exposing the nickel, greatly reduces the wettability.

Resistance to demetallization. The nickel plating is an effective barrier to dissolution and affords total protection against demetallization under even the most aggressive soldering conditions.

Maintenance of solderability. A solder surface of pure tin remains solderable for a considerable time. However, there is a theory that the use of pure tin could give rise to the growth of tin whiskers, causing reliability problems. The addition of a small amount of lead to the tin, however, inhibits their growth. A tin-lead layer has good soldering properties when newly made but is susceptible to oxidation in humid conditions, so protection from the atmosphere is desirable.

OVERVIEW

The important factors to be considered when choosing between nickel barrier or silver/palladium terminations are resistance to demetallization, solderability, the reliability of both the component and the soldered joint, and the cost. With normal soldering temperatures and dwelling times, the resistance to demetallization of silver-palladium is high, and well within acceptable limits, providing the palladium-to-silver ratio is correct (35Pd:65Ag) and the layer is of uniform thickness. This resistance decreases rapidly as soldering temperatures and dwell-times rise above normal levels, especially at the corners where the layer may be thinner.

Nickel barrier terminations on the other hand remain highly resistant even under the most aggressive conditions, providing the manufacturer employs a high level of quality control to ensure that the plating is uniformly deposited.

The solderability of both types remains high under normal storage conditions, whilst in a more aggressive environment the solderability of silver-palladium or pure tin is probably better than that of tin-lead. The extra plating processes required by the nickel barrier terminations, and the possibility of ionic contamination, can cause reliability problems in the finished product. On the other hand, the small amount of silver that dissolves into the joint with silver-palladium tends to strengthen the joint and so improve reliability. The present-day costs of noble metals, especially palladium, makes the silver-palladium types marginally more expensive than the nickel barrier, even though more processing is required for the nickel barrier. With normal manufacturing processes and optmized storage and handling conditions, the deciding criteria may well be the slightly lower cost of the nickel barrier type and the greater reliability of the silver-palladium.

This report is drawn from information submitted by Mullard Ltd.

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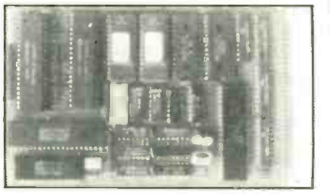

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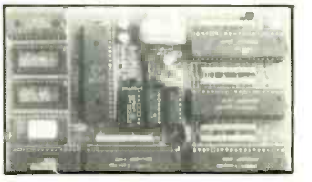

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2	A	4	10.84	2.20
3	M	6	12.54	2.25
4	P	8	17.16	2.58
6	S	12	21.84	2.79
8		16	30.89	3.15
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4	A	8	11.72	2.20
5	M	10	14.49	2.31
6	P	12	16.40	2.55
8	S	16	21.95	2.60
10		20	25.32	2.84
12		24	28.07	2.95
15		20	31.66	3.51
20		40	43.22	5.95

60v		30V	£	P&P
0.5		1	5.69	1.85
1		2	8.67	1.91
2		4	11.15	2.20
3	A	6	16.12	2.34
4	M	8	18.38	2.55
5	P	10	23.23	2.78
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16	S	8	15.73	2.60
20		10	21.17	3.04
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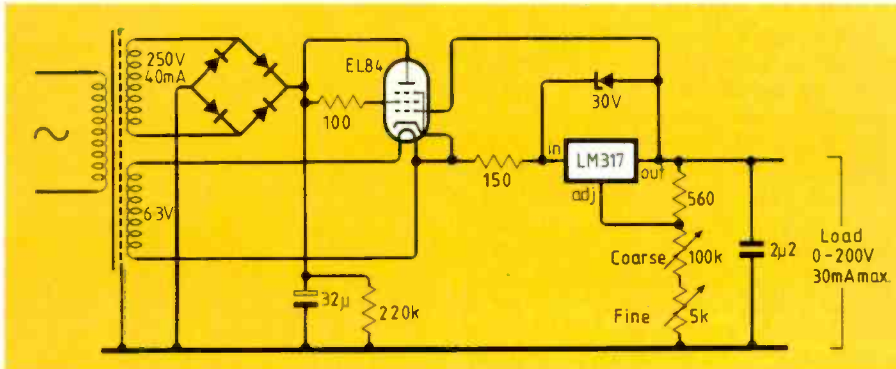
CIRCUIT IDEAS

Current limited 0-200V supply

An outline in the National Semiconductor data book provided the starting point for this 0-200V power supply. Current limiting occurs at 30mA, set by the 150Ω resistor, and load changes up to this point cause output variations of at most 0.2V. Since the valve grid is connected to the output line, load compensation is very fast.

Most of the voltage is dropped by the valve; only about 20V appears across the 317. With my prototype, a short circuit with output set to 200V causes no damage.

M. McDermott
London



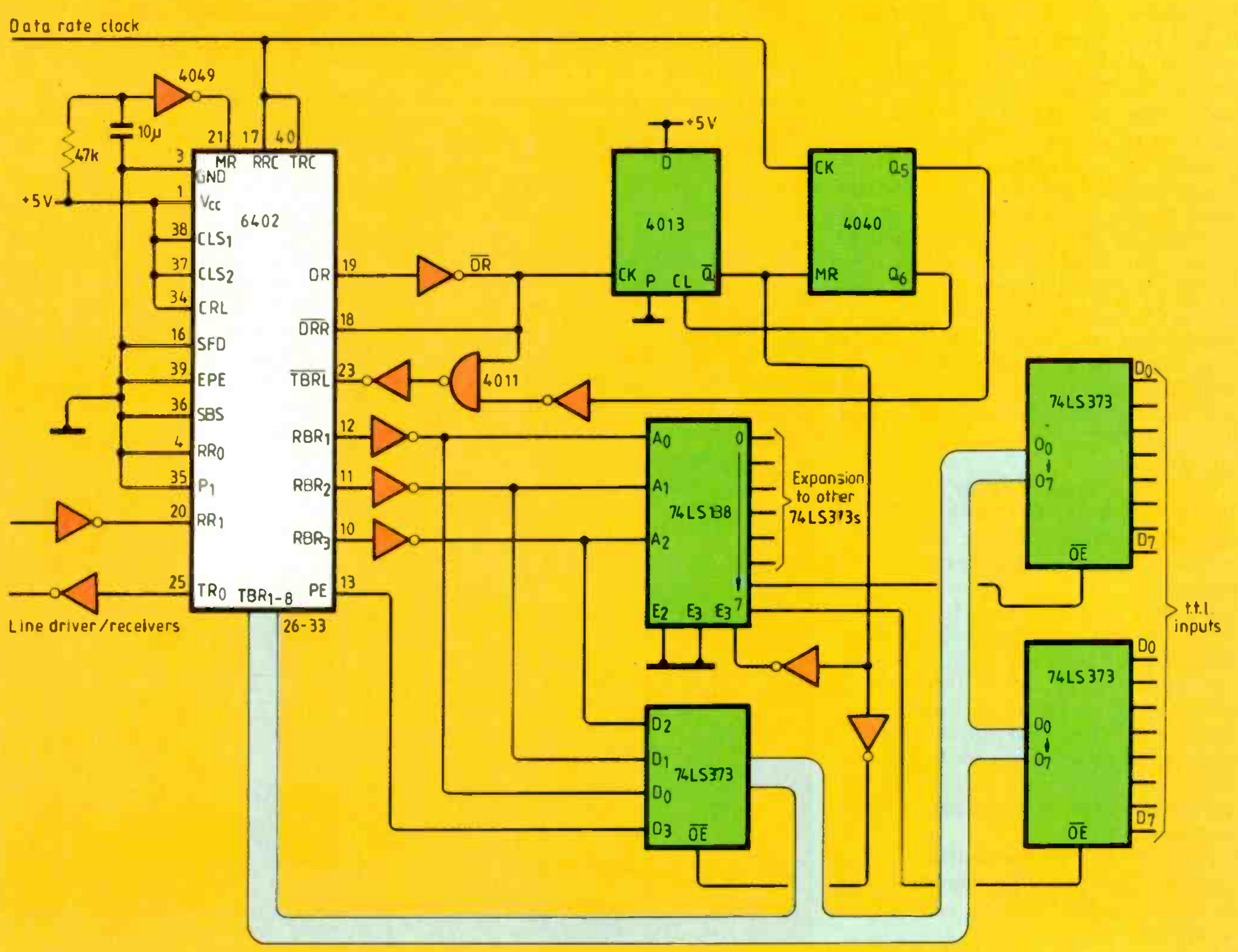
Parallel data multiplexer with RS232 interface

Data on up to 64 digital inputs can be sampled and passed through an RS232 or similar serial port using simple interface hardware. A byte is sent to the uart, the lowest three bits of which (receive-data lines RBR_{1-3}) address one of eight 8-bit ports. One clock cycle later DR goes low, resetting the DR flag and loading the uart for transmission by pulsing TBRL. Eight bits of data from the 74LS373 selected by the decoder are thus transmitted back to the computer.

After 64 clock cycles 4040 output Q_5 goes high which loads a second byte for transmission by the uart. This second byte echoes the original chip address and the parity error flag. Hence each time a byte is sent to the uart, two bytes are returned; one containing the input data and a second for error checking.

Details of serial buffers or bit-rate generators are not given as these will depend on your requirements.

G. Sullivan
Redditch, Worcester



Circuit Ideas

Serial output A-to-D converter

Using a few c-mos i.c.s data from a multiplexed-output analogue-to-digital converter can be turned into an RS232-type serial bit stream. One channel of an analogue multiplexer is used to provide two inputs to the three-digit a-to-d converter. The circuit is suitable for battery operation.

Data is transmitted at 9600 baud, eight bytes every 50ms. One counter/divider scales output of a stable timebase and the other controls three analogue multiplexers. One of these multiplexers selects from eight inputs to encode serialized bytes representing one b.c.d. digit.

1 1 0/1 0/1 2^3 2^2 2^1 2^0

input-multiplexing indicator

switch-state indicator

A second counter/divider controls the serialization and digit-select multiplexers to produce a pattern of eight serial words.

$\underbrace{100\ \ 1\ \ 10\ \ 1}_{\text{input 0}}\qquad \underbrace{100\ \ 1\ \ 10\ \ 1}_{\text{input 1}}$

Serialization and digit-select multiplexers include pull-up resistors at their outputs which function as pull-up resistors for the 3162 outputs. This feature, made possible by the analogue nature of the 4051 multiplexers, eliminates the need for individual multiplexers at each 3162 output.

Output from the digit-select multiplexer drives the timebase prescaler CLEAR input so that the counter pauses until the desired digit appears at the 3162 b.c.d. outputs.

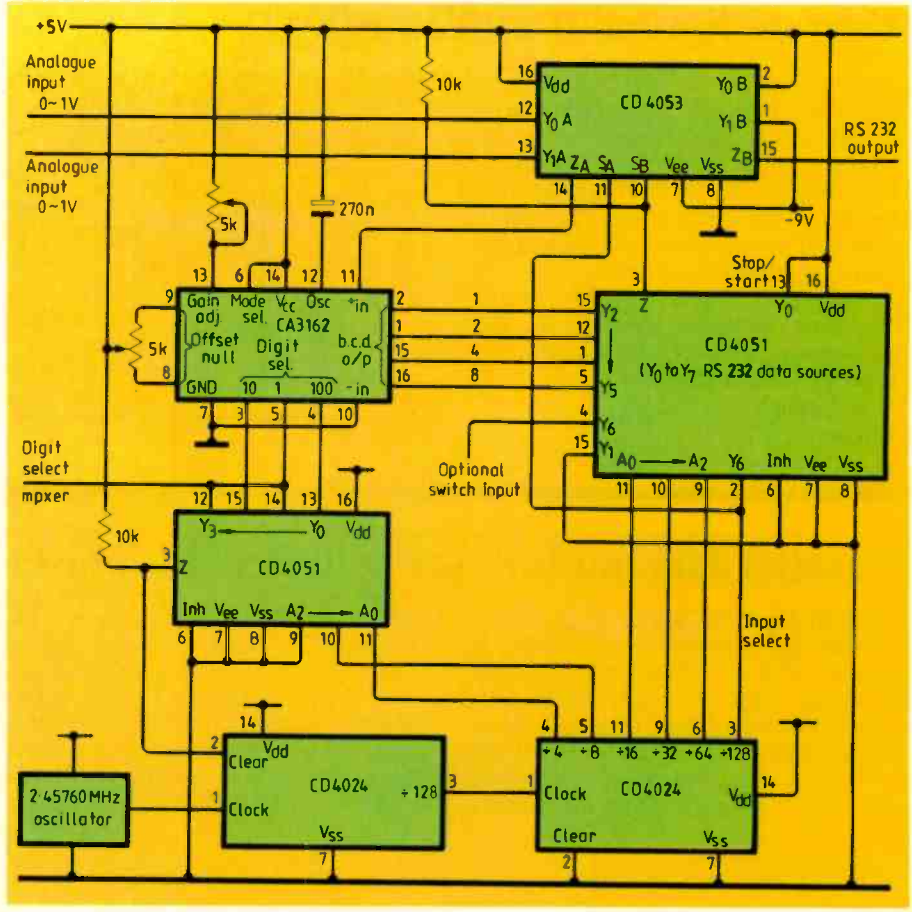
The converter performs a dual-slope analogue-to-digital conversion in approximately 5ms and then outputs the hundreds, ones and tens digits consecutively. Each digit-select line is strobed for about 5ms. Each digit is available for much longer than one byte time so the interval is filled with stop bits.

Only three digits need to be sent to digitize each input but the binary counter digit-select output has four states. The fourth digit-select multiplexer input selects the ones digit which is transmitted after the tens digit to fill this extra byte time.

Alternatively an And gate feeding $A_{0,1}$ digit-multiplex inputs could drive the serialization multiplexer inhibit input to prevent transmission of the extra serial character. Input Y_3 to the digit-select multiplexer could then be grounded instead of being connected to pin 3 of the 3162. The spare section of the 4053 multiplexer could form this And gate.

The sixth bit of the transmitted word can be used to represent the position of a switch.

Samuel Eisenpress
Santa Cruz
California



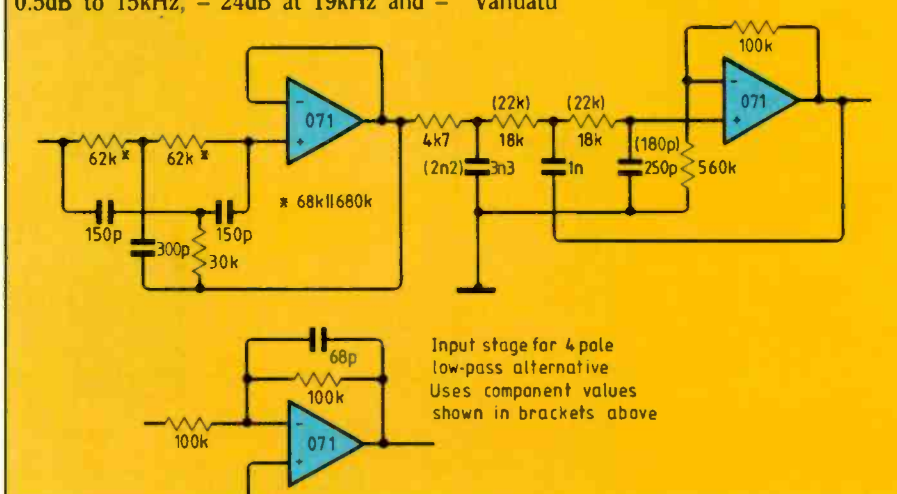
Complex filter using two i.cs

When feeding audio output directly into a low-power f.m. transmitter, severe intermodulation occurred due to h.f. out-of-band products. This was particularly noticeable during tape playback since residual bias noise caused audible beat notes.

My requirement was for steep roll-off filtering above 15kHz with a deep notch at 19kHz to eliminate stereo-tuner multiplex tone. This multiplex-tone and 3-pole low-pass filter uses only two i.cs and mainly preferred values. Its response is flat within 0.5dB to 15kHz, – 24dB at 19kHz and – 20dB at 30kHz falling at 18dB/octave.

A variation elminates the multiplex filter and gives a four-pole low-pass response but attempts to combine four-pole response with 19kHz notch filtering foundered due to component interaction. No doubt computer modelling could overcome this but out here in the middle of the Pacific Ocean we have to rely on empirical solutions.

Tim Mason
Radio Vanuatu
Port Villa
Vanuatu



Maxwell's e.m. theory revisited

If Maxwell's theory is about to be displaced according to the many words in this journal recently, we might take a nostalgic look at it once again.

'JOULES WATT'

"Back to basics," we said, "before expecting a profound paradigm shift. You ought to know a little about the accepted norm." If Maxwell's theory is about to be displaced (no pun!) according to the many words in this journal recently, we might take a nostalgic look at it once again.

"You don't mean, er, those – *curls* and things...?" Not directly, but the curls – and the grads, divs, dels – do seem to remain unpopular with students, probably the reason is bad teaching again...

Yet the developed theory of electromagnetism still holds sway. If there are some phenomena such a theory does not explain, then any new model must explain all that has gone before – plus the new aspects. At least that is the way Thomas Kuhn[1] outlined the situation..

But Maxwell remains a good model, displacement current and all. In saying this, I have mentioned a vital point. It *is* only a model, a kind of template held up against nature, as it were. If the picture fits, so well and good, we can predict some occurances and design a few things and earn some money.

Is it *true*? That is not a relevant question. We don't really care if it is absolutely true, we can never know that anyway. The point is, does it work? If yes, we go ahead and make our name, or even earn the money... Science and technology is pragmatic, whether pragmatism (in William James's sense[2]) is out of fashion or not.

For example, electrons – are they *really* there? Is displacement current real? A number of people have become hot under the collar recently (and not so recently), about the 'truth' of these ideas. But they have missed the point. Nothing is ever with certainty *proved* in science and therefore neither is the engineering based on it. It can only be refuted, when it fails to produce the goods. This time, Karl Popper[3] had a few words to say on the subject, albeit my limited comments are a only a brief scratch on the surface.

WHAT DID MAXWELL SAY AND WHY?

When James Clerk Maxwell was at Edinburgh University, he came into contact with the philosopher William Hamilton. In the cut and thrust of ideas, the relativity of human knowledge held sway, because Hamilton taught that we only know relations between things – not much about things in themselves. This links back to a Kantian view. All this affected the young Maxwell deeply.

At the same time, Maxwell came up against the strict teaching and acute experimental methods of the physicist James Forbes, which also impressed him. It left Maxwell always aware that his theoretical constructs must be refinable in the fires of experimental verification – a view rare in theoretical physicists.

LINES OF FORCE

A little later, Maxwell deeply appreciated the work of Michael Faraday and one of his first important papers[4] on Electromagnetism was his "On Faraday's Lines of Force" (1856). The 'mechanical' properties of the imaginary lines included the tension in length (which explained attraction) and their repulsion sideways (explaining repulsion itself). Maxwell modelled these properties mathematically.

This first paper was followed in 1861 by the paper "On Physical Lines of Force"[5], because in the meantime William Thomson, later Lord Kelvin, had been in lively correspondence with Maxwell, and between the pair of them they had noticed all the analogies between: stream lines in fluid flow, lines of heat flow, electric current flow lines, lines of force in electric fields and lines of force in magnetic fields.

These analogy relationships give partial explanations. They are models, but cross fertilise thinking about different branches of physical science. Yet they warn us not to think electricity is really a fluid water, or really like a state of heat flow agitation...

Further discussion, this time with Stokes, had Maxwell contemplating Stokes' work showing that heat flow in a non-uniform crystal had a direction **A** not always parallel to the direction of maximum temperature gradients θ.

$$\mathbf{A} = \mathbf{T}\theta$$

where **T** is a tensor, describing the anisotropic crystal. Maxwell immediately applied the analogy to magnetism and distinguished the two vectors which he called the "flow" **B** and the "force" **H** and realised that in an anisotropic magnetic medium (like some of our modern ferrites), the lines of force would not always be parallel to the lines of flux. The direct analogy in the electric case was flow lines of current density **J**, with the force **E** setting them up.

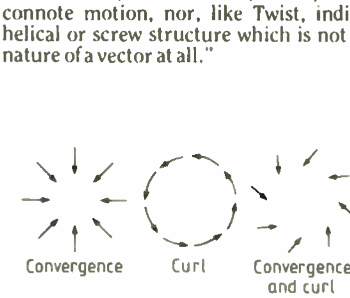
The trouble is that generations of students have been perplexed by these two 'different' vectors **B** and **H** describing the same thing – magnetic field. You might have found this because of bad teaching again and a glance at these original papers often helps.

VECTORS

The analogies led Maxwell to discourse on two classes of vector functions existing in general, *fluxes* and *forces*. A flux **B** is subject to a continuity equation and is integrated over a surface. The picture is 'streaming across'. A force **P** is a vector which is usually derived – but not always – from a single valued scalar function, the *potential* and is integrated along a line. It gives the concept 'force along'. The vectors **B** and **J** are fluxes, **H** and **E** are forces.

In Maxwell's earlier discussions and growing mental pictures, he stuck to three-dimensional Cartesians (the x,y, z axes). But by 1870 after much correspondence with Peter Guthrie Tait and William Thomson, Maxwell[6] himself advanced the ideas of *convergence* (negative divergence), the *curl* and *slope* (later called the gradient). The extract from his paper is interesting:

> ". . . $\nabla\sigma$ has, in general, also a vector portion, and I propose, but with great diffidence, to call this vector the *Curl* or *Version* of the original vector function.
>
> It represents the direction and magnitude of the rotation of the subject matter carried by the vector σ. I have sought for a word which shall neither, like Rotation, Whirl, or Twirl, connote motion, nor, like Twist, indicate a helical or screw structure which is not of the nature of a vector at all."



Maxwell found Tait's enthusiasm for 'quaternions' invented by William Hamilton (not the philosopher, but another Hamilton, the mathematician), had given him the germ of vector analysis – especially via the use of Hamilton's operator ∇. There was much humour in Maxwell's correspondence about ∇ and his play on words regarding the possible names for it: Nabla, or even Atled had been suggested[7].

Maxwell did not fully adopt the complicated quarternion ideas, but used the form,

$$\nabla = \mathbf{i}\frac{d}{dx} + \mathbf{j}\frac{d}{dx} + \mathbf{k}\frac{d}{dx}$$

and realised the vector properties of it in connection with the 'div' and 'curl' operations. It remained to Willard Gibbs in a pamphlet and Oliver Heaviside[8] to oust 'quaternions' but to bring in the full modern vector analysis notation. You will still find it most entertaining to read Heaviside's pithy comments about Clarendon type faces and other notations. Maxwell and certainly Heaviside would immediately recognise our modern presentation of the equations.

Advancing an argument started by Thomson, Maxwell showed that any flux vector had two parts. It had a component from the curl of a force vector plus another part which was the gradient of a scalar function. For magnetism he wrote,

$$\mathbf{B} = \text{curl}\mathbf{A} + \text{grad}\Psi$$

and went on to say that in the absence of magnetic poles (or isolated magnetic charge) there are no sources and therefore $\text{grad}\Psi = 0$.

Therefore he had obtained a complete set of equations between **B**, **H**, **J** and **E**. At this stage, still using Cartesian mathematical arguments, Maxwell showed Faraday's electromagnetic induction is described in our modern notation by,

$$\text{curl}\,\mathbf{E} = -\frac{\partial \mathbf{B}}{\partial t}$$

and from this, by using $\mathbf{B} = \text{curl}\,\mathbf{A}$ showed

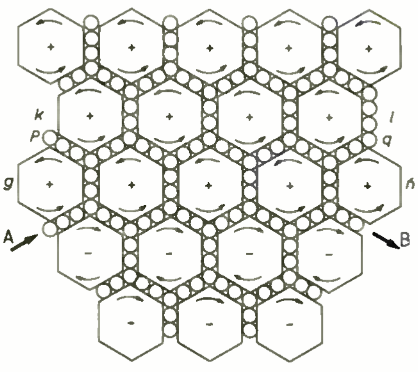
$$\text{curl}\mathbf{E} = \text{curl}\left(\frac{\partial \mathbf{A}}{\partial t}\right) \text{ or } \mathbf{E} = -\frac{\partial \mathbf{A}}{\partial t}.$$

Maxwell called this new function **A** the "electrotonic state" in recognition of Faraday's speculations about a hypothetical state of stress that must surround electrically or magnetically 'charged' bodies.

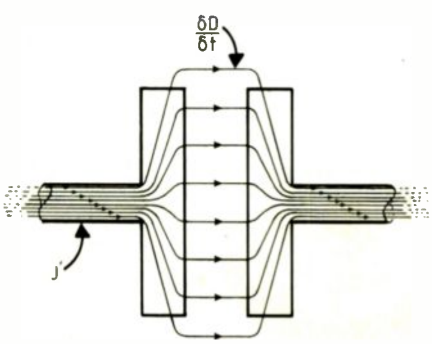
STRUGGLES WITH MECHANICAL ANALOGIES

You will find Maxwell's struggles with how the fields extend around the sources contained in the second "lines of force" paper[5]. He tries analogy again with a kind of mechanical vortex model, see Fig.1. He extended the model from matter to space, postulating an *ether* to contain the vortices. Consider the array of vortices embedded in an incompressible fluid. When they rotate, centrifugal forces cause them to contract longitudinally and they exert radial pressure. This is exactly Faraday's proposal about the properties of lines of force.

But the concept drove Maxwell to see that electricity was not confined to a fluid in the



Maxwell's Figure 2 in his paper, "On Physical Lines of Force". The electric current was represented by the 'ball bearings' running from A to B and the resulting vortex motion was given to the imaginary 'cells' in the surrounding space as shown. The line p to q shows what would happen if another conductor was placed along there, thus explaining induction. One or two of the rotation direction arrows are incorrect.



The flow lines of a current form closed paths according to Maxwell. This means they must pass through the dielectric of a capacitor, including a vacuum. All the current there must be in the form of Displacement or Electric Flux variations as no actual electrons are emitted through the region.

conductor on this view of things, but was disseminated in space – and the energy was 'stored' in the space containing the fields... The function **A**, which we now call the vector potential, acted as a kind of momentum term in the field. The equation $\mathbf{E} = \partial\mathbf{A}/\partial t$ was equivalent to Newton's equation between force and rate of change of momentum.

Now Maxwell hit upon the idea that the medium containing the vortices was elastic – hence the energy storage in the medium was by an elastic distortion. Two remarkable consequences quickly follow. Since the space surrounding a conductor is capable of an elastic displacement – a varying field displaces an equivalent current. This is the first glimmering of the "displacement current" postulate. Secondly, any elastic medium with density ρ and a shear modulus m can transmit transverse waves with a velocity,

$$v = \sqrt{\frac{m}{\rho}}.$$

Maxwell inserted magnetic and electric quantities (based as we now say on permittivity and permeability) and found the wave velocity would almost equal the then accepted value of the velocity of light. With some excitement he wrote in the "Lines of Force..." paper

> "The velocity of light in air, as determined by M. Fizeau*, is 70,843 leagues per second (25 leagues to a degree) which gives
>
> V=314,858,000,000 millimetres
> = 195,647 miles per second ....(137)
>
> The velocity of transverse undulations in our hypothetical medium, calculated from the electro-magnetic experiments of MM. Kohlrausch and Weber, agrees so exactly with the velocity of light calculated from the optical experiments of M. Fizeau, that we can scarcely avoid the inference that *light consists in the transverse undulations of the same medium which is the cause of electric and magnetic phenomena*".

By 1865 Maxwell had written his paper "A Dynamic Theory Of The Electromagnetic Field"[9]. In it, he spelt out the full development of how the electromagnetic waves would propagate. Note the word "field" appears for the first time in the title. He had dropped the "vortices" intermediate analogy stage and relied on a few facts including the really original concept of the 'displacement current'. He effectively noted that the magnetic current is always a 'displacement current' $\partial\mathbf{B}/\partial t$ as there is nomagnetic charge in the Universe. Therefore why not *some* of the electric current at least in the form $\partial\mathbf{D}/\partial t$? The total current then, is always closed and is a set of flow lines

$$\mathbf{J}' = \mathbf{J} + \frac{\partial \mathbf{D}}{\partial t}$$

where **J**' is the total current, **J** the conduction current and $\partial\mathbf{D}/\partial t$ is the displacement current, **D** now being the *electric flux* or *displacement* vector. A changing current might set up a flow pattern in a capacitor like that in Fig.2.

ELECTRICITY, MAGNETISM AND LIGHT

Maxwell saw the significance of his construct. He wrote to his cousin, Charles Cay, "I have also a paper afloat, containing an electromagnetic theory of light, which till I am convinced to the contrary, I hold to be great guns."

Again, the philosopher Hamilton's influence on Maxwell in his youth can be seen. The build up via analogies, his development of the mechanical model – and then dropping it, and finally the analysis of the direct relations between the two classes of phenomena (magnetism and electricity) as a unifying structure – are all based on Hamilton's doctrine of the relativity of knowledge. Einstein said of Maxwell that he saw the future role of field theory in physics, complete with its describing differential equations and seeing that was his stroke of genius.

The revolutionary idea is not really the displacement current proper, (in spite of the heat under many collars!), but the whole 'dissemination' idea into the medium. Maxwell's formal energy densities in the medium which also link with some of Thomson's work, encapsulate this view:

$$\left.\begin{array}{l}\text{magnetic energy density} = \mathbf{B.H} \\ \text{and electric energy density} = \mathbf{D.E}\end{array}\right\}\text{joule m}^{-3}$$

Maxwell writing at the end of his "Dynamics..." paper, even calculated the peak value of the electric field in sunlight, both in the solar constant at the Earth's surface and at the sun.

"The energy passing through a unit of area is

$$W = \frac{P^2}{8\pi\mu V};$$

so that $P = \sqrt{8\pi\mu VW}$,

where V is the velocity of light, and W is the energy communicated to unit of area by the light in a second.

According to Pouillet's data, as calculated by Professor W. Thomson, the mechanical value of direct sunlight at the Earth is 83.4 foot-pounds per second per square foot. This gives the maximum value of P in direct sunlight at the Earth's distance from the Sun, P=60,000,000, or about 600 Daniell's cells per metre. At the Sun's surface the value of P would be about 13,000 Daniell's cells per metre."

The model Maxwell gave explained and predicted optical and electrical phenomena with great vigour and precision. Whichever vectors you take, strictly transverse waves in space appear because of the vector product nature of curl. The equations are the 'telegraphers equations' of space, and look like the transmission line equations Heaviside derived for waves on wires later:

$$\mathrm{curl}\,\mathbf{H} = \mathrm{J} + \frac{\partial \mathrm{D}}{\partial t} \qquad \text{with} \qquad \mathrm{D} = \epsilon \mathrm{E}$$

$$\mathrm{curl}\,\mathbf{E} = -\frac{\partial \mathrm{B}}{\partial t} \qquad\qquad \mathrm{B} = \mu \mathrm{H}$$

$$\mathrm{J} = \sigma \mathrm{E}$$

$$\mathrm{div}\,\mathbf{B} = 0$$

$$\mathrm{div}\,\mathbf{D} = \rho.$$

The wholly transverse solutions eliminated the longitudinal wave requirements that had embarrassed earlier theories of light.

Heinrich Hertz's electrical generation and detection of long maxwellian waves, with all the predicted properties was a supreme vindication. The vast proliferation of engineering uses of these waves up to the present time is a further supreme example.

PREDICTING POWER AND USEFULNESS BUILD UP

But just as important, Maxwell predicted that the waves would exert a *radiation pressure* – thus disposing of the idea that any luminiferous pressure would be a crucial argument for a corpuscular theory of light. Lebedev proved the radiation pressure postulate experimentally in 1900. It explains the repulsion of parts of the tails of comets. Such radiation pressure is vital for Black Body radiation theory. It may be used to derive classically the time dilation formula of special relativity and explains how stars hold up internally, together with their allowed mass range...

Maxwell's famous Treatise[10] sets out the on-going work in book form, but adds little more to his papers and memoirs. In the late 1870s he was about to write a deeper investigation into all these researches, but stomach cancer heralded his early death aged 48 in November 1879 – at the prime of his powers. As usual, we always speculate on what he might have achieved had he lived.

References

1. T.S.Kuhn, The Structure of Scientific Revolutions Univ. Chicago Press, 1970.
2. W.James, Pragmatism and Four Essays from the Meaning of Truth, Meridian Books, 1963.
3. K.R. Popper, Conjectures and Refutations R.K.P. 1972.
4. J. Clerk Maxwell, On Faraday's Lines of Force, Scientific Papers, 1855, 1856, reprinted by Dover, New York, 1952.
5. J.Clerk Maxwell, On Physical Lines of Force Scientific Papers, 1861, 1862.
6. J.Clerk Maxwell, On the Mathematical Classification of Physical Quantities, Scientific Papers.
7. Maxwell had much to say with Tait, Thomson, and many others via the 'halfpenny post' after the Post Office introduced it in 1869. Tait was known as T' and Thomson as T'. These two authors wrote a "Treatise on Natural Philosophy" which was reviewed by Maxwell – who henceforth referred to it as "T and T'". Tait couldn't stand Tyndall, another scientist in the milieu, and referred to him as T" ('where T" is a quantity of the second order...'). Tait had written a book on Thermodynamics in which he had given an equation dp/dt=JCM. Maxwell then signed his cards:"...yours sincerely, dp/dt."
8. O. Heaviside, Electromagnetic Theory vol.1. chap.3, The Elements of Vectorial Analysis and Algebra, The Electrician 1893, Dover reprint.
9. J.Clerk Maxwell, A Dynamical Theory of the Electromagnetic Field, Scientific papers.
10. J.Clerk Maxwell, Treatise on Electricity and Magnetism, Oxford, 1873, 2nd. ed. 1881, 3rd. ed. 1891.

Dividers faster than 3GHz

Bipolar devices offer better phase noise and speed power performance than gallium arsenide equivalents

Advances in semiconductor processing and photolithography at Plessey have produced the first prescaler i.cs for frequencies above 3GHz. They incorporate silicon biploar transistors with 1.5μm emitters and 7GHz f_t at 0.5mW dissipation. Coupling these transistors with 5μm-pitch metal combines the high speed with high packing density.

Work is currently being done to increase speed of the new dividers to 6GHz, which will make them useful for applications like directly synthesizing local oscillators in C-band satellite receiver front ends.

Initially, the SP8800 prescaler series consists of divide-by-two, four, eight and ten i.cs in surface-mount and dil packages. Sensitivity and overload performances are good, as Fig. 1 shows, and power dissipation/radiation are low. Being bipolar, the devices inherently offer better phase-noise and speed/power performance than GaAs equivalents.

Applications include counter prescaling and frequency synthesis. Figure 2 represents a 3.5GHz frequency synthesis loop with one of the new prescalers dividing by four and an SP8704 dividing by 128 or 129. With the world's first military-specification 20mA 1.5GHz synthesizer, Fig. 3, it will be possible to produce a two-chip military-grade frequency synthesis loop.

The SP8850 is currently under development; samples should be available in October.

Nick Cowley

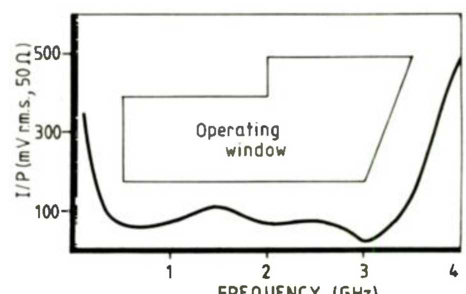


Fig.1

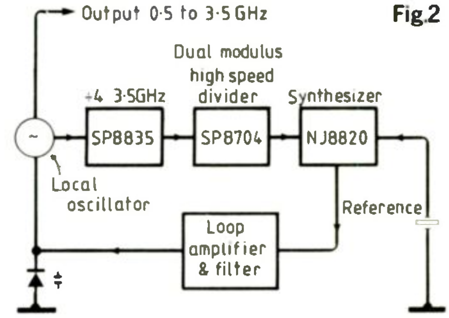
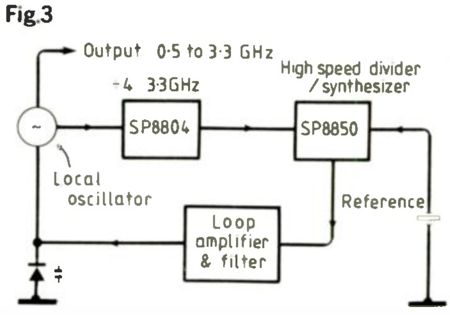


Fig.2

Fig.3



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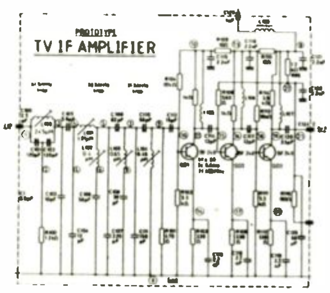

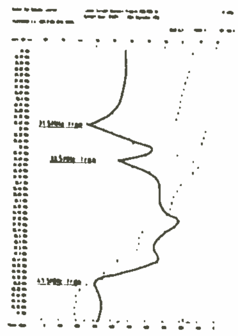

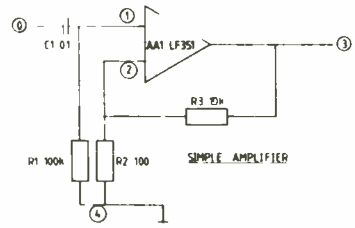

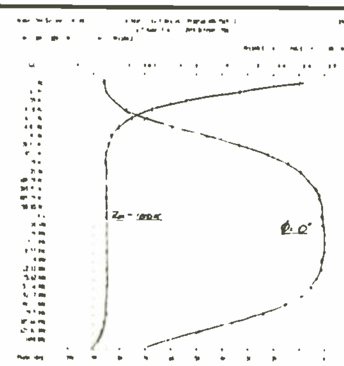

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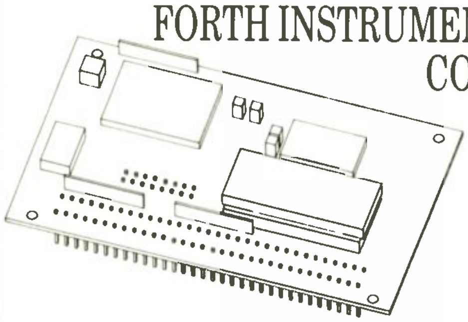

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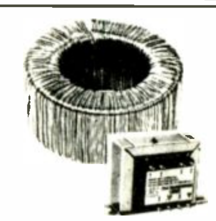

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APPLICATIONS SUMMARY

DIGITAL SIGNAL PROCESSING

Signal processing using analogue methods, where time and/or amplitude are continuous quantities, has several disadvantages compared to digital methods where time and amplitude are discrete quantities. State-of-the-art analogue-processors are approaching the limits of integration for silicon and their parameters are difficult to repeat reliably in mass production; time and temperature instabilities are also a problem.

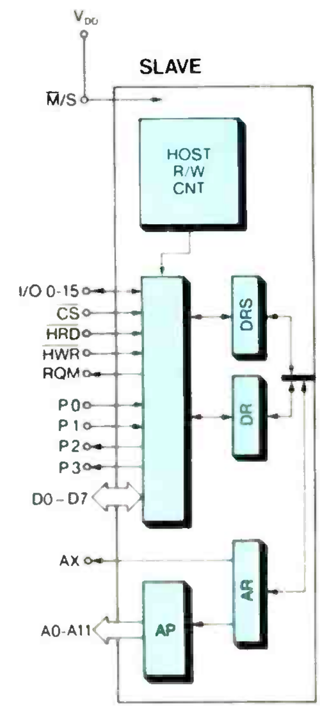
New digital-signal processor architectures increase processing speed. Sequential processing (von Neumann) using a single bus architecture, where instruction and data signals share a common path, has been replaced by parallel processing (Harvard). In Harvard architecture, instruction and data paths are separated. This enables speeds to be increased by pipeline processing in which several tasks can be accomplished in a single instruction cycle.

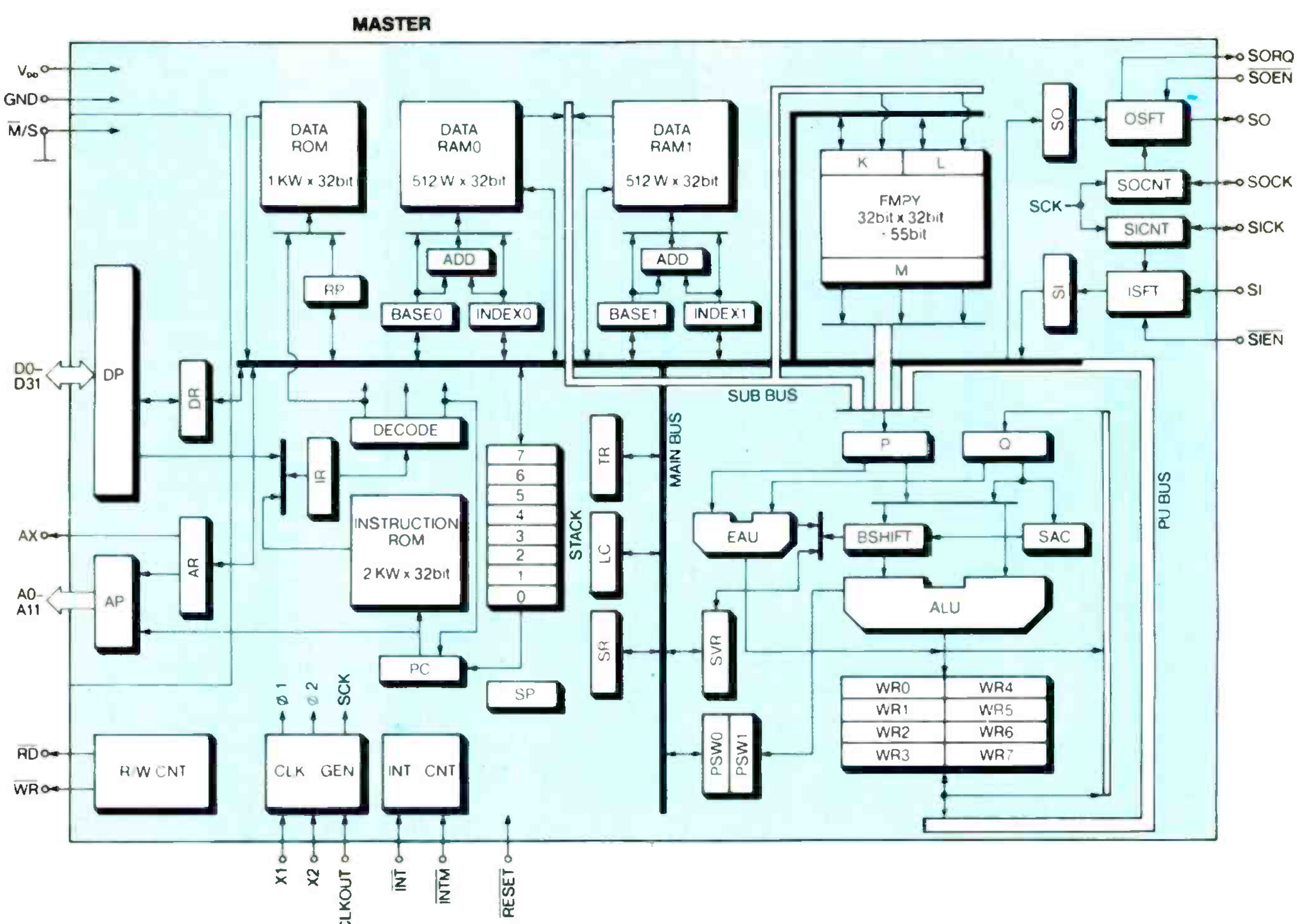
Three stage pipelining (top diagram) is used with NEC's HPD77230 to fetch an instruction, execute an instruction and store results in parallel during a single 150ns cycle. The 77230 advanced signal processor can be operated in either master or slave mode (bottom).

NEC applications handbook 'Increase number crunching capabilities: digital signal processors' discusses the use of d.s. processors and applications including numerical control, speech processing, instrumentation and telecommunications.

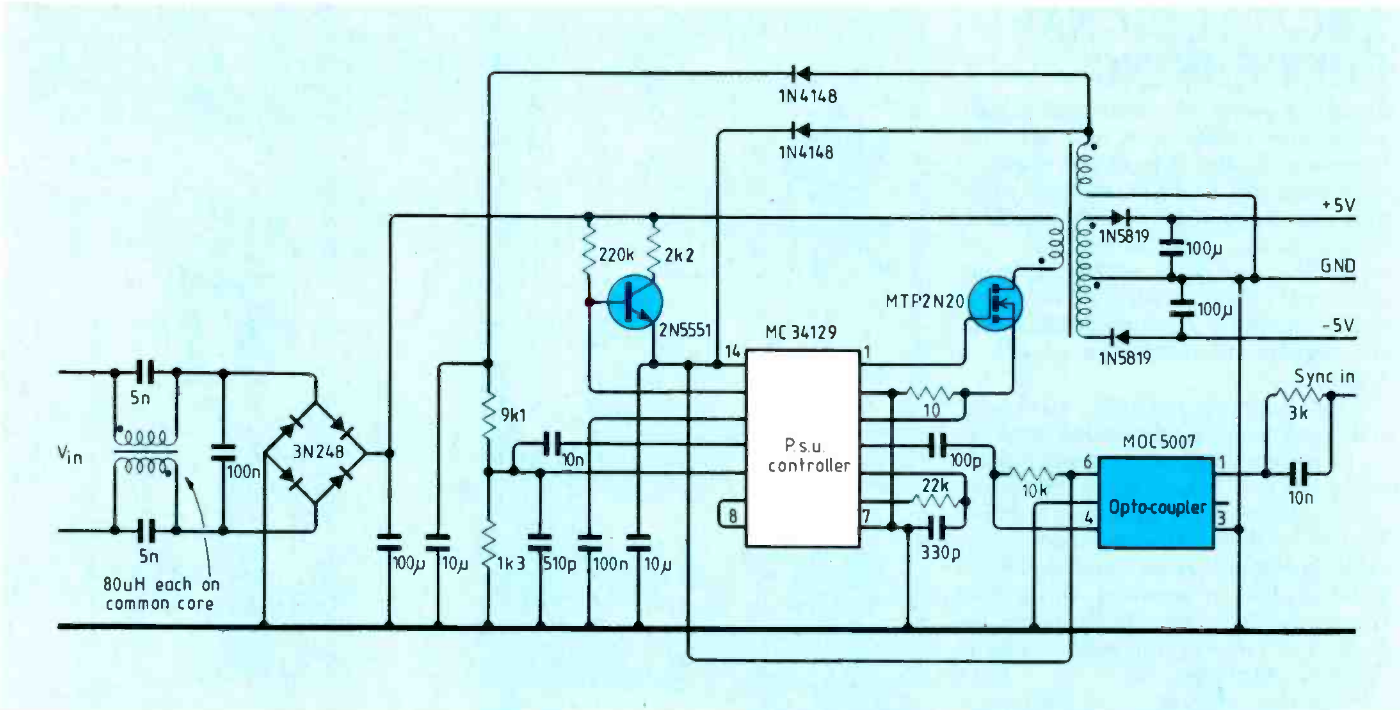
KEY TO DIAGRAMS

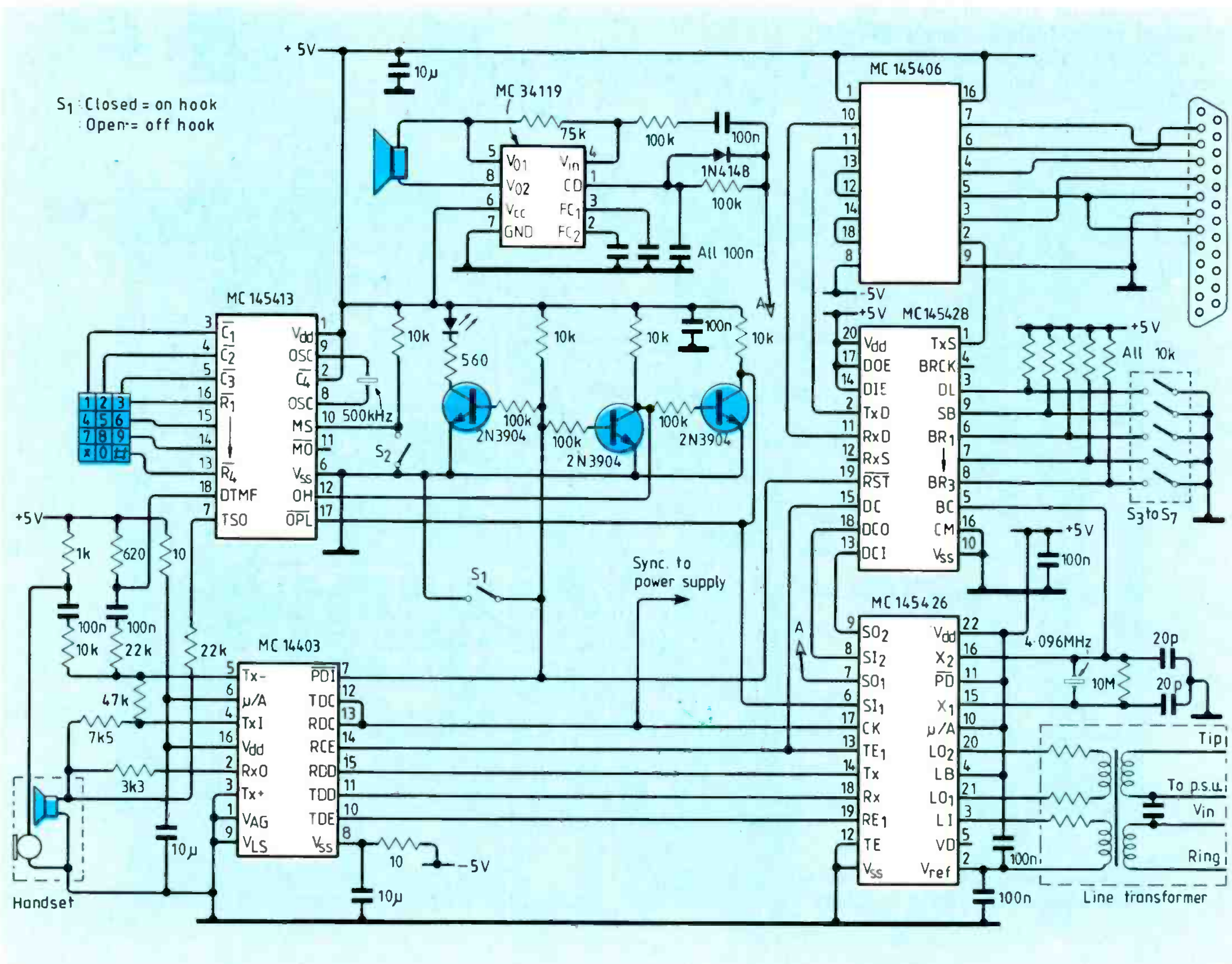
Multiplier	
FMPY	Floating-point multiplier
K.L	FMPY 32bit data registers
M	FMPY multiplication result
ALU	
ALU	Arithmetic and logical unit
EAU	Exponent a.l.u.
P.Q	ALU/EAU data i/p registers
SAC	Shift and count register
BSHIFT	Barrel shift register
SVR	Shift value register
WR0-7	Working register
PSW0.1	Processor status words
WRTC	WR transfer control
Data memories	
RP	Data rom pointer
BASE0.1	Base pointers
INDEX0.1	Index registers
ADD	Adders
Instruction rom	
PC	Program counter
SP	Stack pointer
IR	Instruction register
DECODE	Instruction decoder
Parallel interface	
DP	Data port
AP	Address port
DR	Data register
DRS	Slave data register
AR	Address register
R/W CNT	Read/write control
Serial i/o interface	
SO	Serial output register
OSFT	Output shift register
SOCNT	Serial o/p control reg.
SI	Serial i/p data register
ISFT	Input shift register
SICNT	Serial input control
Control	
INT CNT	Interrupt controller
TR	Temporary register
LC	Loop counter
SR	Status register





APPLICATIONS SUMMARY





APPLICATIONS SUMMARY

Digital voice/data telephone set

Design of a digital voice/data telephone set is discussed in Motorola note AN968. This telephone set provides standard analogue functions while simultaneously transmitting 9600 baud asynchronous data from a computer or terminal.

The voice/data i.cs used are from the MC145422/26 universal digital-loop transceiver family. They provide 80kbit/s full-duplex synchronous communication over 2km on one twisted pair. A pulse/tone dialler and c-mos RS232 i.c. for communication with a computer or terminal are included in the design and an efficient switching p.s.u. provides an isolated supply from the twisted pair's 48V.

Traditional tone signalling on the voice channel is used. Looked at from the p.b.x., the voice/data multiplexer appears as an ordinary telephone. The handset cradle switch is replaced by a relay, S_1, that opens when the telephone is lifted.

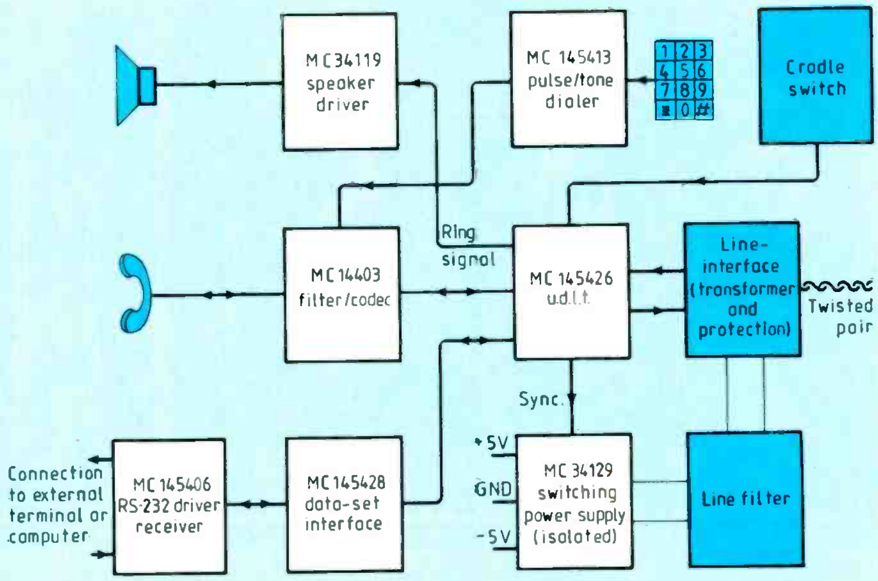
Voice and data signals are converted to digital form compatible with the u.d.l.t. by the 14403 codec/filter and 145428 data-set interface respectively.

Ringing signal from the p.b.x. is detected, sampled and sent to the digital telephone where it feeds a loudspeaker through an amplifier. Analogue voice signals are digitized and reconstructed by the codec/filter duplexer which is linked to the p.b.x. wires via the u.d.l.t.

Asynchronous data to and from the comput or data switch passes through the data-set interface. Outgoing RS232 data is synchronized and sent to the u.d.t.l. full-duplex data channel at 8k bit/s. Conversion of incoming synchronous data to asynchronous form is also performed by the data-set interface.

Direct current is applied to the twisted pair at the multiplexer and transputed over the wires, so no extra supply lines are needed.

Full constructional details are included in the seven-page note. A further note, AN949, describes the voice/data multiplexer.



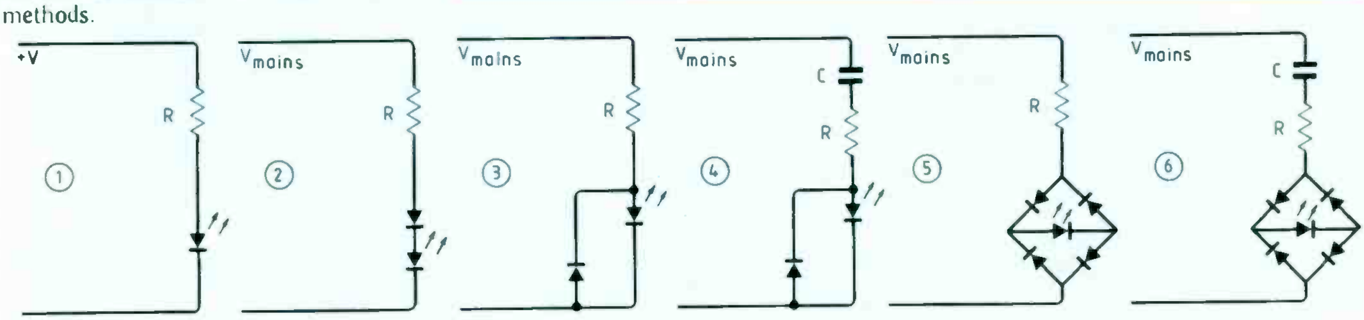
LED DRIVING CONSIDERATIONS

Optimization of led operating conditions is discussed in Three-Five Semiconductor's note No.1. With low-voltage d.c. supplies, connecting a led is simply a matter of calculating an appropriate voltage-dropping resistor. Where the voltage drop is large or power consumption is important, low-power leds can be particularly beneficial.

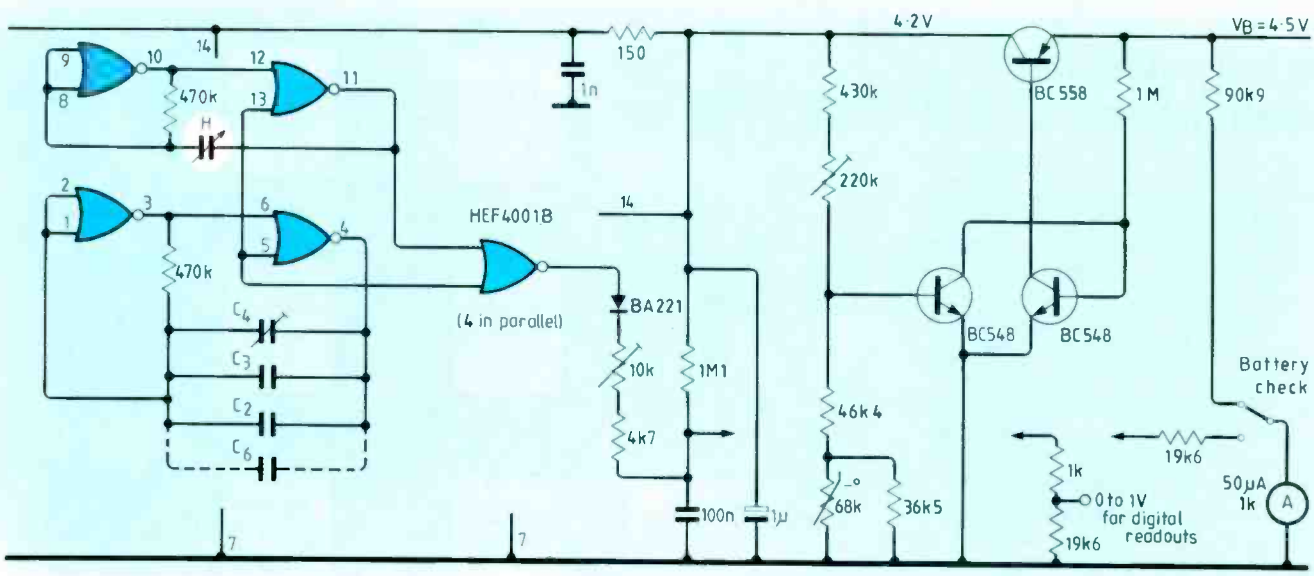
With high voltage a.c. supply simple resistive voltage-dropping elements are wasteful, can be physically large, and do not take into account led reverse voltage. There are more efficient ways of driving leds from a high voltage a.c. source as this table shows.

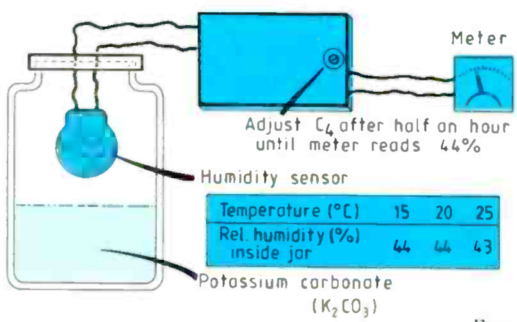
Also included in the note are equations for calculating the voltage-drop elements and further information on each of the six methods.

	Supply	V_{led} 2.2V, V_D=0.6V	20mA standard led	10mA high efficiency	2mA low current	Unit	Light output
1	12V d.c.	R Power dissipated	490 0.196	980 0.098	4900 0.0196	Ω W	Constant
2	240V a.c.	R Power dissipated	5930 4.74	11860 2.37	59300 0.47	Ω W	Pulsed 50Hz
3	240V a.c.	R Power dissipated	5945 9.51	11890 4.76	59450 0.95	Ω W	Pulsed 50Hz
4	240V a.c.	R Power dissipated	11830 4.73	23660 2.37	118300 0.47	Ω W	Pulsed 100Hz
5	240V a.c.	C Power dissipated	0.535 Negligible	0.267 Negligible	0.053 Negligible	μF W	Pulsed 50Hz
6	240V a.c.	C Power dissipated	0.269 Negligible	0.134 Negligible	0.026 Negligible	μF W	Pulsed 100Hz



APPLICATIONS SUMMARY





Battery powered hygrometer

A low-cost hygrometer running from a 100µA, 4.5V supply is one of five applications in the first VT & S Bulletin from Mullard. Electronic hygrometers are lightweight and easy to maintain, operate and calibrate. Having electrical output, they are easily interfaced to other electronic equipment.

Capacitance of the dielectric-foil sensor varies with relative humidity. At 43% relative humidity, the sensor is 122pF within 15% and its range is 10 to 90% r.h. Frequency of one of the two RC oscillators shown is fixed; in the other oscillator, C of the RC network is the sensor so its frequency varies with relative humidity.

Frequency difference between the two oscillators is translated into a pulsed voltage with an average value proportional to the mark/space ratio. This voltage appears at the buffer i.c. output. Because the sensor characteristic is non-linear the average value varies non-linearly with humidity. A diode and passive components following the buffer linearize drive for the meter, pen recorder or led display.

For calibration, the sensor is replaced by a 2% 118pF capacitor and the fixed oscillator frequency adjusted for minimum meter reading. This capacitor is then replaced by a 2% 159pF capacitor and the meter potentiometer is adjusted for maximum meter reading. With the sensor in place, the variable capacitor in the fixed oscillator is again adjusted until a known humidity is correctly displayed. Potassium carbonate in a sealed jar can be used for this. Operating frequency limits of the sensor are 1kHz and 1MHz.

Other notes in the VT & S Bulletin (varistors, thermistors and sensors) cover back-up lighting for fluorescent lamps at switch on, colour tv e.h.t. supply protection, shaver-socket protection and using zinc-oxide varistors.

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Mullard
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01 580 6633

Motorola
ITT Multicomponents
346 Edinburgh Avenue, Slough, Berkshire SL1 4TU
Tel. 0753 824131

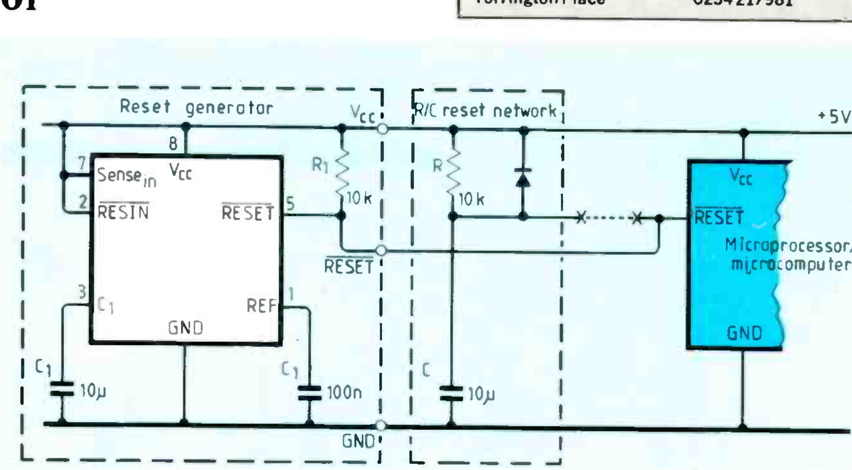
Texas Instruments
Online Distribution
Melbourne House
Kingsway
Bedford MK42 9AZ
0234 217981

Supply-voltage supervisor

When a simple RC network controls the reset line of a microprocessor certain types of power failure can result in incorrect resetting.

At power up the TL7705 supply-voltage supervisor delays rising of the reset line until supply voltage is fully on, as does an RC network. Unlike the RC circuit though, the 7705 pulls the reset line low when supply voltage falls below 3.6V. When supply voltage rises above 3.6V, the reset line goes high after a delay proportional to C_T. Output is undefined when supply voltage falls below 2V.

This circuit is from the Texas Instruments TL7705 applications sample available to designers. A small p.c.b. and three passive components are included in the kit.



Intermural tv signals

It is sometimes forgotten that a simple half-wave dipole correctly positioned can give a signal greater than the usual miniature indoor Yagi-Uda or log periodic antenna.

Television signals show regular standing wave patterns of maxima inside brick buildings. To investigate tyhe usefulness of this effect I made measurements of the geometry and magnitude of the signal pattern set up by the 0.51GHz radiation from the Sandy, Beds transmitter in a brick room at grid reference 761431. The measuring system comprised a half-wave dipole with a sleeve balun feeding a TES MC661C signal-strength meter.

Measured along a line parallel with the y-axis the distance between successive signal strength maxima was 42.7cm and, normalising the peak signal amplitude to unity, the amplitude at the minima was 0.32. Results parallel with the z-axis were 24.0cm and 0.75. These are sketched below.

At the position of minimum signal the direction of polarization was that of the incident signal, approximately N-S. Away from the minima it varied between directions parallel to the y-axis and to the z-axis.

ANALYSIS

The observed signal patterns were tested for compatibility with either a Fresnel or a Fraunhofer diffraction pattern orginating in apertures formed by the irradiated walls. They did not fit either form but a system of interference between direct radiation in the room and wall-reflected radiation was found to agree with experiment.

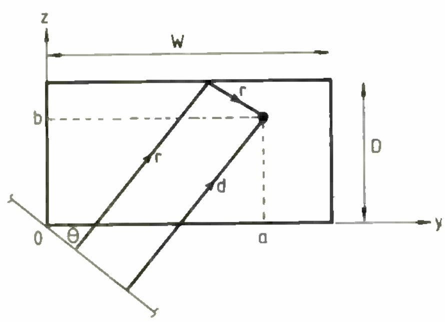
Consider next, direct radiation along d intersecting the once-reflected radiation r at the point (a,b), as depicted next column. The geometrical path difference between d and r is $2\cos\theta\,(D-b)$. Allowing for a π phase change on reflection the optical path difference is $2\cos\theta\,(D-b) + \lambda/2$ where λ is the wavelength of the radiation. For the point (a,b) to be a position of maximum signal

$$2\cos\theta\,(D-b) + \lambda/2 = n\lambda$$

where n is an integer. The separation in values of b for successive maxima is then

$$(\lambda/2)\sec\theta.$$

This is then the peak separation along the z-axis.



The reflected wave fails if the y-value of the point of incidence of r is negative, i.e. where

$$a<4\,(D-b)\tan\theta.$$

In addition, the optical path difference must equal or exceed λ for a maximum to be possible and so

$$b\leq D-(\lambda/4)\sec\theta.$$

Note that this maximum value for b will be very sensitive to λ if θ approaches $\pi/2$.

A similar analysis for radiation reflected from the wall at $y = W$ gives the peak separation along the y-axis as

$$(\lambda/2).\tan\theta.\sec\theta$$

This maxima pattern disappears if

$$a<W-B\tan\theta$$

or

$$a\leq W-(\lambda/4)\tan\theta.\sec\theta.$$

Equating measured and analytical values for peak separation along the z-axis gives

$$42.7=(\lambda/2)\tan\theta\sec\theta$$

and for the y-axis

$$24=(\lambda/2)\sec\theta$$

whence

$$\theta = 60.8^\circ \text{ and } \lambda = 23.4\text{cm}.$$

The value of θ agrees reasonably with the compass value of radiation direction. The free-space wavelength $\lambda_0 = 58.8$cm and so $\lambda_0/\lambda=2.5$.

Moreno discusses the effect on wavelength of the presence of dielectric material in an enclosure showing, for microwaves, a value of 1.5 for λ_0/λ with material having a dielectric constant of 2.45. I suggest that brickwork shows a dielectric constant of about 7 for the 0.51GHz radiation under investigation, making the value of 2.5 for λ_0/λ reasonable.

If the reflection coefficient of the wall is R then the intensity maximum is proportional to $(1-R) + R(1-R)$ and the minimum to $(1-R) - R(1-R)$. The ratio of maximum to minimum amplitude will be $(1+R)/(1-R)$. Thus for y variations:

$$\text{max/min} = 3.25 \quad \therefore R = 0.28$$

$$\text{reflection angle} = 90^\circ - 60.8^\circ = 29.2^\circ.$$

For z variation:

$$\text{max/min} = 1.33 \quad \therefore R = 0.06$$

$$\text{reflection angle} = 60.8^\circ$$

For radiation polarized normally to the plane of incidence the reflectivity should fall to zero when the incident and refracted angle add to 90°. If the incident angle is i and the refractive index η then

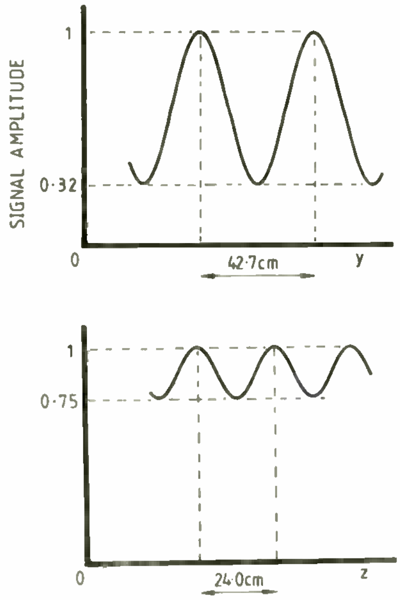
$$i + \sin^{-1}(\sin i/\eta) = 90^\circ$$

for zero reflectivity. As R falls from 0.28 with an incident angle of 29.2° to 0.06 at 60.8°, crude extrapolation puts $R = 0$ at an incident angle of 69°, hence

$$69^\circ + \sin^{-1}(\sin 69/\eta) \approx 90^\circ$$

making $\eta \sim 2.6$ and hence the dielectric constant ~ 6.8.

This analysis assumes throughout that the incident wave is parallel to the ground, or approximately so.



DISCUSSION

At a maximum the internal signal intensity should compare with the external value as $((1-R) + R(1-R))$:1. Taking the reflectivity R as 28% this ratio is 0.92:1 giving an internal signal amplitude of 96% of the external magnitude. The introduction of a large capture-area antenna into the enclosure must be avoided or the signal pattern will be disturbed and constructive interference lost.

If an analagous pattern were obtained from the proposed satellite broadcasts it could be exploited, possibly by a printed array of linked dipoles with their size adjusted to accord with the diminished internal wavelength[2]. Such a system would avoid the cost and aesthetic objections that roof-mounted dish antennas may generate.

1. Microwave Transmission Data. T.Moreno. Dover Publications. 1958.

Q_3	Q_2	Q_1	Q_0	i/p	o/p	Q as a function of Q_0
0	0	0	0	D_0	1	$\overline{Q_0}$
0	0	0	1	D_0	0	$\overline{Q_0}$
0	0	1	0	D_1	1	$\overline{Q_0}$
0	0	1	1	D_1	0	$\overline{Q_0}$
0	1	0	0	D_2	1	$\overline{Q_0}$
0	1	0	1	D_2	0	$\overline{Q_0}$
0	1	1	0	D_3	1	1
0	1	1	1	D_3	1	1
1	0	0	0	D_4	1	$\overline{Q_0}$
1	0	0	1	D4	0	$\overline{Q_0}$
1	0	1	0	D_5	0	Q_0
1	0	1	1	D_5	1	Q_0
1	1	0	0	D_6	0	Q_0
1	1	0	1	D_6	1	Q_0
1	1	1	0	D_7	0	Q_0
1	1	1	1	D_7	1	Q_0

RY generator for RTTY

When designing hardware and software for RTTY reception it is useful to have a constant source of RTTY data.

Three outputs from a clocked 4-bit counter feed A, B and C inputs of a multiplexer to select one of eight inputs.

RTTY characters consists of at least seven and a half units; a start bit, five data bits and one and a half stop bits. Using two stop bits, as with this circuit, does not cause problems.

Characters R and Y are usually used as a test message since they are complementary. For characters RY, the bit pattern is 10010101 10101011. The counter's least-significant bit provides the multiplexer data inputs.

As Q is a t.t.l. signal it can be used to drive the input of the computer directly. To allow testing of the terminal unit, two spare Nand gates provide mark and space frequency; Values of R_2 and C_2 determine frequency shift. Each oscillator is enabled by Q and $\overline{Q}$ outputs from the multiplexer.

Mixing of mark and space frequencies is done with a simple transistor Nand gate built around D_1, D_2 and Q_1. Output is low-pass filtered by R_6 and C_4. Reverse sense RTTY is obtained by swapping over Q and $\overline{Q}$ multiplexer outputs.

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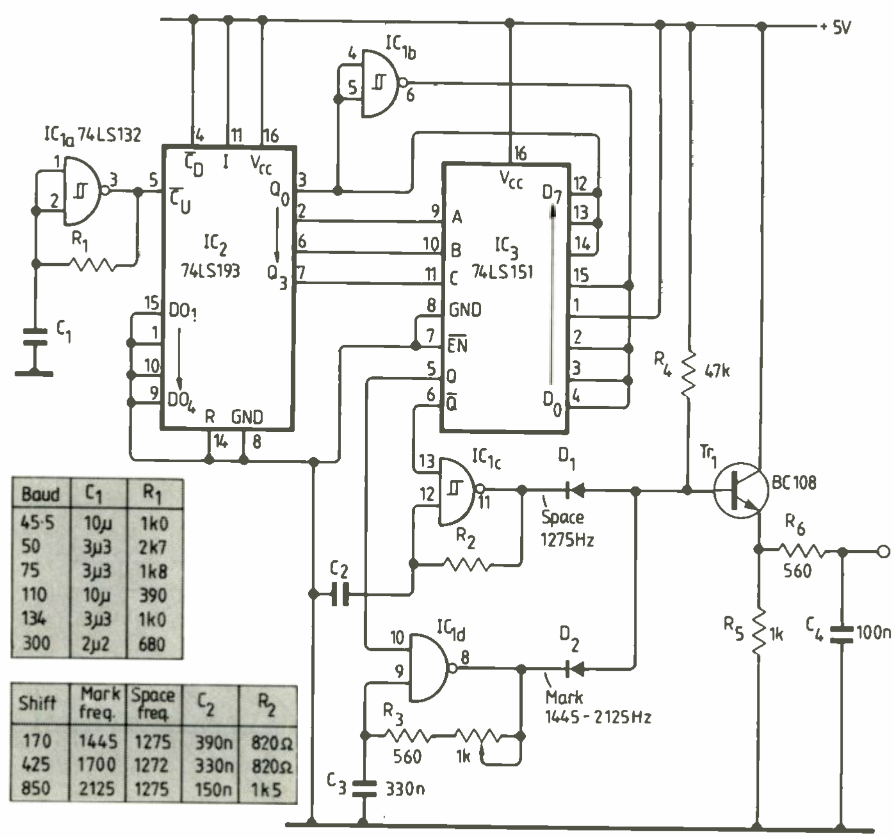

Baud	C_1	R_1
45·5	10µ	1k0
50	3µ3	2k7
75	3µ3	1k8
110	10µ	390
134	3µ3	1k0
300	2µ2	680

Shift	Mark freq.	Space freq.	C_2	R_2
170	1445	1275	390n	820Ω
425	1700	1272	330n	820Ω
850	2125	1275	150n	1k5

Phase-check pulse generator

Witches-hat pulses like those often used to indicate phase on circuit diagrams are immediately obvious on an oscilloscope screen, unlike narrow rectangular pulses where the edges tend to disappear.

Low impendance output is provided by a unity-gain buffer; pulses produced are at 1kHz with a peak level of 1V.

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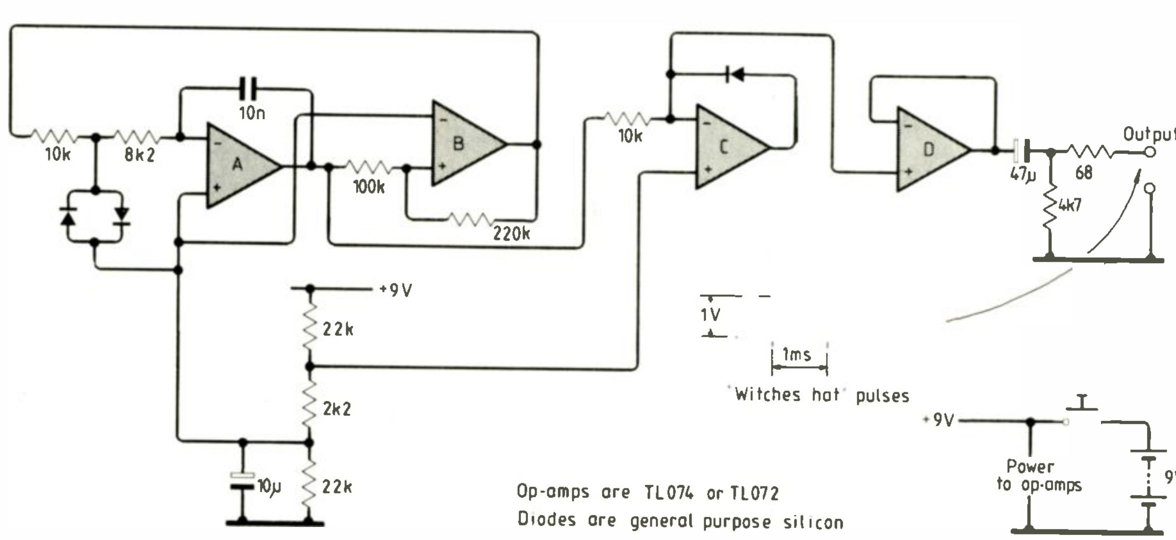
London.



Universal voltage-controlled oscillator with low phase noise

An analysis of noise behaviour for a variety of v.h.f. transistors shows that a j-fet produces the lowest phase noise.

A. DEKKER

For use in a v.h.f. synthesizer, a voltage-controlled oscillator was required with low phase noise. The design was to be such that only the mounting of a suitable tank inductor would guarantee operation at any centre frequency in the band between 10 and 300MHz. As there is no general agreement on which kind of transistor provides the lowest noise in oscillators, the effect of transistor noise was investigated both theoretically and experimentally.

In the general v.c.o. circuit of Fig.1, the most suitable frequency determining element is an LC resonator electronically tuned by variable-capacitance diodes. The drawback is that the frequency is a non-linear function of the voltage, which results in the conversion of amplitude into phase noise. The same phenomenon occurs in the internal capacitances of the semiconductor devices in the amplifier. This counteracts the reduction of the phase noise normally expected when the oscillation amplitude is increased. Therefore there is some optimum oscillation amplitude for minimum phase noise. This explains the necessity of the amplitude control in Fig.1.

So that the oscillation-sustaining amplifier does not affect the resonator Q, its input and output resistances should be much higher than the resonator resistance R_{res}. Hence the amplifier can be modelled as a voltage-controlled current source, which is characterized by its large-signal forward transconductance $S(V_{in})$. The oscillation amplitude is determined by

$$1 - S(V_{in})\,Z_{res}/n = 0 \qquad (1)$$

where n is the voltage transformation ratio of the resonator. The large-signal transconductance can easily be determined graphically from the V-I transfer characteristic of the amplifier. This is shown in Fig.2 for an amplifier with a single transistor. For a stable oscillation amplitude, it is necessary that S is a decreasing function of V_{in}. This is generally not the case for a single-transistor amplifier, apparent from Fig.2, at least not if the input direct voltage of the transistor is constant or cannot change very fast (within a few periods of the oscillation). The oscillation amplitude is finally limited by the supply voltage. This is to be avoided, however, because the transistor impedances will, in part of the oscillation period, be very low and strongly non-linear, resulting in increased phase noise.

This was the main reason to use a differential amplifier. Its large-signal transconductance decreases with increasing input amplitude, Fig.3, at least if it is greater than the input offset voltage. In addition, the input and output impedances of a differential amplifier are high, also when its output current saturates. Furthermore, the differential amplifier does not invert the phase, so that the resonator needs in principle no tap or coupling loop.

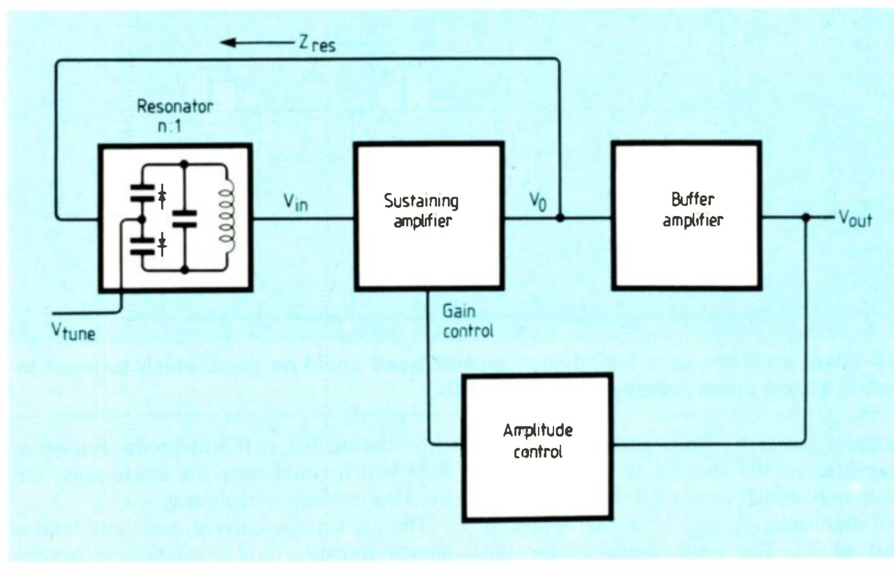
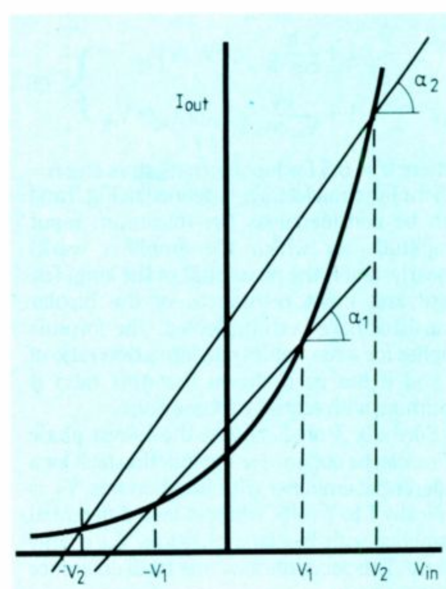


Fig.1. Non-linearity of semiconductor junctions results in conversion of amplitude into phase noise which counteracts the reduction of noise due to increase in amplitude – hence the need for optimization. Oscillation amplitude is related to transconductance (see text), obtained graphically from V-I transfer characteristic, Fig.2.



NOISE CONTRIBUTED BY SUSTAINING AMPLIFIER

The basic oscillator circuit is shown in Fig.4 with fets, but bipolar transistors could also be used. The noise of this circuit has been analysed (ref.1) under the assumption that the parasitic capacitance C_s of the source bias circuit has been compensated by the capacitor C_s' (ref.2). The result is the well-known formula

$$\mathcal{L}(\Delta f) = c\,\frac{FkT}{P_{av}}\left(\frac{f_o}{2Q\Delta f}\right)^2 \qquad (2)$$

where F is the noise figure of the amplifier, f_o the frequency of oscillation, P_{av} the available

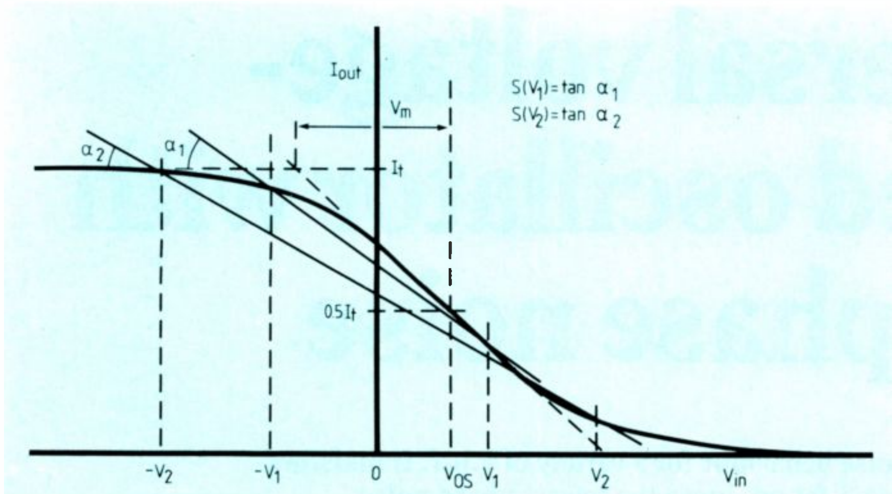


Fig.3. Unlike a single-transistor amplifier a differential amplifier has the virtue that large-signal transconductance is a decreasing function of input voltage.

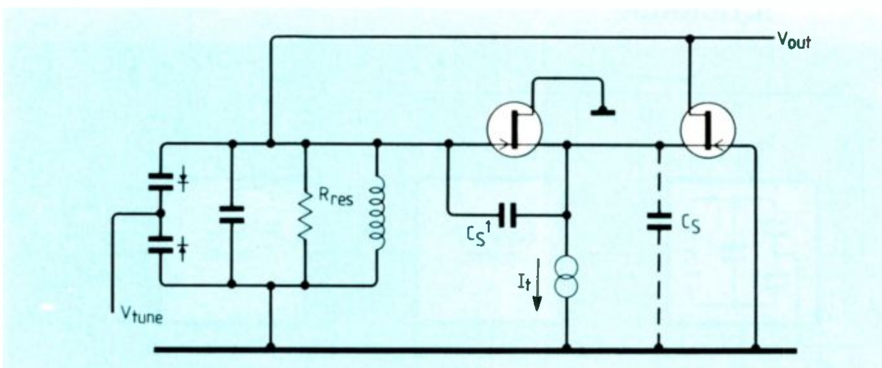


Fig.4. Basic oscillator uses fets, though bipolar types could be used, which turn out to produce a lower phase noise by as much as 10dB.

resonator power $V_o^2/8R_{res}$ and c is a factor depending on the amount of a.m. to p.m. conversion, which equals 0.5 for low oscillation amplitudes V_o and 1 for the optimum value of V_o. The noise figure F for the differential amplifier is

$$\left.\begin{array}{ll} 1+\dfrac{b}{\cos\Phi}, & \text{for } V_o \leq V_m \\ 1+\dfrac{bV_o}{V_m\cos\Phi}, & \text{for } V_o \geq V_m \end{array}\right\} \quad (3)$$

where b = 0.5 for bipolar transistors and b = 1.5 for junction fets, V_m is defined in Fig.3 and can be considered as the maximum input amplitude for which the amplifier works linearly, and is the phase shift of the amplifer. Base and input resistances of the bipolar transistor have been neglected. The formula applies for a resonator transformation ratio of 1 and it has been shown that this ratio is optimum with respect to phase noise.

Formula 3 predicts that the lowest phase noise can be obtained using junction fets: for a differential amplifier with junction fets, V_m is typically 1 to 2 volts, whereas for a differential amplifier with bipolar transistors V_m is only 50mV. This accounts for some 10dB difference in phase noise.

NOISE CONTRIBUTED BY BUFFER AMPLIFIER AND CURRENT SOURCE

Current noise injected into the resonator by the buffer amplifier is amplified with the oscillator closed loop gain $1/(1 - S\,Z_{res}/n)$ and should thus be kept as low as possible. Voltage noise is of minor importance, since it does not enter the oscillator. It only produces a noise floor which could raise the phase noise far from the oscillation frequency.

The input noise current density of both a bipolar transistor and a junction fet is proportional to $g_m(f/f_T)^2$ for high frequencies, with g_m the low frequency forward transconductance. The best input device for the buffer amplifier is thus a low g_m junction fet with high transition frequency. The buffer input capacitance which loads the resonator is non-linear and may be lossy at high frequencies, and so it should be minimized. A source follower loaded by the high input impedance of an emitter follower keeps the influence of the gate-source capacitance low because there is no significant r.f. voltage across it. The emitter follower can provide the output power to drive e.g. a 50ohm line.

Current noise injected into the resonator can be further reduced by taking the buffer input signal from the sources of the oscillator transistors.

If the collector of a bipolar transistor providing the tail current of the differential amplifier is coupled directly to the sources of the oscillator transistors, half of its current noise will enter the resonator. This noise can be an order of magnitude higher than the current noise of the oscillator transistors and would therefore significantly increase the phase noise. The tail current source should therefore be carefully isolated from the oscillator circuit for high frequencies. The isolation also eliminates an extra non-linear capacitance in the oscillator circuit and so reduces a.m. to p.m. conversion.

EFFECTS OF l/f NOISE

Low frequency noise, in particular l/f noise, modulates the transconductance and junction capacitances of the oscillator transistors and so causes amplitude and phase noise. The amplitude noise is further converted into phase noise in the voltage-dependent junction capacitances.

The use of low frequency feedback decreases the noise in the collector or drain current and so the transconductance fluctuations. Further, the gate or gate bias circuit should have a low impedance at low frequencies. In bipolar transistors, the l/f noise source works in parallel with the base-emitter junction current noise source and therefore the effect of low frequency feedback by an emitter resistor is limited. The l/f noise suppression is already nearly maximal for an emitter resistor equal to the absolute value of the total impedance of the base circuit.

In theory, the effect of transconductance fluctuations could be reduced by high frequency resistive feedback in the sources or emitters. This didn't work in practice, probably because of the phase lag and signal leakage to ground caused in combination with the parasitic capacitances.

It is often assumed that fets produce more l/f noise than bipolar transistors. But our experiments showed the lowest phase noise was consistently achieved using fets. Apart from the inherently lower high frequency noise of fets in oscillator circuits, the lower phase noise could also be caused by the weak dependence of transconductance on drain current, which reduced the effect of l/f noise. Furthermore, bipolar transistors with low l/f noise often have a high base resistance and are therefore not usable in v.h.f. oscillators.

Other sources of l/f noise are the transistor providing the tail current to the differential amplifier and the amplitude control circuit driving it. Tail current fluctuations cause amplitude noise, which is also converted into phase noise. Experiments showed that in general the lowest phase noise was obtained by shorting the low frequency tail current variations with a large electrolytic capacitor. Only if the oscillator transistors themselves produced a large l/f noise, was it favourable to make the amplitude control loop fast, so that the large amplitude noise of the proper oscillator was suppressed.

MINIMIZATION OF AM-TO-PM CONVERSION

The voltage dependency of the junction capacitances causes a.m.-to-p.m. conversion. The non-linearity of each junction capacitance should therefore be compensated by the non-linearity of another one at which the r.f. voltage is equal, but in antiphase. The gate-drain capacitances of the oscillator transistors are automatically linearized, since they are anti-parallel.

The gate-source capacitances are in anti-series, and thanks to the compensation capacitor C_s' their voltages are opposite. The electronic tuning of the oscillator is accomplished by two matched varactors in anti-series, where any asymmetry in parasitic capacitances should be compensated.

OPTIMUM RESONATOR IMPEDANCE

The oscillator phase noise is inversely proportional to the resonator power, which in turn is inversely proportional to the resonator impedance, which should thus be made as low as possible. There is, however, a bound below which decreasing the resonator impedance does not improve any more or even deteriorates the oscillator c.n.r. This is caused by several factors:

- At too low a value of the resonator impedance the oscillator transistors can no longer provide sufficient output power.
- The l/f corner frequency of transistors increases with drain or collector current.
- Due to the base resistance of bipolar transistors, the equivalent input noise voltage cannot be decreased below a certain threshold and will even increase when the collector current gets too high.

Then there is the practical problem of decreasing the resonator impedance while keeping a sufficient electronic tuning range because the capacitance variation of v.h.f. varactors is limited. The impedance could be transformed downward by coupling the resonator via a tap to the oscillator circuit. This increases, however, the r.f. voltage to the varactors and so the a.m.-to-p.m. conversion.

CIRCUIT DIAGRAM

The circuit diagram of Fig.5 needs little explanation. Oscillation frequency is determined by L_3, C_3, C_4, D_1 and D_2. Resistors R_1 and R_2 provide low frequency feedback to reduce the l/f noise and the input offset voltage of the differential amplifier. Their optimum value is a compromise between l.f. feedback and amplitude control range. Coupling capacitor C_2 has a low impedance at the oscillation frequency, but forms practically an open circuit at low frequencies. Components L_1, L_2 and C_5 prevent the r.f. noise of Tr_5 entering the oscillator and C_6 shorts the transistor l.f. noise. The low-frequency decoupling capacitors are connected to the positive supply voltage to prevent modulation of the drain gate capacitances by noise on the power supply.

Capacitor values of C_1 and C_4 are of the order of some pF. They balance the voltages across the gate source junctions of the differential amplifier and across the varactors, to reduce a.m.-to-p.m. conversion. Besides, C_1 improves the frequency response of the amplifier.

To change frequency by a large amount L_3, R_1 and R_2 are the only components that need to be replaced. If the electronic tuning sensitivity is not critical, the oscillator can be tuned with C_3 over more than one octave.

PHASE NOISE MEASUREMENTS

The phase noise of the oscillator of Fig.5 was measured using several types of transistors in the differential amplifier. The place of the tap on the resonator coil and the amplifier tail current were experimentally optimized for lowest phase noise. The results are shown in the table.

The Table shows that the lowest phase noise

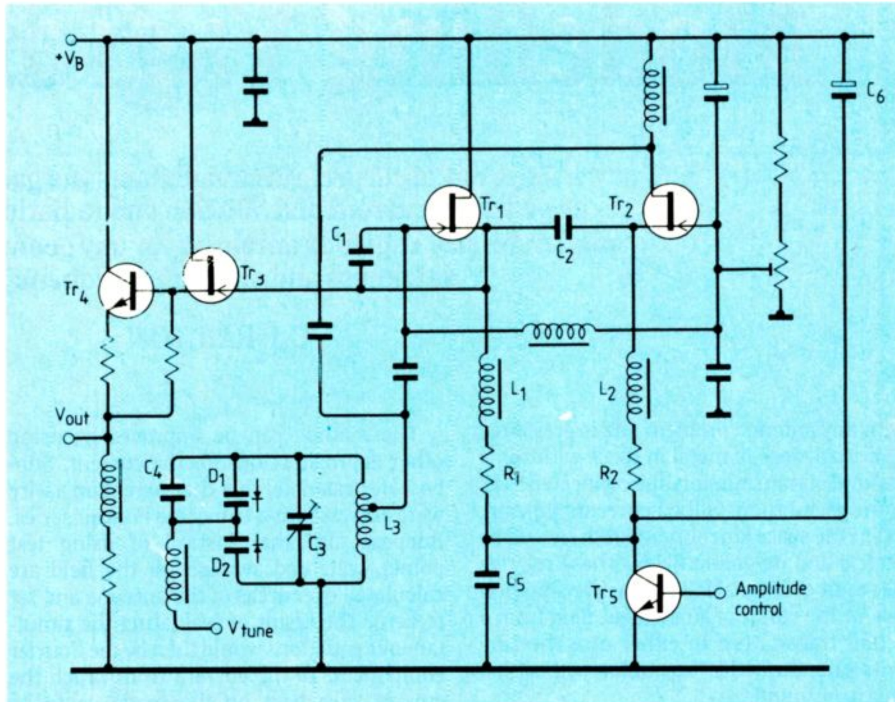


Fig.5. To change frequency by a logic current, the only components to be charged are L_3 and R_1, R_2. As it stands, it can be tuned over an octave with C_3.

can be obtained with junction fets. Besides, the phase noise of an oscillator with fets turned out to be less sensitive to the place of the resonator tap and the amplifier tail current.

TABLE 1. Lowest phase noise obtained at oscillation frequency of 100MHz at 5kHz from the carrierfor several types of transistors in the differential amplifier.

Transistor	Remarks	£(5kHz) (dBc/Hz)
2N3823	v.h.f junction fet	−116
BF198	v.h.f. bipolar	−106
CA3127	v.h.f. bipolar array	−105
BCY59C	low l/f noise bipolar	− 91
BFR90	low noise wideband	− 80
BFQ69	low noise wideband	− 70

The phase noise of the oscillator with the 2N3823, BF198 and CA3127 was close to the value estimated with equations 2 and 3. The high noise of the BCY59C is probably due to its high base resistance. The extremely high phase noise obtained with the BFR90 and BFQ69 is caused by a.m.-to-p.m. conversion of amplitude noise generated by l/f noise. By increasing the speed of the amplitude control circuit, the phase noise was reduced to −90dBc/Hz.

References

1. Dekker, A. P.: Approximate noise analysis of a feedback oscillator using a non-linear differential amplifier, to be published in AEÜ (Electronics and Communication, Fed. Rep. of Germany).

2. Dekker, A. P.: Compensation of parasitic source capacitance in a fet differential amplifier, *Letters*, vol.22, no.17, 14 Aug. 1986, pp.885–886.

A. P. Dekker is now with Nokia Telecommunications, Espoo, Finland, having completed this work at the Dr Neher Laboratories of the Dutch PTT, Leidschendam.

Non-switching class B amplification

From page 742

Under nulling condition, y = x + z, and after elementary trigonometry:

$$B^2 = A^2 + C^2$$

$$e = \arctan(C/A).$$

Now as only the output and the error signal are recorded, substitute $A^2 = B^2 - C^2$. So finally

$$e = \arctan \frac{C}{\sqrt{B^2 - C^2}}$$

Appendix 2 – Experimental amplifier

To eliminate influence from other distortion mechanisms as much as possible careful circuit design and layout were needed. Separate power supplies for the voltage gain stage and power stage were used and high current ground was separated from the signal ground (see ref. 13). Test equipment ground was connected to the input signal ground except for Fig. 8 recording, where the whole test set-up was floating and the test amplifier "live" output was connected to the transient recorder ground.

The voltage gain stage was designed around a high performance operational amplifier to simplify control over the open-loop bandwidth and gain, which were chosen to represent typical values found in modern power amplifiers.

Bias control was designed to be variable over a wide range to achieve requirements for class B and class A bias. The circuit must behave as a symmetrical low-impedance voltage source for the output stage. Class NSB operation was achieved by opening the contacts of S1a and S1b and adjusting the quiescent current to the same value as the one chosen for class B operation. Class A quiescent current was set to three amps.

Modelling Yagi antennas

A suite of Pascal programs calculates the gain, terminal impedance, current distribution and radiation pattern of moderate-size Yagi-Uda antennas for any geometry, element thickness and operating frequency.

C.J. RAILTON

In any antenna problem one is presented with a piece of metal in space with some kind of transmission line connected to it. In the metal there will be currents flowing, and in the space surrounding it there will be electric and magnetic fields. These may be the result of a signal fed via the transmission line, or the result of an incident field from a distant transmitter; in either case the currents and the fields are unknowns which need to be found.

Maxwell's equations give the information required to proceed. Firstly they allow calculation of the electric field anywhere in space resulting from a specific current distribution. Secondly, they require that the value of the total electric field tangential to a conductor is zero. The conductor can be thought of as providing a short circuit to the electric field. From these two conditions it follows that if the current distribution on the antenna is known and the tangential electric field is calculated anywhere on the antenna surface, then we will get minus the incident field.

In this form the problem becomes that of finding a function of space which, when certain mathematical operations are performed on it, give a specified answer. One way of tackling this is to approximate the unknown current function by a large number of point currents of unknown amplitude scattered over the metal surface. Clearly, if an infinite number of points were taken, the actual current could be represented exactly. But a sufficiently large number will give a reasonable approximation. Suppose also that instead of insisting that the field is zero everywhere on the metal, we insist that it be zero on a large number of selected test points scattered over the surface. These points could be, but do not have to be, the same as those at which the point currents were located. One could not evaluate the field at each test point resulting from each point current source and set each one to zero. This would result in a set of simultaneous equations from which the amplitudes of the point current sources could be calculated. The value of the current between the points could be found by interpolation. Thus the problem is solved.

In practice this method, known as point matching, will work if the number of points is high, which means that a very large array of simultaneous equations has to be solved, resulting in the requirement for much computer storage and processing, and the likelyhood of significant rounding error.

The method can be improved by using other approximations for the current. Suppose, for example, that the current on a wire were expressed as a truncated Fourier series. Suppose also that instead of using test points, weighted averages of the field are calculated over areas of the antenna and set to zero. The result of evaluating the simultaneous equations would then be the Fourier components of the current from which the current anywhere on the metal could be evaluated. By doing this, accurate results are obtained with smaller systems of equations, but the calculation of each coefficient of the simultaneous equations becomes more laborious.

The way in which the current is expressed as a combination of known functions, such as impulse functions or trigonometrical functions in the above examples, is referred to as expanding the current in a set of basis functions. The way in weighted average of the resulting field is taken is referred to as a test function. Clearly we have complete freedom as to what functions to use, and in theory they will all give the same answer. In practice, it is crucial that a good choice is made; the penalty is a great deal of computation and an inaccurate answer.

In the computer programs described, the basis functions and the test functions are the same. Each wire on the antenna is divided into segments, and the current in each segment is approximated by a suitable function. The greater number of segments specified for each wire, the more accurate will be the answer, and the greater the computation time. The points at which the antenna is connected to a transmission line must be in the centre of a segment. In the usual case of centre feeding this is no disadvantage. It is usually desirable, for best efficiency, to specify more segments on the driven element than on those elements towards the ends of the array. This is because greater inaccuracy can be tolerated on those elements carrying little current before the calculated parameters are unduly affected.

GENERAL THEORY

Analysing any radiating structure consists essentially of calculating the currents in the conductors and the fields surrounding them for a given excitation. This excitation can be a current or voltage generator as in the case of a transmitting antenna, or an incident field as in the case of a receiving antenna.

If the current distribution is known everywhere on the structure then it is comparatively easy to determine the resulting scattered fields anywhere in space. This is done by evaluating the following integral which is derived from Maxwell's equations:

$$E_s(r) = \int (\nabla^2 + k^2)\, G(r,r')\, J(r')\, d^3r' \quad (1)$$

$$\text{where } G(r,r') = \frac{\exp k(r-r')}{|r-r'|}$$

$$k = 2\pi/\lambda$$

Determining the currents for a given incident field, however, is not so straightforward. To do this, use the fact that at the surface of a perfect conductor the tangential component of the total electric field must be zero. Any incident field induces a voltage across the conductor, and the resulting current produces a scattered field which exactly cancels the incident field on the conductor's surface. Since currents can only flow on conductors it follows that anywhere in space the scalar product of current density and the total electric field is zero. That is,

$$(E_i(r) + E_s(r)).J(r) = 0 \quad (2)$$

where E_i is the incident electric field and E_s is the scattered electric field. Take the scalar product of both sides of equation 1 with $J(r)$ and substitute equation 2 into equation 1:

$$\int (\nabla^2 + K^2)\,(G(r,r').J(r')).J(r)d^3r' = -E_i(r).J(r) \quad (3)$$

and the problem is to find a function $J(r)$ such that this equation is satisfied for all values of r. Once we have managed to find such a function we know by the uniqueness theorem that it is the correct solution. A common method of solving such equations is the method of moments or weighted residuals, a special case of which is used in the computer program Galerkin's method.

The first stage in this method is to express the unknown current function $J(r)$ as a series of known basis functions $J_s(r)$:

$$J(r) = \sum_{s=0}^{\infty} a_s J_s(r) \quad (4)$$

Any permissible function $J(r)$ can be represented by an infinite number of coefficients

a_s provided that the functions $J_s(r)$ form a complete set of functions that are non-zero only on the surface of a conductor. In theory, any such set can be used in the calculation but, as we shall see, some choices yield results more quickly and more accurately than others.

A simple way of arriving at a set of basis functions which illustrate the technique is to divide the conductor surface into a large number of small areas. On each area there would be one and only one non-zero basis function. Eact basis function would be non-zero on one and only one area where it would have a value of unity. As the number of areas into which the surface is divided increases, the real current distribution is more closely approximated. Such a set of basis functions would be appropriate for a solid metal body but there are better sets available for a wire antenna.

Substitute equation 4 into equation 1 to get the following expression for the scattered field:

$$\int (\nabla^2+k^2)\sum a_s G(r,r')J_s(r')d^3r' = E_s(r) \quad (5)$$

Since the basis functions are non-zero only on the surface of the conductors, multiply both sides of equation 5 by each of the basis functions, integrating over all space and making use of equation 2, gives

$$\int (\nabla^2+k^2)\sum_{s=1}^{\infty} a_s \int G(r,r')J_s(r)d^3r\, d^3r' = -\int E_i(r)\, J_r(r)\, d^3r \qquad r = 1 \ldots \infty. \quad (6)$$

This is an infinite set of simultaneous equations for the infinite number of unknown coefficients, a_s, which determine the current distribution on the structure. In practice we take a finite number of basis functions and ignore the effect of the higher order terms of the sum.

With a good choice of basis functions, a_s tends rapidly to zero as s increases so that this approximation will not cause significant errors. For example, if the first term in the series happened to be the actual distribution then all the terms except the first would be zero. Conversely if the functions are badly chosen and the basis functions are very different to the actual current distribution, then a large number of terms must be retained with the consequent increase in effort, rounding error and the likelihood of numerical instability.

In fact, if we had multiplied equation 5 by any set of test functions which are non-zero only on the conductors then we would end up with a valid set of simultaneous equations. If in addition the set of functions were complete, we could equally well proceed with this new set of equations.

The choice of test functions, like the choice of basis functions, is largely a matter of educated guesswork and experience. The case where the basis functions and the test functions are chosen to be the same is known as Galerkin's method. For the problem under consideration (as well as many others) this choice leads to an efficient formulation.

Once a set of basis functions is decided equation 6 can be solved, allowing calculation of currents and fields in all space.

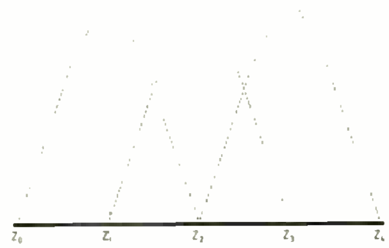


Fig.1. A single wire showing three overlapping piecewise sinusoidal functions. Current flowing in the wire is approximated by a linear combination of these three functions. The accuracy of the approximation can be improved by using a greater number of these basis functions.

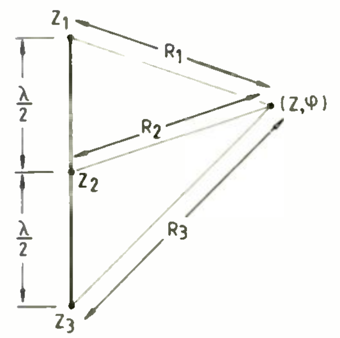


Fig.2. E field at the point (z,φ) due to a piecewise sinusoidal current in the section of wire lying between points (z1,0) and (z3,0) is calculated using equations 9 and 10.

APPLICATION TO YAGI-UDA ANTENNA

The basis functions appropriate to a Yagi antenna must, from inspection of the geometry, have the following properties: they must be zero everywhere except on the wires and they must fall smoothly to zero at the ends of the wires.

Simple functions which have these properties are the following:

$$\left.\begin{aligned} J_s(z) &= \frac{\sin(k|z-l_s/2|)}{\sin(kl_s/2)} \quad \text{on wire s} \\ &= 0 \qquad\qquad\qquad \text{elsewhere} \end{aligned}\right\} \quad (7)$$

where l_s is the length of the s^{th} wire z is the distance measured from the centre of the wire.

This approximate current distribution is widely used in published tables for the self and mutual impedance of dipoles and for array antennas. In fact this approximation is only good if the wires are of the order of a half-wave long. For this assumed current distribution function, equation 5 becomes a set of simultaneous equations of order N where N is the number of wires. Solution of this set would give the magnitudes of the currents on each element. Results for parameters such as gain and impedance based on this assumed current would not be accurate, but would give a rough idea.

A better approximation can be obtained by using more than one basis function for each wire, such as the following

$$\begin{aligned} J_{sp}(z) &= \frac{\sin k\,(z-z_{p-1})}{\sin k\,(z_p-z_{p-1})} \quad z_{p-1} < z < z_p \\ &= \frac{\sin k\,(z_{p+1}-z)}{\sin k\,(z_{p+1}-z_p)} \quad z_p < z < z_{p+1} \end{aligned} \quad (8)$$

where $p = 1 \ldots N$ $z_p = pl/(n+1) - 1/2$, l is the length of the s^{th} wire, and N the number of basis functions on the s^{th} wire.

Here we are approximating the current on the s^{th} wire by dividing it into N overlapping segments and specifying that each of the N basis functions are non-zero only on one segment.

These functions are shown in Fig.1 for one wire. They form overlapping sinusoids that go to zero at the wire ends, as required by the boundary conditions. If N is chosen to be 1 then we recover equation 7. As N is increased, the actual current can be better approximated, yielding a more accurate answer at the expense of greater computation.

We are at complete liberty to specify a different number of basis functions on different wires. Indeed, it is desirable to a specify a larger number of basis functions for the driven element than for the others, especially when calculating terminal impedance.

However, there is no guarantee that the solution will improve as the number of basis functions is increased. Although we are ensuring that the boundary conditions are being satisfied on the average in more places, we are saying nothing about how well they are satisfied in any one place. It is quite possible for the value of the calculated total field to oscillate widly about zero from place to place and still satisfy equation 6. But in practice, for sensibly chosen basis functions, Galerkin's method is well behaved.

Experience has shown that the piecewise sinusoidal basis functions given in equation 8 are well suited to the Yagi problem. In addition, with this choice of basis functions, the integral of equation 1 is available as in a simple closed form which can be expressed in cylindrical coordinates as follows:

$$E_z = j30\left\{-\frac{\exp(-jkR_1)}{R_1 kl/2} + \frac{\exp(-jkR_2)\sin kl}{R_2\sin^2(kl/1)} - \frac{\exp(-jkR_3)}{R_3\sin(kl/2)}\right\} \quad (9)$$

$$E_\phi = \frac{j30}{\phi}\left\{\frac{(z-z_1)\exp{-jkR_1}}{R_1\sin(kl/2)} + \frac{(z-z_2)\exp(-jkR_2)\sin kl}{R_2\sin^2(kl/2)} - \frac{(z-z_3)\exp{-jkR_3}}{R_3\sin(kl/2)}\right\} \quad (10)$$

where the dimensions are defined in Fig.2.

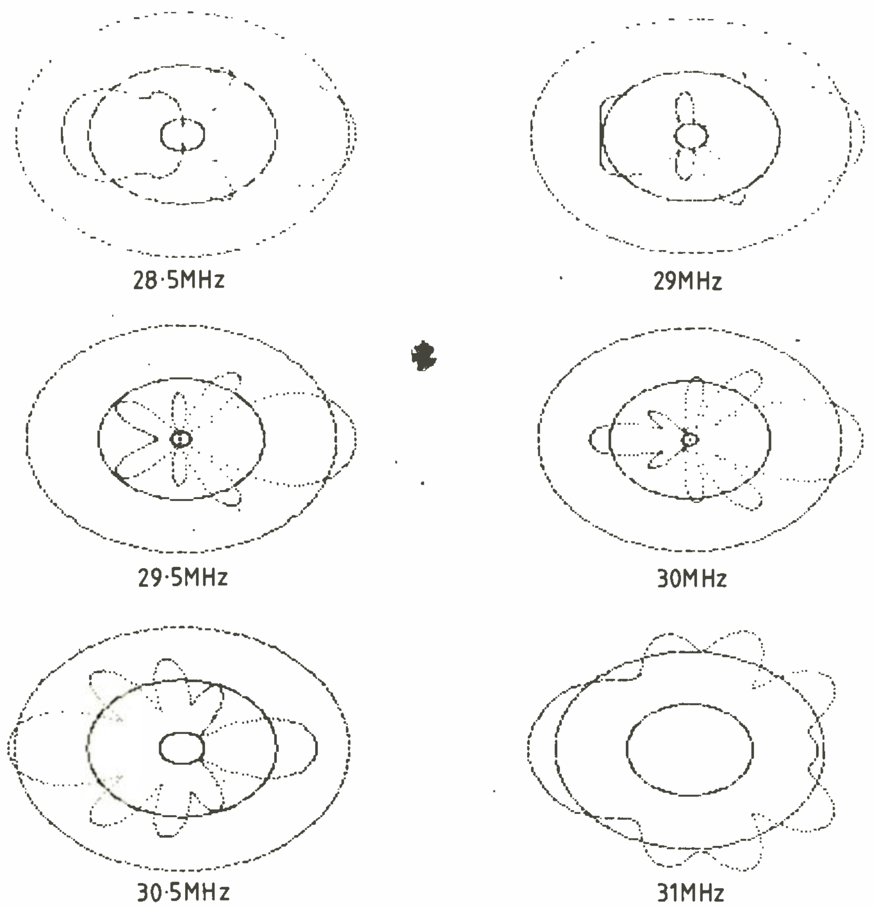


Fig.3. Polar radiation patterns of a 30MHz seven-element Yagi using wires of radius 25mm.

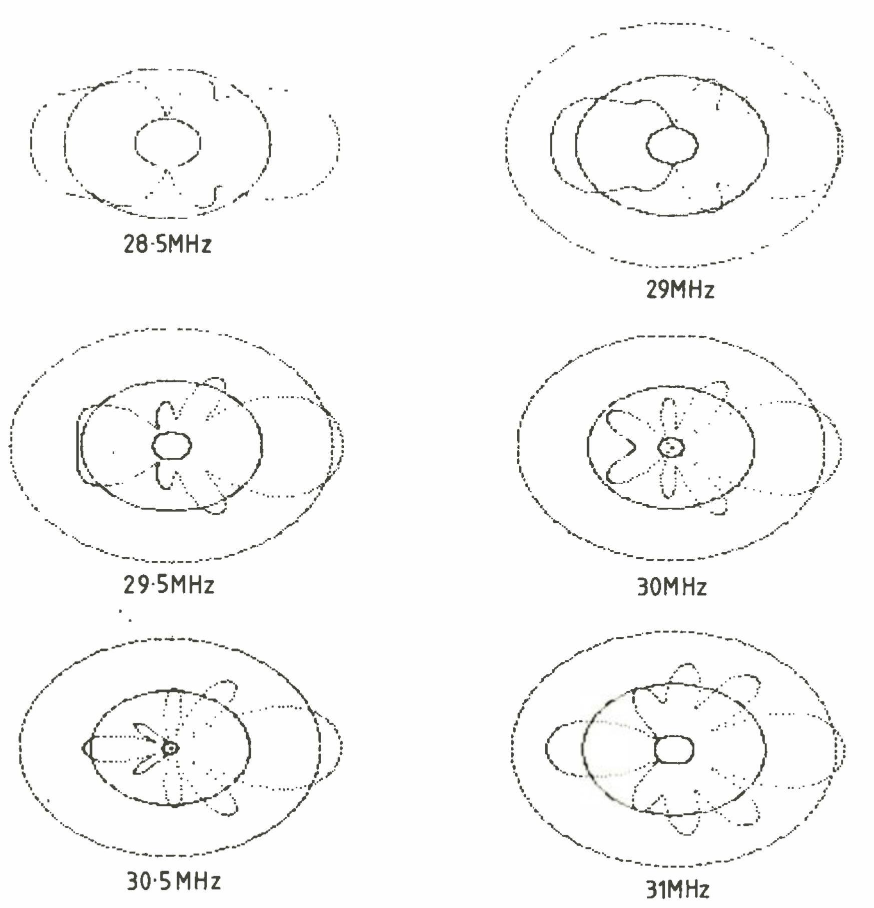


Fig.4. Polar radiation patterns of a 30MHz seven-element Yagi, this time with wires of 10mm radius.

In the case of a Yagi all the elements are parallel and so we need only concern ourselves with the z-directed field. No theoretical difficulty would prevent extension to elements placed at any desired orientation if required.

Substituting equation 9 into 6 gives

$$\sum_p \sum_s a_{sp} \int_{l_{rq}/2}^{l_{rq}/2} J_{rq} E_{zsp}\, dz = \int E_{zi} J_{rq} dz \qquad (11)$$

for $q = 1 \ldots$number of elements $r = 1 \ldots$number of basis functions on the q^{th} wire, and where l_{rq} is the length of the r^{th} segment on wire q, E_{zsp} is given in closed form by equation 9.

The integral is the mutual impedance between the segments rq and sp. Integration can be carried out numerically without undue trouble. The problem is now reduced to the evaluation of a number to calculate the values of the coefficients and hence the approximate current on the elements.

EXCITATION

We now have a computation method which allows us to find the currents on a Yagi antenna for a given incident field. To calculate useful parameters such as the gain and the terminal impedance, it is necessary to consider the incident field produced by a transmission line connected to the drive element.

Various models for the feed point of an antenna have been used and they vary in accuracy and complexity. A simple but effective one is the delta gap. Here we assume that the driven element has an infinitesimal gap at the driven point. Across this gap is applied a voltage source such as a transmission line. With this model, the integral on the right hand side of equation 11 becomes equal to the magnitude of the voltage sources times the value of the test function at the driven point.

Clearly this model is only an approximation of a real feed system, but it does give good answers and it is widely used.

Once the currents have been calculated by means of equation 11, the terminal impedance is immediately given as the drive voltage divided by the current in the driven segment. To calculate the gain we need to know the magnitude of the radiated field far from the antenna. For large distances equation 9 and 10 become

$$E_z = \frac{j30}{R}\left\{-\frac{\exp -jkR_1}{\sin (kl/2)} + \right.$$

$$\left. + \frac{\exp (-jkR) \sin kl}{\sin^2(kl/2)} - \frac{\exp -jkR_3}{\sin (kl/2)}\right\} \qquad (12)$$

$$E_\phi = E_z \tan \Phi \qquad (13)$$

where Φ is the angle of elevation of the point of observation.

The gain is given by

$$\frac{(|E_z|^2 + |E_r|^2)\, Z_0}{4\,\pi\, P_{in}}$$

where P_{in} is the total power delivered to the antenna.

PROGRAM DESCRIPTION

The program is split into three parts, partly for reasons of space and partly from convenience. It is possible to run the programs on most computers which have a Pascal compiler with very little change. The only machine-specific part of the program is the graphics routines which are written in Z80 machine code. It is likely that equivalent graphics library routines would be available on other machines.

First of all, the program GETWIRES takes information from the keyboard about the geometry of the antenna to be analysed. It then produces a file which is used by the next part. This avoids the need to type in the geometry each time an analysis is to be done.

The actual analysis is carried out in the program YAGI which calculates the currents on each segment for a given excitation and frequency. The radius of the wire used can be specified, as can the number of segments into which to divide each wire. In this way the accuracy of the solution can be traded against computer time.

The main procedures in the program perform as follows:

GETIMP calculates the mutual impedance between segments of specified length and position at a given frequency and with the assumed piecewise sinusoidal current distribution. This is carried out by numerically evaluating the integral in equation 11. Function F is the integrand, and the integral is carried out by function GAUSINT by means of the gaussian quadrature method.

CLUFAC and CLUSOLVE solve the set of complex simultaneous equations represented by a coefficient matrix A and a vector B, the result is given in a vector X.

DOSELF calculates the mutual impedance between all segments on a particular wire and sets the appropriate elements of the matrix ZMAT. Because all the segments on any given wire are the same length and are placed contiguously, only one calculation per segment need be performed.

DOOTHERS calculates the mutual impedance between all segments on a given wire with all segments on another given wire and sets the appropriate parts of matrix ZMAT. Since, in general, the segments on different wires can be of different lengths, each value is worked out separately.

SETDRIVEN requests information about the excitation of the antenna and stores the information in the structure DRIV.

DOANT calculates on each segment for a specified excitation and frequency and calculates the terminal impedance. For a two-element array the mutual impedance between the wires is also calculated.

OUTCURR saves the calculated currents for use by the program PLOTFIELD.

PLOTFIELD takes the information calculated by YAGI and produces a polar of the far-field radiation pattern. By means of a screen copy routine, the diagrams together with annotations can be printed onto a dot matrix printer.

RESULTS

To show the sort of results which can be obtained from the programs two different Yagis have been analysed. Figures 3 and 4 show a series of polar diagrams for a seven-element Yagi with wire thicknesses of 25mm and 10mm respectively. Spacing is 3m. Reflector length 4.75m, driver length 4.55m and director lengths are 4.39m. Notice how the radiation pattern breaks down as the frequency approaches 31MHz.

Figure 5 shows gain plotted against frequency for this antenna and Fig.6 shows terminal impedance versus frequency. The effect of varying the element thickness can be clearly seen. This antenna was analysed by Thiele[1] for a frequency of 30MHz and wire radius of 25mm using a reaction matching technique. The results for gain and impedance are in good agreement.

These results, especially the plots against frequency, are not quick to obtain and an overnight run is likely to be the norm. The programs have, however, been designed to run with little intervention so that this should not present a great problem.

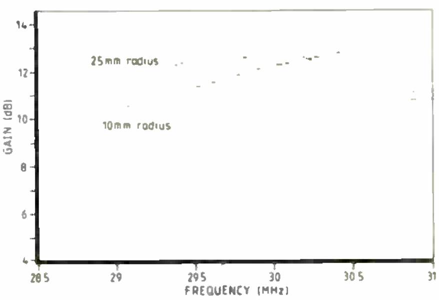


Fig.5. Gain as a function of frequency for the antennas of Figs 3 & 4.

Fig.6(a) (below, left). Resistive part of the terminal impedance as a function of frequency, showing the effect of varying the wire radius.

Fig.6(b) (below, right). Reactive part of the terminal impedance of the seven-element array as a function of frequency for wire radii of 25 and 10mm.

PROGRAM EXTENSIONS

Any moderately-sized array of parallel wires can be analysed by the programs as described. But it is possible to extend the programs to cope with skew wires or bent wires such as a folded dipole or a cubical quad. With different basis functions it would be possible to analyse the effects of metal structures in the vicinity of the antenna, as the case of vehicle-mounted antennas.

References

1. Antenna Theory and Design, by Stutzman and Thiele, Wiley, 1981, p226.
2. Radio Communication Handbook, Radio Society of Great Britain, 1969, p14.22.

Enquiries about software described in this article should be addressed to the author at Cadney, Highfield Road, Whiteshill, Stroud, Gloucester GL6 6AJ.

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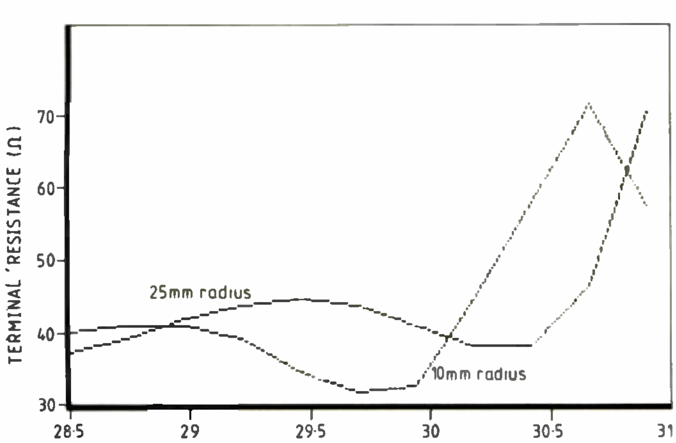

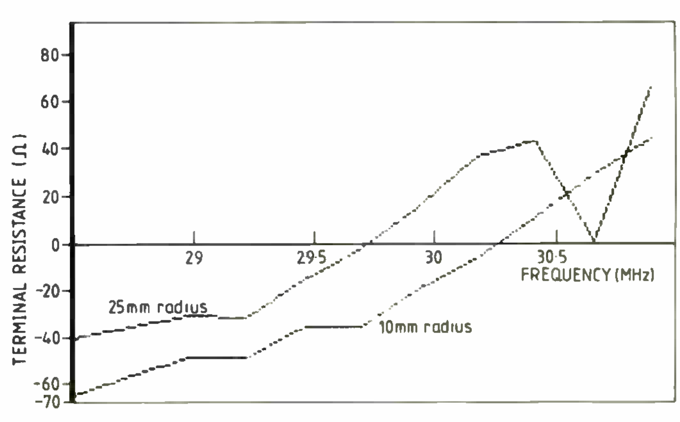

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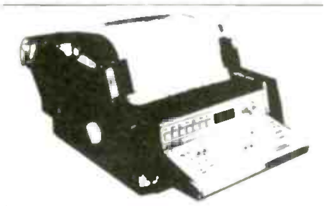

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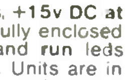

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Pioneers

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7. Alexander Graham Bell (1847-1922): speech shaped current

Institution of Electrical Engineers.

What do the following items have in common: the National Geographic Society, the American magazine *Science*, aircraft ailerons, and sheep with four nipples? No, it's not Trivial Pursuit. All were steered into existence by the same man, the inventor of the telephone.

To most people the telephone is one of the greatest inventions of all time. Yet one American newspaper reporter wrote "It is an interesting toy . . . but it can never be of any practical value."

That reporter was not alone in dismissing the new invention. A British official thought it might prosper in the colonies but not in Britain since "we have an abundance of messenger boys". And the great Western Union Telegraph company rejected an offer to buy the patent. "Bell's profession is that of a voice teacher," they observed. "Yet he claims to have discovered an instrument of great practical value in communication which has been overlooked by thousands of workers who have spent years in the field."

The patent Western Union turned down was one of the most lucrative ever issued, for the commercial success of the telephone was as immediate as it was dramatic. Although Bell at first gave lectures and demonstrations to raise much-needed cash (reserved seats cost 50 cents and the first profit was $149) the success of the telephone made him and his assistant, Thomas Watson, financially secure by 1881. The telephone was by then a mere five years old.

Western Union did, however, get one thing right in their assessment of Bell: he was indeed a teacher of the deaf.

Born in Edinburgh on March 3, 1847, he was christened Alexander. On his eleventh birthday he decided he would like a second Christian name and chose Graham. He and his two brothers inherited a family tradition of teaching elocution. His grandfather had practised in London and his father was the inventor of a phonetic alphabet called Visible Speech. Both Bell's mother and wife were deaf. Helping deaf people learn to speak became his main career.

Bell received his early education from his mother and he became an accomplished pianist. At ten years of age he started school. By the time he entered University College, London at 20, he had taught elocution at Elgin, Edinburgh and Bath.

At university he studied anatomy and biology. But before that, in a letter to his father, he had written up his first scientific research, on the resonant pitches of mouth cavities. As a result of this he was introduced to the work of Helmholtz and gained his first knowledge of electricity.

His brothers died early from tuberculosis. Partly fearing for the health of their remaining son, the family quit Britain for the healthier climate of Canada on August 1, 1870.

In Quebec, Bell taught his father's Visible Speech to deaf pupils and began to teach teachers of the deaf. In 1873 he was appointed professor of vocal physiology at Boston University. Nine years later he became a US citizen, and very proud of the fact he was too.

MAKING SOUND VISIBLE

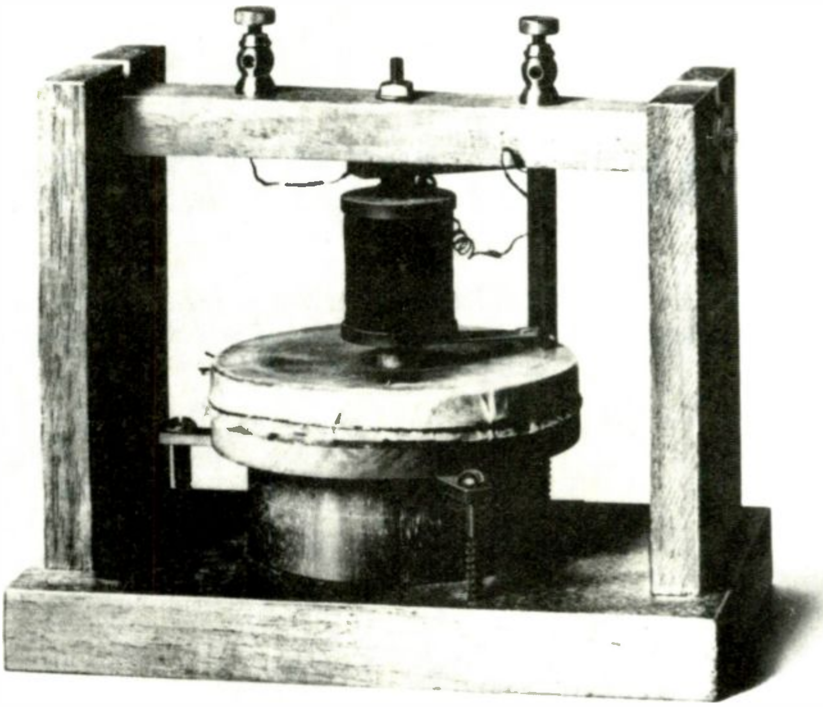
Work with the deaf turned Bell's intellect to all things related to the human voice. In searching for teaching aids he came across the phonautograph, a device with a conical mouthpiece and a stretched membrane which vibrated in response to the voice. The mechanical vibrations were conveyed to a stylus which traced the wave pattern of the voice on to a moving piece of glass blackened with soot.

These and other attempts to make a visual record of a human voice for use as a teaching aid for the deaf were crucial to the invention of the telephone. The step from a mechanical record of voice waves on blackened glass to electrical waves in a wire was the mark of genius. But it did not come in a flash.

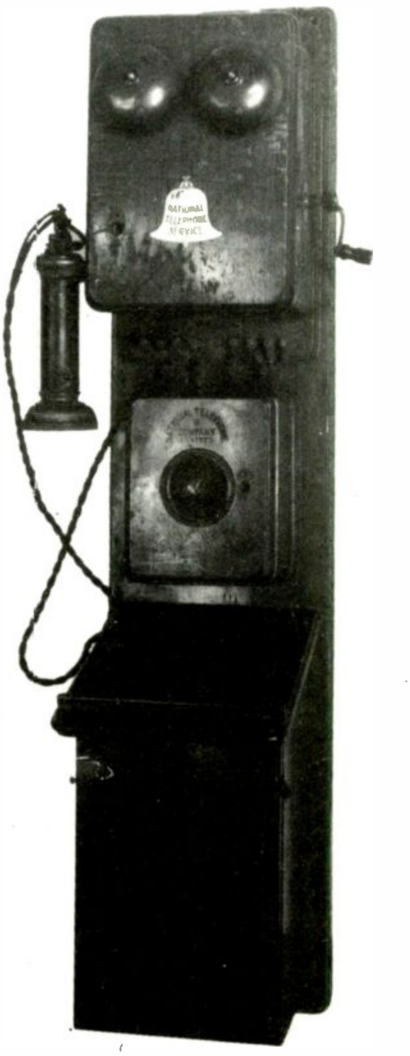
For several years Bell had been actively interested in telegraphy and a parallel problem with which he now wrestled was how to use an intermittent electrical current to transmit musical tones via the telegraph. This he thought possible if the vibrations of the air could be somehow reproduced in an electrical current.

In the summer of 1874 he visited his father's home in Brantford, Canada, taking with him a human ear provided by the Harvard Medical School. The idea was to use the ear and the small bones of the ear to make an improved phonautograph: a piece of hay acted as the stylus. The human-ear phonautograph worked!

If the relatively massive bones of the ear



This instrument was used to transmit the first speech sounds electrically in 1875. The parchment diaphragm is attached to a magnetized metallic reed. Piture from AT&T.



An early British instrument, of about 1890: a wall telephone of the National Telephone Company. Picture from British Telecom.

could be vibrated, thought Bell, why not a small piece of steel? The basic concept of the telephone now crystallized, though its practical achievement was still far away. When a practical realization came we can be thankful that the mouthpiece did not need a human ear cut from a corpse.

Whilst continuing his work with the deaf in Boston, Bell had for some time been working on ideas for a multiple telegraph, one which would enable simultaneous signalling of many messages to take place along a single line. By this time he had met a young machinist, Thomas A. Watson, and towards the end of 1874 they worked together at Bell's idea for multiple telegraphy. In that same year Bell explained his telephone idea to the aged Joseph Henry, seeking his advice as to whether to publish the idea so that others could work at it or to finish it himself. Henry told Bell to finish the work himself. When Bell confessed that he did not have the electrical knowledge needed Henry's advice was blunt: "Get it!"

Bell meantime had obtained financial backers: not for the telephone, but for the multiple telegraph, for which his backers had greater hopes. (When the telephone became a success Bell himself insisted that it be part of the agreement.)

A LITTLE ACCIDENT

With his experience of the phonautograph and his mental concept of the telephone, a little accident with the multiple telegraph equipment showed Bell how to achieve his dream of electrical speech.

The multiple (or harmonic) telegraph was to work as follows. At the transmitter and receiver there were tuned vibrating reeds. A reed at the transmitter tuned to a frequency f_1 could, according to the theory, send a pulsed signal which would only be detected by a reed also tuned to f_1 at the receiver. Several reeds tuned at different frequencies (f_1, f_2, f_3, etc) should enable several pulsed signals to be transmitted simultaneously.

On June 2, 1875, in the middle of a baking hot afternoon, Watson and Bell were retuning the reeds when one of Watson's transmitter reeds stuck. The adjustment screw had been screwed too far. To restart Watson plucked it and Bell, at the receiver, gave a loud shout.

Held too hard, the reed had failed to interrupt the current and had produced a continuous sine wave instead. Bell recognised the answer to his dreams. The rest of the afternoon and evening were spent repeating and repeating the discovery.

By the time they parted Bell had sketched out a diagram of the first telephone and begged Watson to try to build it ready for the next evening. "And, as I studied the sketch on my way home to Salem on the midnight train," Watson recalled, "I felt sure I could do so." He did. The next evening the first faint sounds (not speech) were transmitted and received. As yet unintelligible they proved Bell's basic idea.

During the ensuing months, work on the multiple telegraph took enforced priority over the telephone, along with ill health, personal crisis, and teaching duties. An American patent covering the telephone was allowed on Bell's 29th birthday, March 3, 1876. It was actually issued four days later.

On the evening of March 10, intelligible speech was achieved using a 'liquid' transmitter and a tuned-reed receiver. In the new transmitter, designed by Bell and built by Watson, a metal wire attached to a diaphragm was dipped into acidulated water. The water and wire were part of the electrical circuit. As sound waves vibrated the diaphragm, the wire moved up and down in the liquid and so varied the resistance of the circuit. The telephone had arrived.

New transmitters and receivers followed, some using liquids and some employing the relative movements of magnetized coils and pieces of iron. These were demonstrated at the Centennial Exhibition in Philadelphia on June 25, 1876 (the day of Custer's last stand) and impressed all who saw them. Lord Kelvin, who was one of the technical judges, ran the 100-yard length of the gallery from the receiver to the transmitter to congratulate the inventor.

COMMERCIAL SUCCESS

Watson, after some persuasion, resigned his well-paid full-time job to take up full-time work on the telephone. He received a tenth share of the patent. In November, using yet another new design, successful tests were conducted between Boston and North Conway in New Hampshire using a railway telegraph wire, a distance of over 100 miles.

A company was formed in July 1877 two or three months after the first regular telephone lines opened in Boston. Other Bell companies followed swiftly for various reasons, and a reorganization in 1880 created the American Bell Telephone Company.

Western Union meanwhile had set up in competition after the principle of the telephone had become known. Bell sued for infringement of his patents and won. The Bell patents were repeatedly defended in the courts, on about 600 cases, before the Supreme Court eventually upheld all Bell's claims.

Bell meanwhile had married Mabel Hubbard, one of his private pupils and the daughter of one of his financial backers, on July 11, 1877. The marriage was long and happy despite the loss of two of their four children at birth. In August they sailed to Europe to promote the telephone, leaving Watson in charge for over a year. At the time of the wedding a couple of hundred telephones were in operation.

By 1881 both Bell and Watson had moved on to other interests.

Bell continued his absorbing interest in teaching the deaf to speak well. His interest in hereditary deafness led him to studies of longevity and breeding. In 1909, after 20 years' selective breeding, he had a flock of sheep with four or more milk-producing nipples rather than the usual two! Therein lies a tale in itself.

In 1880 France awarded Bell the Volta Prize of 50 000 francs. This he used to establish the Volta Laboratory Association in Washington to work with the deaf. Two years later he conceived the idea for the journal *Science* which began publishing in 1883. In its first eight years Bell and his father-in-law subsidized the journal to the tune of around $100 000.

Bell also helped organize and finance the National Geographic Society and was its president for several years, and he gave $5000 to establish the Smithsonian Astrophysical Laboratory.

For the last 25 years or so of his life one of his main interests was aviation. With a gift of $50 000, he founded the Aerial Experiment Association under whose auspices some of the earliest flights took place in 1908. Bell and the Association held the patent for the design of ailerons for wings and rudders.

He also invented a tetrahedral constructional technique known as space frame, tried to introduce the Montessori educational method to America, and developed an interest in designing hydrofoil boats. One of his hydrofoils gained the world water speed record in 1919 at 70.86 miles per hour.

Amongst the honours Bell received was the freedom of Edinburgh (this birthplace), the opening of the first trans-continental telephone link between New York and San Francisco in 1915, and the naming of an island after him.

After his death in 1922, at the age of 75, he was buried in a rock tomb on top of a mountain. Every telephone in North America was silent for one minute during his funeral.

Next in this series of pioneers of electrical communication will be Oliver Heaviside.

Tony Atherton works at the Independent Broadcasting Authority's engineering training college in Devon. His book, From Compass to Computer, A History of Electrical and Electronics Engineering, was published by Macmillan in 1984.

68000-family Pascal machine

If you need to decide which computer language to use for your next industrial control system, one of the new breed of Pascal compilers may be ideal.

W.P. STANLEY

Pascal was designed as an easy-to-learn language to teach students how to write programs, which humble beginning it shares with Basic but unlike that language, Pascal enforces the concept of structured programming. To someone who has used Basic, Pascal may appear to be pedantic, it lacks a 'goto' statement for instance, but its strength is that it forces the programmers to understand the true nature of the task before starting to write a program. This means that the program is produced in the correct construction, if not in detail, the first time round as opposed to a poorly concieved core modified by layers of 'goto' statements and extra modifications to get it to work. Even if the time taken to write in both forms is the same, the real cost advantage of Pascal is that the resulting program is self-documenting to a large extent, which leads to easier and faster maintenance.

One of the strengths of Pascal is its comprehensive selection of data types available to the programmer, which now encompass boolean, character (byte), enumerated type, integer, longinteger, hex, longhex, real, string, array, record, devices and files, and pointers. The string functions, so long a weak point in Pascal, have now been enhanced to give similar performance to those in Basic, which has always enjoyed powerful string operators.

Pascal has been limited by some of the same problems as Basić in that it was only available in an interpretive form or with intermediate code output which produced slow executing programs. This tended to preclude control by the programmer as to where variables were held; the compiler or interpreter allocated space in the memory, usually via the stack, or optionally on a reverse stack, the 'heap', without any bearing on the wishes of the programmer. For industrial control, or for any application which wants to poke its nose outside the confines of the operating system, it is essential to be able to access absolute addresses in the memory map to talk to i/o ports. This is now possible in Pascal because the user can specify how the variables are held; on the stack (by default), at an extended (absolute) address, program counter relative, defined in another module or, on 16bit processors, in a c.p.u. register.

A requirement for most programs is the ability to perform simple operations on all relevant classes of data without large processing overheads; things like OR, EOR, AND, NAND and shift. This limitation is overcome in the latest generation of Pascal compilers, which can produce compact 'romable' position-independent object code that is frugal on memory and has a runtime library overhead proportional to the function used. To give figures for one particular compiler, the Omegasoft 68000 Pascal compiler, typical runtime overhead is between 1 and 3Kbytes, with a minimum of about 50 bytes and a maximum of 10K using every function and data type; the compiler efficiency is about 0.4 that of hand-coded assembler but the execution speed is fast. This compares well against a C compiler running on the same operating system; the code efficiency is about the same and the Pascal programs usually execute faster. This is not intended to show that Pascal compilers are 'better' than C compilers, simply that they are comparable and that C code is not automatically the optimum solution.

Another development, which has become more common in the later compilers, is to surround the compiler with a suite of utilities that make the task of converting the program into debugged object code much easier. In the example of Omegasoft Pascal, this takes the form of a easy-to-use linkage creator which asks the user a series of questions about the physical properties of the hardware and produces a small assembler program as a result. This sets all the relevant stack pointers for the main Pascal program and also produces a procedural file which will assemble and link all the needed modules.

A type of utility that has become popular is the interactive debugger, which will allow the programmer to debug software at Pascal line level, to be able to breakpoint to a line

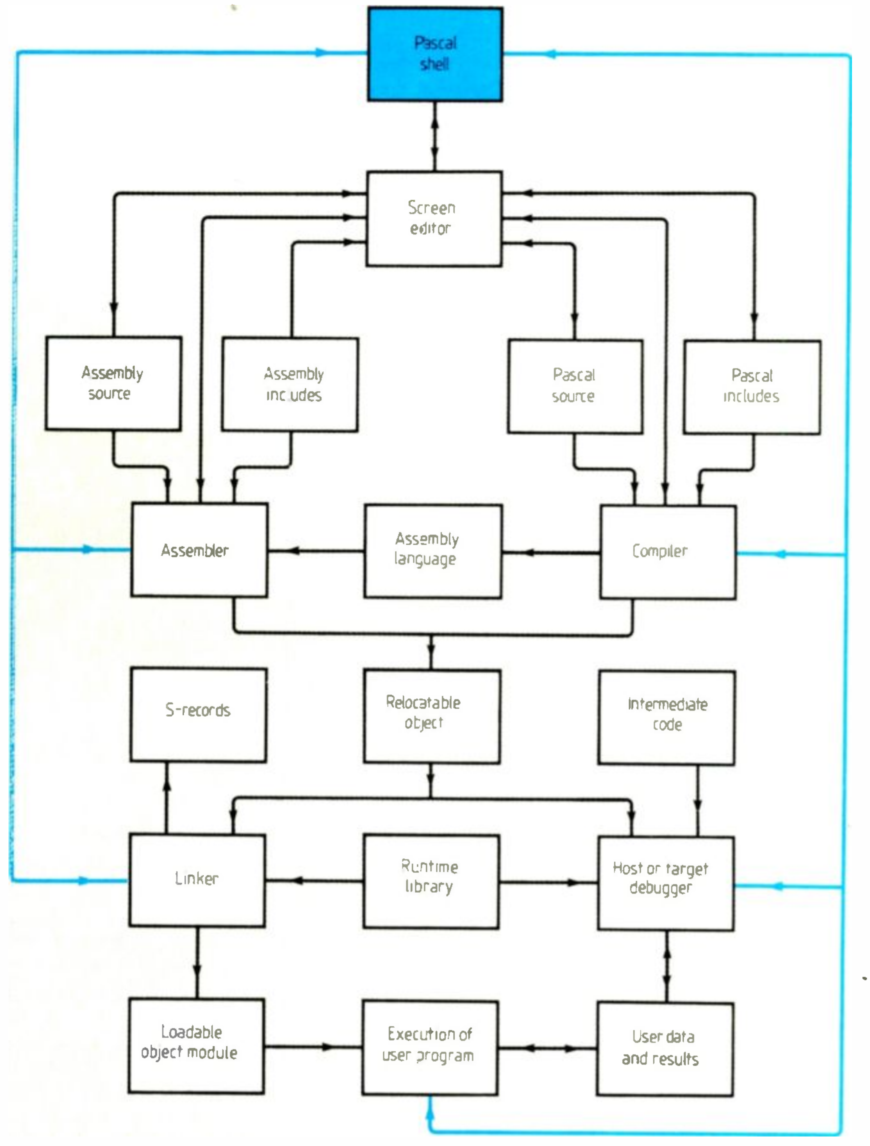
68000-FAMILY PASCAL ENVIRONMENT UP-DATE

- Can now compile programs from inside the editor so that syntax checking of a new piece of code is now very quick. Errors found by the compiler in this mode are passed back to the editor on a stack, and can be popped off the stack by an editor command to quickly move from error to error.
- Compiler now supports longreal types in the IEEE 64-bit format and can support the 68881 floating point coprocessor as a peripheral.
- A 'Pascal shell' provides a complete Pascal programming environment for each project. This keeps track of all the related files in a suite of programs so that when changes are made to one file it it easy to recompile and link all the modules back together with just a few keystrokes. It also allows considerable control over the recompilation; you can specify to recompile all files modified after a certain date and time, or after the date on a particular file. Only the files related to the task are kept inside the shell environment so that the rest of the operating system 'clutter' is not obscuring the work. All the Omegasoft utilities are catered for from inside the shell. It is possible to edit a set of files, then tell the shell to recompile and load the debugger, leaving the user ready to start debugging, or recompile, assemble and link and produce 'romable' code files.
- An optimized 68020 version of the compiler will support f.p.u. (68881 and 68882) directly on the coprocessor interface with in-line code, and should be available in July or August.
- Source code of the pascal shell, linkage creator, screen editor and runtime library are included for reference.

number, display or change variables by name, trace by line or by procedure. The more sophisticated debuggers, usually found on 16 or 32-bit processor versions, will allow assembler modules to be added for debug along with other Pascal modules, and permit macro definitions of the debugger commands. They may even have an assembler-level debug inside which will allow debug and disassembly of assember or Pascal programs. A software tool with this kind of capability is quite a large program in its own right, and a fully-fledged one may take over 100Kbytes of memory space and assumes that the industrial i/o hardware is in its own memory map. As it takes so much memory to support all these features, this kind of debugging is only found on the larger 16/32bit processors and although eight-bit versions are available, the powerful features have been trimmed down to allow them to fit into a 64Kbyte address space.

To give another example, this time Omegasoft's 6809 Pascal compiler, where the debugger uses overlays to maximize the size of program it can debug; has no assembler level phase and cannot support macros, though it can single-step, set breakpoints, examine and change variables. It takes about 30Kbytes of memory which, when added to the operating system leaves about 15 to 20Kbytes for the program to be debugged, should allow room for between 100 and 400 lines of Pascal, depending on the functions being used. Many applications will fit into this space, but if not then it is possible to write larger programs as a series of modules, and debug the modules separately before joining them all together to produce the final object program.

For 16/32 bit processors the overhead of 100K for the debugger in a development environment is not a problem as memory for these systems is now relatively cheap. If development is done on a modular hardware system such as VME, this may not be too much of a problem as the necessary functions can be plugged into the target system so that in effect it is a development system with large amounts of ram and mass storage. After the debugging is complete the excess items can be removed from the system. If the target system is a limited-function system that has been designed for a specific purpose without room to accommodate the host debugger, a different approach is needed, and this is provided by a target debugger.



First introduced to the 6809 market in 1980, Omegasoft Pascal has been expanded and refined, with major extension to the ISO level 0 standard that allow its use for industrial control and other real-time applications. It is newly available from Certified Software Corporation of California (RCS Microsystems in the UK) to run under OS-9, P-DOS, Versados and CP/M-86K operating systems.

This technique was first used by Digital Equipment Corp. for their 'Micropower Pascal' and has subsequently been adopted by other vendors. It involves writing a small program, usually in assembler, to copy data from the target serial port to and from ram on the target system. The bulk of the debugger now resides in the users host or development system, which will have mass storage and plenty of ram, and the program to be debugged is passed to the target via the serial port. When excecuted, this target debug affords the user the same power as the host debugger, but only requires a small overhead in the target memory.

Pascal has become an excellent tool for writing software in the industrial control environment. The standard ISO core compiler with its large selection of data types and extensive intrinsic library functions has been extended to permit easy access to hardware and to overcome some of its previous limitations. The result is that programs can be written in Pascal, which produces clear and concise listing documentation, that can be just as efficient and fast as any other compiler. Added to that are the benefits of interactive debugging on a host or target system and the extra utilities for making stand-alone 'prommable' code easily. Could this be the language that reaches parts of your control system that other languages cannot reach?

William Stanley is Omegasoft product manager with RCS Microsystems of Hampton Hill, Middx. tel. 01-979 2204.

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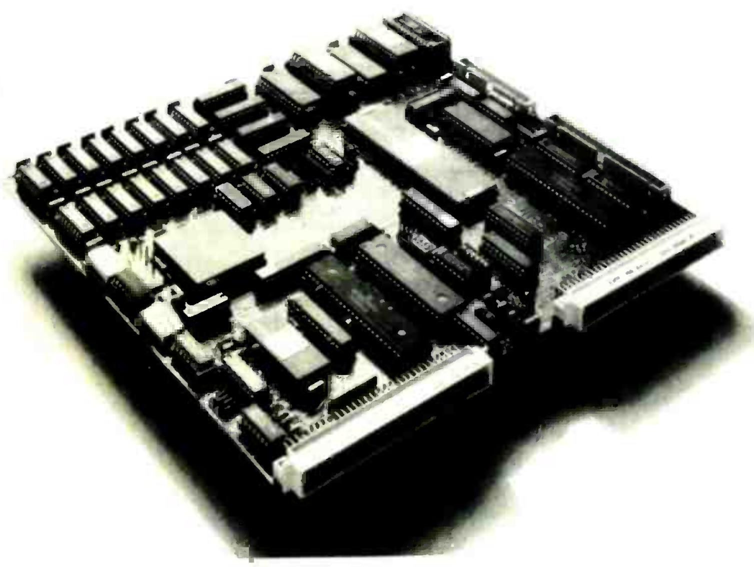

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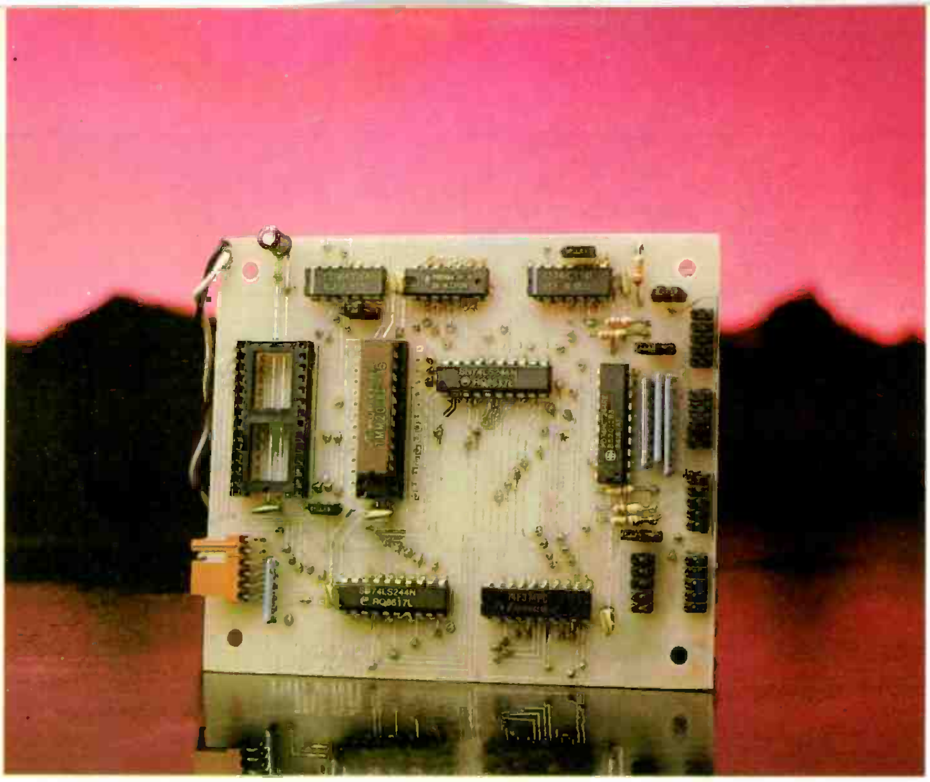

Video frame store

Fast look-up table enables the unit to manipulate moving images in real time for flicker-free special effects.

D. E. A. CLARKE

The frame store* is a powerful tool for image capture, but in its basic form it has no facilities for real-time image processing. Manipulation of images must therefore be done entirely by the host computer.

The look-up table is a significant enhancement because it enables the real-time manipulation of pixel grey-levels to be achieved either by selecting pre-programmed (rom-based) tables or by down-loading computer generated tables from the host c.p.u. into an on-board high speed ram. These ram-based tables can be updated during the field blanking interval on a frame-by-frame basis.

Look-up tables can be devised for contrast-stretching (linear or non-linear), histogram equalization, image negation, clipping, noise magnification etc. and the effect of these operations can be observed on live as well as frozen images.

The look-up table is constructed on a single p.c.b. designed to stack with the rest of the frame store boards. Installation is extremely simple, involving ribbon cable jumpering to the other boards without any modifications (other than to add appropriate connectors).

Two memory sockets are provided, one for a high-speed ram chip (typically 2K×8, 60ns) and one for a high-speed prom (typically 2K×8, 60ns). Both sockets can accommodate slower ram or eprom chips and 150ns devices are adequate for the 256×256

*Earlier articles in this series appeared in *Electronics & Wireless World* from November 1986 to March 1987. A correction to a drawing in the March issue was given the following month at the foot of page 385.

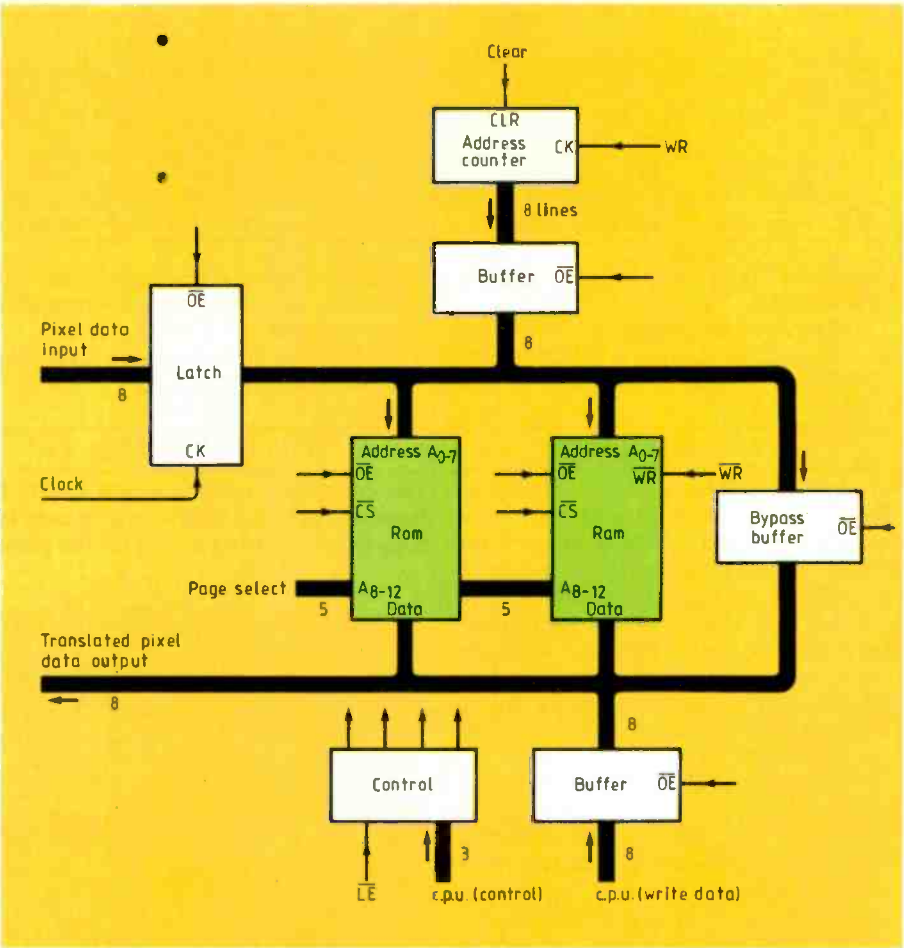

Fig.1. The look-up table allows pixel grey-levels to be manipulated in real time. Look-up data can be in rom, or can be downloaded into ram from the host computer.

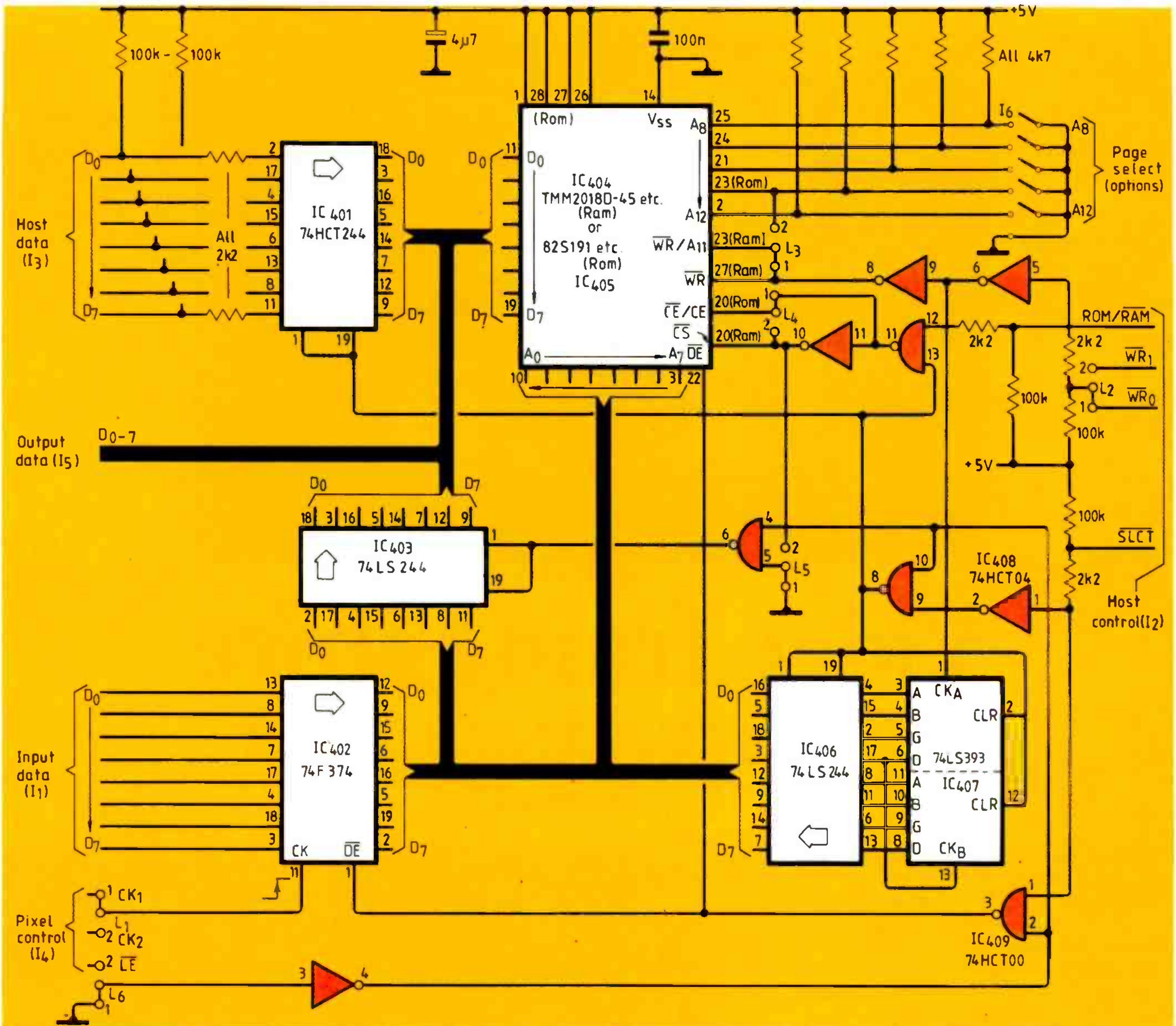

Fig.2. All components fit on a single p.c.b. which can be jumpered to the other boards. A source of components is given opposite.

configured frame store which clocks at about 5.8MHz.

The p.c.b. is configurable for several types of rom and ram devices in 24/28-pin and 300/600 mil packages.

SYSTEM CONFIGURATION

The look-up table is shown in block diagram form in Fig.1. The board is designed to be inserted between the sample bus and the digital-to-analogue converter on the analogue board as shown in Fig.4 (upper). Both live and frozen image pixels are then processed in the same way but the image data in the frame store memory always contains true data. The colour palette can be located on the look-up table input bus or on the translated pixel output bus.

Two other configurations are also possible:

1. The look-up table can be positioned between the analogue-to-digital converter and the image memory as shown in Fig.4 (lower) and the image data in ram will then be translated prior to storage as well as display.
2. Both configurations can be implemented simultaneously using two look-up table boards to achieve both image write data translation and image read data translation at the same time.

The latter configuration cannot usually be justified for normal applications.

CIRCUIT OPERATION

The complete circuit is shown in Fig.2. Incoming eight-bit pixel data is retimed by IC_{402} which latches the data on the rising edge of the sample clock; a complete clock cycle is then available for memory access because output data is latched by the d.a.c. and colour palette boards on the next rising edge of CLOCK. This extra delay of one pixel causes the displayed image to be displaced to the right, and shifts into view a hidden pixel at the left of the picture while blanking the pixel on the right. This is of no consequence for displayed images since there are several perfectly valid hidden pixels, but image

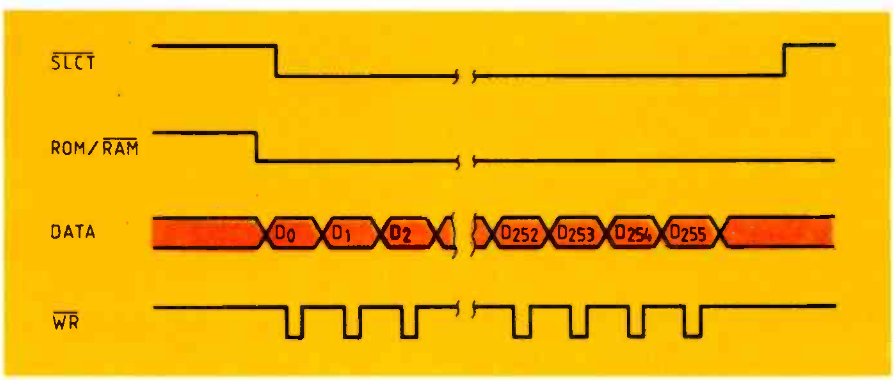

Fig.3. Sequence for downloading data to the look-up table's on-board ram.

manipulation software should be designed to take the displacement into account.

The latched pixel data directly addresses the on-board rom or ram and the resultant output data becomes the new pixel value. It follows that 256 grey levels can be translated into 256 alternative values depending upon the contents of the addressed table.

Using 8K×8 memory devices gives the capability for up to 32 tables selectable by optional external switches.

Ram or rom-based tables are selected by the host control signal ROM/$\overline{\text{RAM}}$ which when high (or open-circuit) selects the rom or, if a rom is not fitted, the bypass buffer IC_{403}. The bypass mechanism enables the frame store to be operated without the host's having to initialize the on-board ram. Various control signals are derived by IC_{408} and IC_{409}; these are 74HCT series devices as is the host data buffer IC_{401} for ease of interfacing and good noise immunity.

The host gains access by asserting $\overline{\text{SLCT}}$ which enables the address counter IC_{407}, enables buffers IC_{406}, IC_{401}, disables latch IC_{402}, disables buffer IC_{403} and three-states the ram/rom output buffers. The ram is enabled by taking ROM/$\overline{\text{RAM}}$ low and data written by pulsing $\overline{\text{WR}}$ low. The address counter is incremented on the rising edge of $\overline{\text{WR}}$ which provides for very fast table updating.

Taking $\overline{\text{SLCT}}$ high enables pixel translation by enabling the latch IC_{402} and either the rom or ram depending upon the control signal ROM/$\overline{\text{RAM}}$ and disabling buffers $IC_{401,406}$. Link 1 normally selects CK_1; Link 2 allows two look-up table boards to be individually programmed by pulsing the appropriate $\overline{\text{WR}}$ line.

Link 3 will normally be in position 1 for 2K×8 ram devices when pin 23 is $\overline{\text{WR}}$. Link 4 allows the use of rom devices when the polarity of pin 20 changes. Link 5 should be in position 2 when a rom is not fitted; this enables the bypass buffer IC_{403} (which can otherwise be omitted).

When the look-up table is positioned between the sample bus and the a-to-d on the analogue board, it must be disabled during c.p.u. frame memory update; the signal $\overline{\text{CE}}$ is used for this purpose and is selected by Link 6 in position 2.

PROGRAMMING

The sequence for programming the look-up table ram is shown in Fig.3. The $\overline{\text{SLCT}}$ line is taken low, ROM/$\overline{\text{RAM}}$ is taken low and data is output to IC_{401}; $\overline{\text{WR}}$ is then pulsed low and the cycle repeated. Finally, $\overline{\text{SLCT}}$ is taken high to enable the look-up table.

This example program generates a table for negative displayed images:

```
PROGRAM NEGATIVE;

BEGIN;
   OUTPUT( SLCT ) := 0;                        {SELECT HOST ACCESS MODE}
   OUTPUT( ROM/RAM ) := 0;                                 {SELECT RAM}
   FOR COUNT := 0 TO 255 DO                      {UPDATE 256 LOCATIONS}
     BEGIN;
       OUTPUT( DATAPORT ) := NOT COUNT; {OUTPUT NOT COUNT AS DATA}
       OUTPUT( WR ) := 0;         {STROBE RAM AND INCREMENT ADDRESS}
       OUTPUT( WR) :=1;
     END;
   OUTPUT( SLCT ) :=1;                       {ENABLE PIXEL TRANSLATION}
END.
```

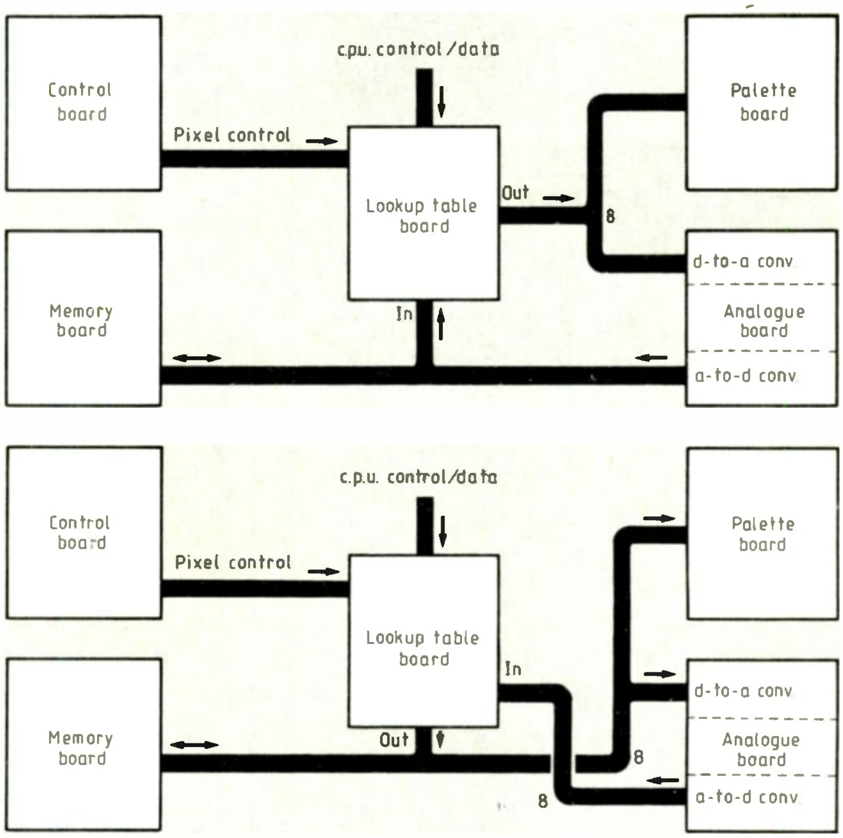

Fig.4. Two contrasting arrangements of the look-up table: above, the frame store memory always contains true data; below, image data is translated prior to storage.

Table 1: Link programming All are two-way change-over links

Link	Position 1	Position 2
1	normal	
2	personality (see text)	
3	TMM2108 ram	6264 ram
4	active low	active high rom select
5	rom fitted	auto-bypass in rom-less system
6	board location (see text)	

INSTALLATION

Note when installing the look-up table that there is an option for separate data buses for the d.a.c. and a.d.c. on the analogue board, as shown in Fig.11 of the December 1986 article. The links which connect these buses together should be left open-circuit and an additional connector installed so that separate connectors are available for d.a.c. and a.d.c. data. There is provision for this on the p.c.bs available for this project.

The ribbon cable carrying pixel data between the memory board, colour palette (if fitted) and the converter board should now be connected as follows:

memory→look-up (input)→a.d.c.

An additional jumper cable should be assembled and used to connect

look-up (output)→palette→d.a.c.

Finally, the look-up table p.c.b. must be connected (in parallel with the other boards) to the pixel control bus and the host interface buses by clamping additional connectors to the appropriate ribbon cables.

FEATURES OF THE LOOK-UP TABLE

- **Eight-bit picture element data input**
- **Eight-bit translated data output**
- **256 entries per table**
- **Throughput to 15MHz**
- **Up to 32 rom-based tables**
- **Up to 32 ram-based tables**
- **Auto bypass**
- **User-configurable hardware options**
- **Simple installation**

With the addition of a clock generator, an eight-bit counter to simulate incoming pcls and a d.a.c. at the output this design could also be used as a programmable arbitrary waveform generator with time resolution down to 65ns. For a suggested design which avoids the need to modify the p.c.b. send a stamped, self-addressed envelope to the editorial office. Mark your covering envelope 'Video frame store'.

P.c.bs and components are available from Ipswich Electronics Ltd, Hadleigh Road Industrial Estate, Ipswich IP2 0HB, tel. 0473-216056; semiconductor devices from Technomatic Ltd, 17 Burnley Road, London NW10 1ED, tel. 01-723 1177.

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MC1351P	1.50
MC1352P	1.00
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SN76110N	0.89
SN76115N	1.25
SN76131N	1.30
SN76226DN	2.95
SN76226N	1.05
SN76533N	1.65
SN76544	2.65
SN76650N	1.15
SN76660N	0.80
STK014	7.95
STK015	7.95
STK025	11.95
STK078	11.95

STK085	8.95
STK433	5.95
STK435	7.95
STK437	7.95
STK439	7.95
STK461	11.50
STK463	11.50
TA7061AP	3.95
TA7108P	1.50
TA7120P	1.65
TA7130P	1.50
TA7176AP	2.95
TA7203	2.95
TA7204P	2.15
TA7205AP	1.15
TA7222AP	1.80
TA7227P	4.25
TA7310P	1.80
TA7313AP	2.95
TA7321P	2.25
TA7146P	2.50
TA7609P	3.95
TA7611AP	2.95
TAA310A	3.50
TAA320A	3.50
TAA350A	3.50
TAA570	1.95
TAA661B	1.95
TBA700	1.70
TBA120AS B/C/ SA/SB/T/U	1.00
TBA395	1.50
TBA396	0.75
TBA440N	2.55
TBA480Q	1.25
TBA510	2.50
TBA510Q	2.50
TBA520	1.10
TBA520Q	1.10
TBA530	1.10
TBA530Q	1.10
TBA540	1.25
TBA540Q	1.35

TBA550Q	1.95
TBA560C	1.45
TBA460CQ	1.45
TBA570	1.00
TBA651R	2.50
TBA720A	2.45
TBA750Q	2.65
TBA800	0.89
TBA810AS	1.65
TBA810P	1.65
TBA820M	0.75
TBA820Q	1.45
TBA890	2.50
TBA920	1.65
TBA950/2X	2.35
TBA990	1.49
TCA270	1.50
TCA270SQ	1.50
TCA650	3.50
TCA940	1.65
TCEP100	2.50
TDA440	3.50
TDA1001	2.95
TDA1002A	2.95
TDA1006A	2.50
TDA1035	2.50
TDA1037	1.95
TDA1074A	2.50
TDA1170	1.95
TDA1190	2.15
TDA1270Q	5.50
TDA1327	1.70
TDA2002	1.95
TDA2003	1.95
TDA2004	2.95
TDA2005	2.95
TDA2006	1.95
TDA2020	2.95
TDA2030	2.80
TDA2523	2.95
TDA2524	1.95
TDA2530	1.95
TDA2532	1.95

TDA2540	1.95
TDA2545A	2.15
TDA2451	2.15
TDA2560	2.15
TDA2571A	4.50
TDA2581	2.95
TDA2593	2.95
TDA2600	6.50
TDA2610	3.50
TDA2611A	1.95
TDA2640	3.50
TDA2680A	2.75
TDA2690	2.45
TDA3310	2.95
TDA3560	5.50
TDA4600	2.50
UPC566H	2.95
UPC575C2	2.75
UPC1025H	1.95
UPC1028H	1.95
UPC1032H	1.50
UPC1156H	2.75
UPC1158H	0.75
UPC1157C2	1.95
UPC1181H	1.25
UPC1182H	2.95
UPC1185H	3.95
UPC1191V	1.50
UPC1350C	2.95
UPC1353C	2.45
UPC1365C	3.95
UPC2002H	1.95
555	0.36
556	0.60
723	0.50
741	0.35
747	0.50
748	0.35
7805	0.65
7808	0.60
7815	0.65

SEMICONDUCTORS

AAY12	0.25
AC125	0.20
AC126	0.45
AC127	0.20
AC128	0.28
AC128K	0.32
AC141	0.28
AC142K	0.79
AC176	0.22
AC176K	0.31
AC187	0.25
AC187K	0.28
AC188	0.25
AC188K	0.37
ACY17	1.15
AD149	0.70
AD161	0.39
AD162	0.39
AD161/2	0.90
AF106	0.50
AF114	1.95
AF115	2.95
AF116	2.95
AF117	2.95
AF121	0.60
AF124	0.65
AF125	0.65
AF126	0.65
AF127	0.65
AF139	0.40
AF150	0.60
AF178	1.95
AF239	0.42
AFZ12	3.75
ASY27	1.25
AU106	6.95
AU113	6.95
BC107A	0.11
BC107B	0.11
BC108	0.10
BC108B	0.12
BC109	0.10
BC109B	0.12
BC109C	0.12
BC114	0.11
BC116A	0.15
BC117	0.19
BC119	0.24
BC125	0.25
BC139	0.20
BC140	0.31
BC141	0.25
BC142	0.21
BC143	0.24
BC147B	0.12
BC148A	0.09
BC148B	0.09
BC149	0.09
BC157	0.12
BC158	0.09
BC159	0.09
BC174A	0.09
BC177	0.15
BC178	0.15
BC182	0.10
BC182LB	0.10
BC183	0.10

BC183L	0.09
BC184LB	0.09
BC204	0.10
BC207B	0.13
BC208B	0.13
BC212	0.09
BC212L	0.09
BC213	0.09
BC213L	0.09
BC214	0.09
BC214C	0.09
BC214L	0.09
BC237B	0.09
BC238	0.09
BC239	0.12
BC251A	0.12
BC252A	0.15
BC258	0.25
BC258A	0.39
BC2284	0.30
BC300	0.30
BC301	0.30
BC303	0.26
BC307B	0.09
BC327	0.10
BC328	0.10
BC337	0.10
BC338	0.09
BC347A	0.13
BC461	0.35
BC478	0.20
BC527	0.20
BC547	0.10
BC548	0.10
BC549A	0.10
BC550	0.14
BC557	0.08
BC557B	0.80
BC558	0.10
BCY33A	1.60
BD115	0.30
BD124P	0.59
BD131	0.42
BD132	0.42
BD133	0.40
BD135	0.30
BD136	0.30
BD137	0.32
BD138	0.30
BD139	0.32
BD140	0.30
BD144	1.10
BD150C	0.29
BD159	0.65
BD160	1.50
BD166	0.95
BD179	0.72
BD181	0.45
BD182	0.70
BD183	0.70
BD201	0.83
BD202	0.65
BD203	0.78
BD204	0.70
BD222	0.46
BD223	0.59
BD225	0.48

BD232	0.35
BD233	0.35
BD234	0.35
BD236	0.49
BD237	0.40
BD238	0.40
BD242	0.65
BD246	0.75
BD376	0.32
BD410	0.65
BD434	0.65
BD437	0.75
BD438	0.75
BD520	0.65
BD538	0.65
BD597	0.95
BD589	0.45
BD701	1.25
BD702	1.25
BD707	0.90
BDX32	1.50
BF115	0.35
BF119	0.35
BF119	0.65
BF127	0.39
BF154	0.20
BF158	0.22
BF160	0.27
BF167	0.27
BF173	0.22
BF177	0.38
BF178	0.26
BF179	0.34
BF180	0.29
BF181	0.29
BF182	0.29
BF183	0.29
BF184	0.28
BF185	0.28
BF194	0.11
BF195	0.11
BF196	0.11
BF197	0.11
BF198	0.16
BF199	0.14
BF200	0.40
BF241	0.15
BF245	0.30
BF257	0.28
BF258	0.28
BF259	0.28
BF271	0.26
BF273	0.18
BF336	0.34
BF337	0.29
BF338	0.32
BF355	0.37
BF362	0.38
BF363	0.65
BF371	0.25
BF394	0.19
BF422	0.32
BF457	0.32
BF458	0.36
BF459	0.36
BF467	0.68
BF494	0.45
BF495	0.45
BF595	0.23
BF597	0.25
BFR39	0.23
BFR81	0.25
BFR88	0.30
BFR90	1.50
BFR91	1.75

BFT42	0.35
BFT43	0.35
BFW92	0.85
BFX29	0.55
BFX84	0.26
BFX85	0.32
BFX86	0.30
BFX88	0.25
BFY50	0.21
BFY51	0.21
BFY52	0.25
BFY90	0.77
BLY48	1.75
BRY39	0.45
BR100	0.26
BR101	0.49
BR103	0.55
BRC4443	1.15
BT100A/0	20.85
BT106	1.49
BT116	1.20
BT119	3.15
BT120	1.65
BU105	1.95
BU108	1.69
BU124	1.25
BU126	1.60
BU204	1.55
BU205	1.30
BU208	1.39
BU208A	1.52
BU208D	1.85
BU3276	1.20
BU407	1.24
BU500	2.25
BU508A	1.95
BU526	1.90
BU80Y	2.25
BUY69B	1.70
MJ3000	1.98
MJE340	0.40
MJE520	0.48
MPSA13	0.29
MPSA92	0.30
MRF237	4.95
MRF450A	13.95
MRF453	17.50
MRF454	26.50
MRF455	17.50
MRF475	2.95
MRF477	13.50
MRF838	13.95
OC16W	4.50
OC23	9.50
OC25	1.50
OC26	1.50
OC28	5.50
OC29	4.50
OC32	5.50
OC42	1.50
OC44	1.25
OC45	1.00
OC70	1.00
OC71	0.75
OC72	2.50
OC75	1.50
OC81	1.00
OC84	1.50
OC139	12.50
OC171	4.50
OC200	4.50
OC201	5.50
OC205	10.00
R2008B	1.45
R2010B	1.45

R2322	0.58
R2323	0.66
R2540	2.48
RCA16334	0.90
RCA16335	0.80
SKE5F	1.45
TIP29	0.40
TIP29C	0.42
TIP30C	0.43
TIP31C	0.55
TIP32C	0.42
TIP33C	0.95
TIP34B	0.95
TIP41A	0.45
TIP41C	0.45
TIP42C	0.47
TIP47	0.65
TIP120	0.60
TIP125	0.65
TIP142	1.75
TIP161	2.95
TIP2955	0.85
TIP3055	0.55
TIS91	0.20
TV106 2	1.50
2N1308	1.35
2N2219	0.28
2N2222	0.29
2N2905	0.40
2N3053	0.40
2N3054	0.59
2N3055	0.52
2N3702	0.12
2N3703	0.12
2N3704	0.12
2N3705	0.20
2N3706	0.12
2N3708	0.12
2N3733	9.50
2N3733	2.75
2N3792	1.35
2N4427	1.95
2N4444	1.15
2N5294	0.42
2N5296	0.48
2N5298	0.60
2N5485	0.45
2N5496	0.95
2SA715	0.60
2SC495	0.80
2SC496	0.80
2SC1096	0.80
2SC1106	2.50
2SC1172Y	2.20
2SC1173	1.15
2SC1306	1.40
2SC1307	2.95
2SC1364	0.50
2SC1449	0.80
2SC1678	1.25
2SC1909	1.25
2SC1945	3.75
2SC1954	0.95
2SC1957	0.80
2SC1969	1.95
2SC2028	1.15
2SC2029	1.95
2SC2078	1.45
2SC2091	0.85
2SC2098	2.95
2SC2166	1.95
2SC2314	0.80
2SC2371	0.36
2SD234	0.50
3SK88	0.95

DIODES

AA119	0.80
BA115	0.13
BA145	0.16
BA148	0.17
BA154	0.06
BA156	0.15
BA157	0.30
BAX13	0.04
BAX16	0.12
BB105B	0.30
BT151	0.79
BY126	0.10
BY127	0.11
BY133	0.15
BY164	0.45
BY176	1.20
BY179	0.63
BT182	0.55
BY184	0.35
BT199	0.40
BY206	0.14

BY208-800	0.33
BY210-800	0.33
BY223	0.90
BY298-400	0.22
BY299-800	0.22
BYX10	0.20
BYX36-150R	0.20
BYX38-600R	0.60
BYX55-600	0.30
BYX71 600	1.75
BZY95C30	0.35
CS4B	8.00
CS107	16.50
OA47	0.15
OA90	0.10
OA91	0.15
OA95	0.10
OA202	0.20
IN21DR	5.00
IN23B	5.00
IN23C	5.00
IN23ER	5.00
IN23WE	5.00

IN4001	0.04
IN4003	0.04
IN4004	0.05
IN4005	0.05
IN4007	0.06
IN4148	0.02
IN4448	0.10
IN5401	0.12
IN5402	0.14
IN5403	0.12
IN5406	0.13
IN5407	0.16
IN5408	0.16
ITT44	0.04
ITT923	0.15
ITT2002	0.20

ZENER DIODES

BZX61 Series	0.15
BZY88 Series	0.10

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CME1428W	39.00
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CME1431GH	39.00
CME1431W	39.00
CME202GH	45.00
CME2024W	45.00
CME2325W	45.00
CME3218W	45.00
CME3132GH	45.00
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CV1526	19.00
CV2185	15.00
CV2191	19.00
CV2193	15.00
CV5119	85.00
CV5320	85.00
CVX389	55.00
D9-110GH	39.50
D10-210GH	45.00
D10-210GH68B	65.00
D10-230GH	35.00
D10-230GM	35.00
D10293-GY/90	55.00
D13-30GH	49.50
D13-51GL/26	85.00
D13-51GM/26	85.00
D13-45GH/01	55.00
D13-610GH	59.00
D13-511GH	59.00
D13-611GM	59.00
D13-630GH	59.00
D14-150GH	75.00
D14-150GM	75.00
D14-162GH/84	59.00
D14-172GR	55.00
D14-172GV	55.00
D14-173GH	55.00
D14-173GM	53.00
D14-173GR	55.00
D14-181GH/98	65.00
D14-181GJ	55.00
D14-181GM	53.00
D14-181GM50	59.00
D14-182GH	59.00
D14-200BE	89.00
D14-200GA/50	85.00
D14-200GM	75.00
D14-210GH	75.00
D14-270GH 50	75.00
D14-310W	110.00
D14-320GH 82	85.00
D14-340GH/KM	45.00
D14-340KA	45.00
D16-100GH	65.00
D16-100GH 65	69.00
D16-100GH/67	65.00
D16-100GH/79	69.00
D16-100GH/97	65.00
D18-160GH	69.00
D21-10GH	65.00
DG7-5	55.00
DB7.6	35.00
DB7.36	55.00
DG7.32	45.00
DG13.2	45.00
DH3-91	55.00
DH7.91	45.00
DP7.5	35.00

DP7 6	35.00
DN13 78	35.00
F16-101GM	75.00
F16-101LD	75.00
F21-130GR	75.00
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F31-10GM	75.00
F31-10GR	75.00
F31-10LC	75.00
F31-10LD	75.00
F31-12LD	75.00
F31-13GR	75.00
F31-13LD	75.00
F31-13LG	75.00
F41-123LC	185.00
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M7-120W	19.00
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M14-100GM	45.00
M14-100LC	45.00
M17-151GVR	175.00
M17-151GR	175.00
M19-100W	45.00
M19-103W	55.00
M23-110GH	55.00
M23-111LD	55.00
M23-112GM	55.00
M23-112GV	55.00
M23-112GW	55.00
M23-112KA	55.00
M24-120GM	59.00
M24-120LC	59.00
M24-120WAR	59.00
M24-121GH	55.00
M28-12GH	55.00
M28-13LC	49.00
M28-13LG	49.00
M28-13GR	49.00
M28-131GR	55.00
M28-133GH	55.00
M31-101GH	55.00
M31-182GR	55.00
M31-182GV	53.00
M31-184W	65.00
M31-184GH	85.00
M31-184P31	65.00
M31-185W	69.00
M31-190GH	55.00
M31-190GR	55.00
M31-190LA	55.00
M31-191GV	55.00
M31-191W	45.00
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coils + trans available

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M38-121GHR	65.00
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M38-341P31	65.00
M38-344P39	65.00
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M43-12LG/01	65.00
M44-120LC	65.00
M50-120GH	65.00
M50-120GR	65.00
M50-120GV	65.00
M50-120LC	65.00
SE3A/P31	40.00
SE4/D/P7	45.00
SE428P31AL	55.00
SE42BP31	55.00
SE5FP31	55.00
T948H	65.00
V5004LD	59.00
V6048CAL	59.00
V6048J	49.00
V6064BP31	55.00
V6069GH	55.00
V6070P31	65.00
V7030	59.00
V7031GH	59.00
V7031 67A	59.00
V7035A	49.00
V7037GH	45.00
V8004GR	65.00
V8006GH	65.00
V8010A	65.00
38PI	11.50
3DPI	11.50
3H OBM	55.00
3WPI	18.50
4EPI	30.00
5BHP1	30.00
58HP1FF	30.00
5BHP31	30.00
5CPI	10.00
5TO1A	15.00
6EP7/S	39.00
12CSP4	45.00
13BPI	13.50
138PA4	17.50
17DWP4	25.00
32J/1085	69.00
1273	39.00
1564	45.00
1844	80.00
9442E1	75.00
95447GM	75.00
95449GM	75.00
7709631	78.50

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4 watt	2R4-10K	0.20
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11 watt	1R-15K	0.25
17 watt	1R-15K	0.30

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DSR-10-R Suitable for Sony SLC5 SLC6 SLC7	39.50
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Sanyo Head for VTC 5300/5000	49.50

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Panasonic 3000B	3.75
Panasonic NV7000	3.50
Panasonic NV8600B 8610B/VOII	3.75
Sanyo VTC 5500	3.75
Sanyo VTC 9300	3.75
Sanyo VTC 9300P	3.90
Sharp VC 6300	3.75
Sharp VC 7300	3.75
Sharp VC 8300	3.75
Sharp VC 9300	3.75
Sony SL 3000B	3.75
Sony SL 8000 8080	4.50
Sony SL C7/J7	4.00
Toshiba V5470	4.50

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SANYO ORIGINAL PART NUMBER	MODEL	DESCRIPTION	
4-529-10800B	VTC5150	Reel Motor 3 6W	9.95
4-527T-23501	VARIOUS	Motor Assy	9.75
4-527V-51000	5150	Capston Motor	29.95
143-0-4904-00900	FVHP615	Gear Idler Assy	5.95
143-2-457T-05900	VTC9455	Stopper Reel Base	0.55
143-0-545T-01701	VARIOUS	Pinch Roller Assy	8.95
143-0-545T-01700	VARIOUS	Pinch Roller Assy	1.95
143-0-551T-VTC9300		Idler Assy	0.95
143-0-661T-03800	VARIOUS	Loading Roller	0.95
143-0-662T-01201	VTC5150	Reel Drive Pulley	8.50
143-0-9974-00100	FVHP615	Mod Kit IC BA6304A	1.95

Video Head Cleaning Tape (VHS Automatic wet/dry)	6.50
Video Head Aerosol Cleaner	0.85
Video Copying Lead and Connector Kit 'Z/V'	7.95

VIDEO ALIGNMENT TAPES

S-2P Colour Bars 30 min	49.50
S-3P Stairsteps 30 min	49.50

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ITT CVC20	6.35
ITT CVC30	6.35
PHILIPS G8 550	6.96
RANK T20A	6.91
THORN 3000/3500	7.57
THORN 8500	8.00
THORN 9000	8.00
UNIVERSAL TRIPLER	5.45

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ELC1043/06 MULLARD	8.65
U321	8.25
U322	8.25
U324	11.00

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DECCA ITT CVC20 6WAY	7.95
ITT VCVS 7 WAY	10.19
PHILIPS G8 (550) 6 WAY	14.49

200MA QUICK BLOW FUSES

100MA	8p each
200MA - 5 AMP	5p each

THERMISTORS

VA1040	0.23
VA1056S	0.23
VA1104	0.95
VA8650	0.45
VA1097	0.25

20MM ANTI SURGE FUSES

100MA-800MA	15p each
1A-5AMP	12p each

REPLACEMENT ELECTROLYTIC CAPACITORS

DECCA 30 (400-400 250V)	2.85
DECCA 80 100 (400 305V)	2.99
DECCA 1700 (200-200-400-350V)	3.55
GEC 2110 (600/300V)	2.25
ITT CVC20 (200 400V)	1.80
PHILIPS G (600 300V)	2.25
PHILIPS G9 (2200 × 63V)	1.19
PHILIPS G11 (470 250V)	2.35

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4 LINES

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AH238	39.00
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ARP12	0.70
ARP34	1.25
ARP35	2.00
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AZ31	2.50
BL63	2.00
BS814	55.00
BT17	25.00
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C6A	20.00
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C1134	32.00
C1148A	115.00
C1149/1	195.00
C1150/1	135.00
C1534	32.00
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CK1006	3.50
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DA42	17.50
DA90	4.50
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DAF96	0.65
DC70	1.75
DC90	3.50
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DET18	28.50
DET22	35.00
DET23	35.00
DET24	39.00
DET25	22.00
DET29	32.00
DF91	1.00
DF92	0.60
DF96	1.25
DF97	1.25
DH63	1.20
DH77	0.90
DH79	0.56
DH149	2.00
DK91	1.20
DK92	1.50
DL35	2.50
DL63	1.00
DL70	2.50
DL73	1.50
DL92	1.25
DL93	1.10
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DLS10	13.50
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E55L	49.50
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E81L	12.00
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E1148	1.00
EA50	1.00
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EA79	1.95
EABC80	0.70
EAC91	2.50
EAF42	1.20
EAF801	2.00
EB34	1.50
EB41	3.95
EB91	0.85
EBC33	2.50
EBC41	1.95
EBC81	1.50
EBC90	0.90
EBC91	0.90
EBF80	0.95

EBF83	0.95
EBF89	0.70
EBF93	0.95
EBL1	2.50
EBL21	2.00
EC52	0.75
EC70	1.75
EC81	7.95
EC86	1.00
EC88	1.00
EC90	1.10
EC91	5.50
EC92	1.95
EC93	1.50
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EC8010	12.00
ECC32	3.50
ECC33	3.50
ECC35	3.50
ECC81	1.50
ECC81 Special Quality	2.25
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ECC88	0.95
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ECC801S	6.95
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ECF80	1.15
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ECF801	0.85
ECF805	2.50
ECF806	10.25
ECH3	2.50
ECH4	3.00
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ECH42	1.50
ECH81	1.00
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ECH84	1.00
ECH2000	1.50
ECL80	0.60
ECL82	0.79
ECL83	2.50
ECL84	0.74
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ECL86	0.95
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EF37A	2.50
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EF70	1.20
EF71	1.50
EF72	1.20
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EF83	3.95
EF85	0.50
EF86	2.25
EF86 Mullard	4.50
EF89	1.50
EF91	1.95
EF92	2.15
EF93	0.95
EF94	0.95
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EF97	0.90
EF98	0.90
EF183	0.65
EF184	0.65
EF730	1.80
EF731	3.50
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EL32	0.95
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EL34	2.50
EL34 Mullard Philips	4.50
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EL36 Mullard	2.50
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EL38	6.50
EL41	3.50
EL42	2.00
EL81	6.95
EL83	7.50
EL84 Brimar	0.95
EL84 Mullard	2.95
EL85	4.50
EL86	1.75
EL90	1.75
EL91	6.00
EL95	1.75
EL153	12.15
EL183E	3.50
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EL360	6.75
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EM81	0.70
EM84	1.65
EM85	3.95
EM87	2.50
EN32	15.00
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EY81	2.35
EY83	1.50
EY84	5.95
EY86/87	0.50
EY88	0.55
EY91	5.50
EY802	0.70
EZ40	2.75
EZ41	2.75
EZ80	0.75
EZ81	0.75
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GZ31	2.50
GZ32	2.50
GZ33	4.50
GZ34	2.50
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HBC91	0.80
HF93	0.75
HF94	1.50
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HL23DD	4.00
HL41	3.50
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HL90	0.70
HL92	1.50
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HT2	4.00
HY90	1.00
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KTW63	2.50
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LB7-20	95.00
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M502A	60.00
M537A	60.00
M5143	155.00
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
ME1401	29.50
ME1402	29.50
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MH4	3.50
MHL6	4.00
ML4	4.50
MP25	195.00
MS4B	5.50
MU14	3.50
MZ1-100	125.00
N37	12.50
N78	9.85
OA2	1.15
OA2WA	2.50
OA3	2.50
OB2	1.15
OB2WA	2.50
OC2	2.50
OC3	1.50
OD3	1.70
OM4	1.00
OM5B	3.00
OM6	1.75
ORP43	2.50
ORP50	3.95
P61	2.50
P41	2.50
PABC80	0.75
PC86	0.75
PC88	0.75
PC92	3.50
PC97	1.10
PC800	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	0.40
PCF200	1.80
PCF201	1.80
PCF800	0.40
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
PCL800	0.80
PCL805	0.90
PE1-100	69.00
PEN25	2.00
PEN40DD	2.50
PEN45	3.00
PEN45DD	3.00
PEN46	2.00
PE06-40N	42.00
PFL200	0.95
PL21	2.50
PL36	1.75
PL38	1.50
PL81	0.72
PL81A	0.72
PL82	0.60
PL83	0.52
PL84	0.78
PL88	1.00
PL95	2.95
PL302	1.00
PL345	12.50
PL500	1.10
PL504	1.15
PL508	1.75
PL509	4.85
PL519	4.95
PL802T	3.50
PL820	2.95
PL5557	29.50
PY32	0.60
PY33	0.50
PY81	0.70
PY82	0.70
PY83	0.70
PY88	0.65
PY500A	1.95
PY800	0.79
PY801	0.79
QB3-300	72.00
QB3-1750	139.50
QB5-3500	595.00
QE03-10	4.95
QE08-200	145.00
QF40	65.00
QP25	1.00
QQE02-5	19.50
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QQE03-20	29.50
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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
QS75/20	1.50
QS75/40	3.00
QS92/10	5.00
QS95/10	4.85
QS108/45	4.00
QS150/15	6.95
QS150/30	1.15
QS150/45	7.00
QS1200	3.95
QS1202	3.95
QS1203	4.15
QS1205	3.95
QS1206	1.05
QS1207	0.90

QS1208	0.90
QS1209	3.15
QS1210	1.50
QS1211	1.50
QS1212	3.20
QS1213	5.00
QS1215	2.10
QS1218	5.00
QU37	9.50
QV03-12	5.75
QV05-25	2.50
QV06-20	29.50
QV08-100	145.00
QV2-2500	45.00
QY3-125	65.00
QY4-250	70.00
QY4-400	76.00
R10	4.00
R16	12.00
R17	1.50
R18	2.50
R19	2.50
R20	1.20
R1169	55.00
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RG1-240A	14.50
RG3-250A	3.50
RG3-1250A	35.00
RK2K25	62.50
RK-20B	12.00
RL16	1.50
RPL16	12.00
RPY13	2.50
RPY43	2.50
RPY82	2.50
RR3-250	15.00
RR3-1250	35.00
RS613	45.00
RS685	54.95
RS5688	52.15
S6F17	5.95
S6F33	28.95
S11E12	38.00
SA30/2K	12.00
S104/1K	10.00
S109/1K	15.00
S130	5.59
S130P	5.95
SC1/800	5.00
SC1/1100	6.00
SC1/1200	5.00
SC1/1300	6.00
SC1/200	9.00
SP41	5.00
SU42	4.95
TB2.5/300	85.00
TB2-300	45.00
TB3/2000	395.00
TD1-100A	25.00
TD03-10F	35.00
TD3-12	4.00
TDD4	5.50
TP25	1.50
TSP4	7.00
TT11	1.50
TT21	45.00
TT22	45.00
TT100	69.00
TTR-31MR	65.00
TY2-125A	85.00
TY4-400	85.00
TY8-600W	365.00
TYS2/250	375.00
U18-20	2.75
U19	11.95
U24	2.00
U25	0.90
U26	0.90
U37	9.00
U41	6.95
U50	2.00
U82	3.00
U191	0.70
U192	1.00
U193	0.65
U251	1.00
U801	0.75
UABC80	0.65
UAF42	1.00
UBF80	0.60
UBC41	2.25
UBC81	1.50
UBF89	1.00
UBL21	1.75
UC92	1.20
UCC84	0.70
UCC85	0.60
UCF80	1.00
UCH21	1.20
UCH41	2.50
UCH42	2.50
UCH81	1.00
UCL82	1.75
UCL83	2.50
UF41	1.15
UF42	1.50
UF80	1.75
UF85	1.20
UF89	2.00
UL41	5.50
UL44	3.50
UL84	1.50
UL85	0.85
UU5	3.50
UU7	8.00
UU8	9.00
UY41	3.50
UY85	0.70
V235A/1K	250.00
V238A/1K	295.00
V246A/2K	315.00
V2406/1K	225.00
V241C/1K	195.00
V339	3.50
V453	12.00
VL5631	10.95
VP4B	4.50
VP133	2.00
VR75/30	3.00
VR101	2.00
V105/30	1.50
VR150/30	1.15
VT52	2.50
VU29	4.50
VU39	1.50
W21	4.50

W77	5.00
W729	1.00
W739	1.50
X24	4.50
X66/X65	4.95
X76M	1.95
XC24	1.50
XC25	0.50
XFW47	1.50
XFW50	1.50
XG1-2500	75.00
XG5-500	22.50
XL628FT	7.50
XNP12	2.50
XR1-1600A	49.50
XR1-3200A	79.50
XR1-6400A	149.50
Y502	25.00
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
Z302C	12.00
Z359	9.00
Z505S	15.00
Z520M	4.00
Z521M	8.00
Z700U	3.00
Z749	0.60
Z759	19.85
Z803U	18.95
ZA1000	12.50
ZA1001	1.50
ZM1005	8.00
ZM1020	6.00
ZM1021	8.00
ZM1023	7.95
ZM1041	14.00
ZM1082	9.00
ZM1084	10.00
ZM1177	9.00
ZM1202	55.00
ZM1263	4.00
1B22	10.00
1B27	55.00
1B35A	45.00
1B63A	75.00
1C1	2.50
1C5GT	2.50
1FD1	2.50
1G3GT	2.50
1J3GT	2.50
1K3	2.50
1N2	4.50
1N5GT	2.50
1P28	25.00
1P39	19.50
1R5	0.90
1T4	1.00
1U4	1.75
1U5	1.00
1X2B	1.40
1Z2	8.95
2AS15A	11.50
2B7	1.50
2B22	69.50
2C39A	32.50
2C39BA	39.50
2C40	37.00
2C42	29.50
2C43	60.00
2C51	0.75
2C53	45.00
2CY5	1.50
2D21	1.95
2D21W	3.15
2E22	49.00
2E26	7.95
2J42	93.00
2J55	295.00
2K25	35.00
2K25 Raytheon	75.00
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/147J	7.50
3A/167M	10.00
3A3A	3.95
3A4	1.10
3A5	4.50
3AL5	0.95
3AT2	3.35
3B2	3.00
3B4	4.95
3B7	4.50
3B24	10.00
3B26	24.00
3B28	15.00
3BZ6	1.50
3C4	1.00
3C23	19.00
3C45	24.00
3CB6	1.50
3CN3BA	2.50
3CS6	0.95
3CX3	2.50
3CY5	1.00
3D6	4.50
3D21A	29.50
3E22	49.50
3EH7	1.95
3EJ7	1.95
3Q4	2.50
3V4	1.75
3W4GT	2.50
4B551B	115.00
4-65A	65.00
4-250A	79.50
4-400A	87.50
4-1000A	425.00

4B32	35.00
4BQ7A	1.75
4BZ6	1.95
4C27	25.00
4C28	25.00
4C35	145.00
4CX1000A	425.00
4CX4000A	1100.00
4CX250B	49.00
4CX250B EIMAC	59.50
4D32	125.00
4CX250BN	75.00
4CX250K EIMAC	95.00
4CX125C EIMAC	125.00
4CX350A	95.00
4CX350F	79.50
4XC1500B	398.50
4E27	195.00
4GS7	2.25
4J52	75.00
4JC6A	2.95
4KT6	1.50
4X150A	35.00
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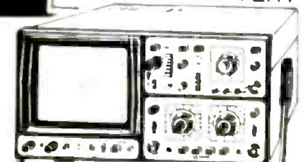

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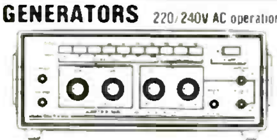

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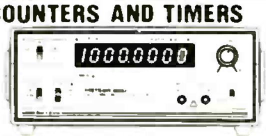

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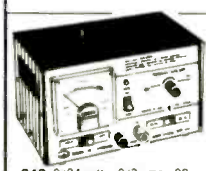

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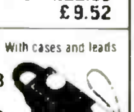

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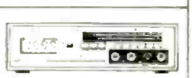

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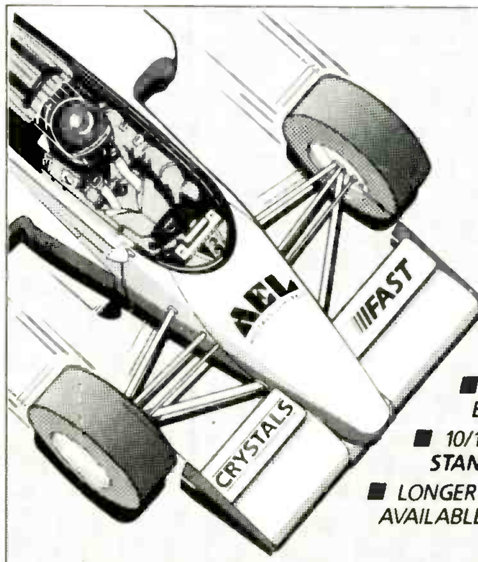

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68020 cache design

On-chip cache memory increases performance but its size is limited. An external cache with 25ns rams takes care of much larger repetitive loops.

DAVID BURNS and DAVID JONES

A cache is a high-speed memory local to the microprocessor that holds the most recently executed instructions or data. Being closely coupled to the microprocessor, cache memory can be accessed much faster than main memory.

Studies of modern programming techniques show that programs spend most of their time repetitively executing a few tight loops of code. Cache memory speeds up execution by holding loops just executed so that when they are used again they can be accessed much faster than if they were held in main memory or back-up storage.

With the 68020, small loops of code are captured efficiently in the 256byte on-chip cache but performance can be increased still further by adding an external cache to hold larger repetitive loops.

A fast external cache increases performance particularly when low-cost dynamic ram is used for main memory. Access time of the dynamic ram is relatively long but refreshing and propagation delays increase overall access time even further.

When an external cache is used, a memory-management unit can be added to a 68020 system without performance degradation. With no external cache, adding a paged memory-management unit such as the MC68851 for example can cause the introduction of an extra clock cycle when accessing external physical memory.

Adding a large external cache allows the processor to execute considerable amounts of code from the cache without having to access main memory. Using fast static ram for the cache, no wait states are needed so processor operation is as fast as possible.

Size of the external cache has a great effect on the hit rate, i.e. the percentage of time that the processor is executing from the cache as opposed to main memory. From Fig.1 you can see that a considerable hit rate

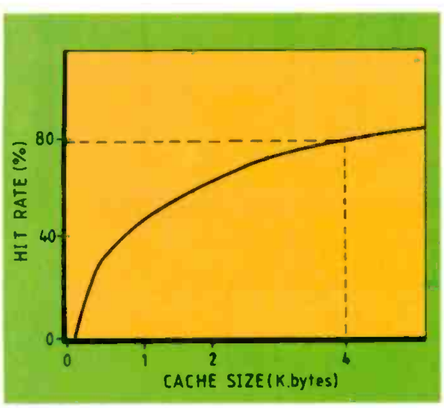


Fig.1. With a 4Kbyte cache, the processor executes from cache memory about 80% of the time.

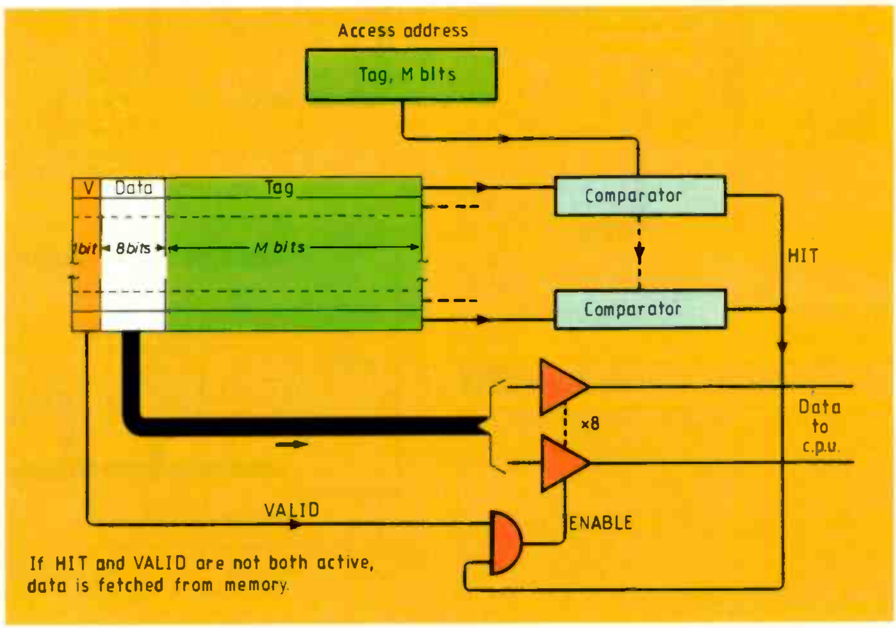


Fig.2. Each data item in the cache has an associated tag entry to allow the data to be retrieved. In a fully-associative (content addressable) cache, the tag entry holds a full address and control bits.

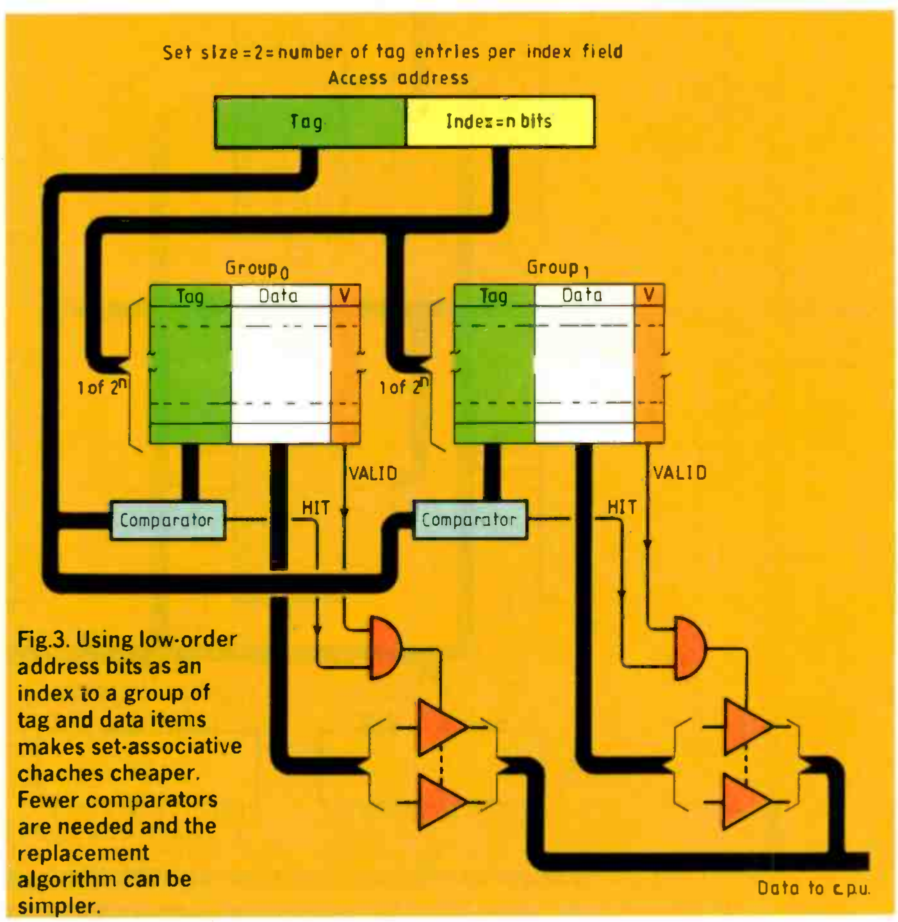
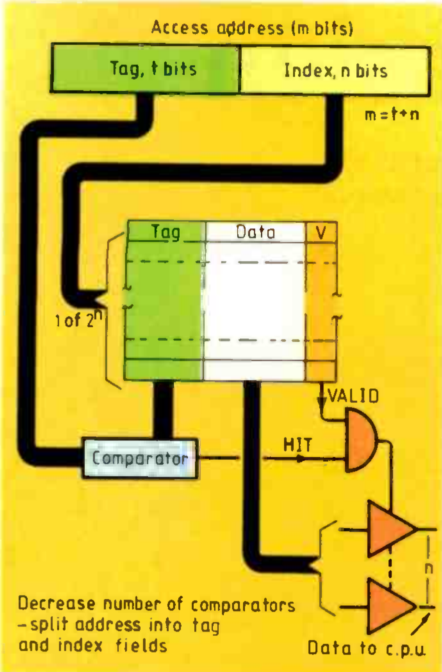
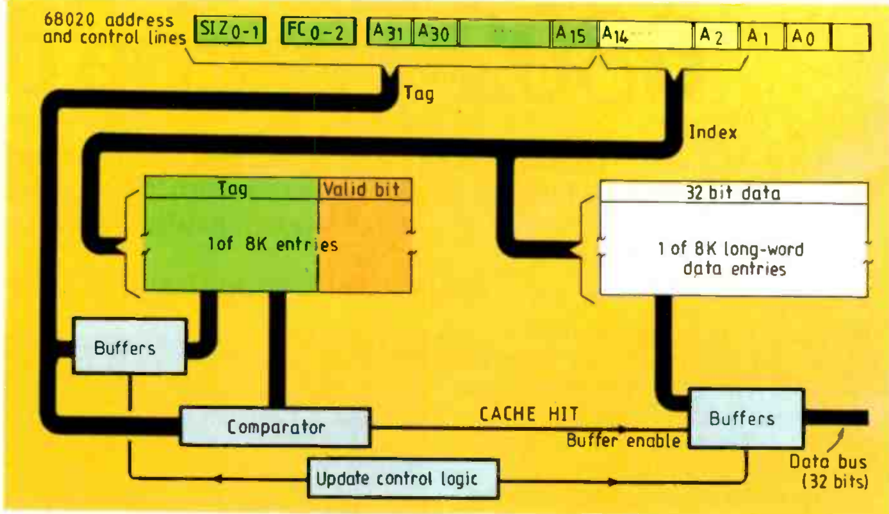
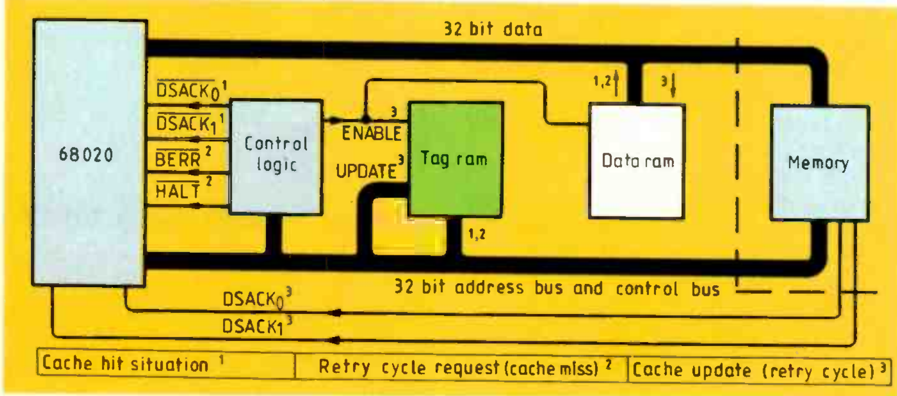


Fig.3. Using low-order address bits as an index to a group of tag and data items makes set-associative chaches cheaper. Fewer comparators are needed and the replacement algorithm can be simpler.







ARTICLES IN THE SERIES

68000 family architecture	December 1986 pp106-109
68020 architecture	January 1987 pp103–106
68020 extra instructions	February pp209–212
68020 display processing	March pp333,334
68881/68882 floating-point coprocessors	May pp535–537
68851 memory-management coprocessor	June pp614–616

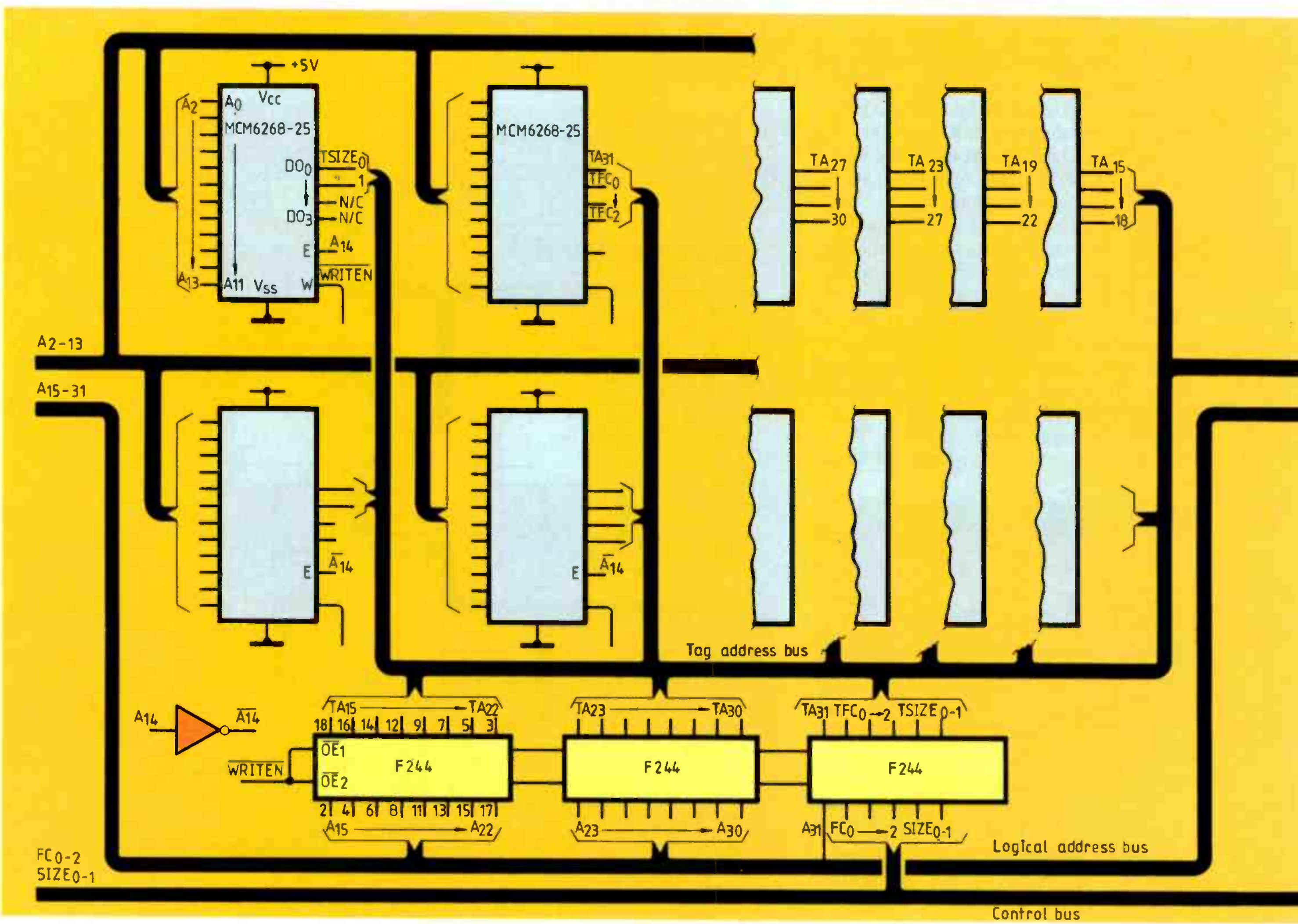


Fig.4. Direct-mapped caches, top left, use only one comparator and replacement algorithms are unnecessary. A block the same size as the cache is produced by the index field so there is only one group.

Fig.5. Cache design for the 68020 using 32Kbyte organized in 8Kbyte long words, top right. Cache entries are held in 32Kbyte of data ram while tag data with valid bit is held in tag ram.

Fig.6. When a cache hit occurs, data from cache ram is placed on the bus but when a miss occurs, halt and bus error signals are sent to the processor to make it retry the previous cycle. This is to allow time for cache updating.

Fig.7. Using 25ns static rams a very fast cache can be made. The tag field consists of ram accessed by the address and control bus.

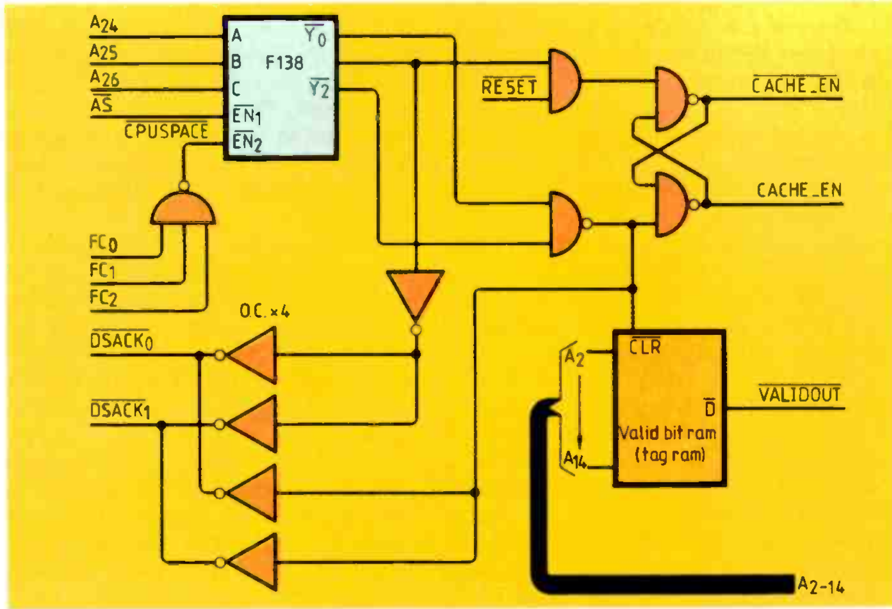


Fig.8. Simplified cache control logic pro viding enable, disable and clear facilities.

can be achieved using a 4Kbyte cache. Increasing the cache size further results in only small improvement.

In a typical cache, each data item, be it 8, 16 or 32 bits, has an entry associated with it called a tag field, Fig.2. This tag field contains information that allows the data to be located.

In most caches the tag field contains a large proportion of the address bus, the function codes and a valid bit indicating whether or not a data item has been entered and is valid. Differentiation between user and supervisor address spaces is provided by the function-code entry.

There are three basic types of cache – fully associative, set associative and direct mapped. Figure 2 shows a fully-associative architecture in which the tag field contains the complete address bus and function-code bits.

Each tag entry has an associated comparator. When an access begins, the present access address is compared with each of the tag fields and if a match is detected (a hit), it indicates that the associated data item can be used for the cycle. Because every tag has a comparator, the tags can be compared in parallel which speeds up the process.

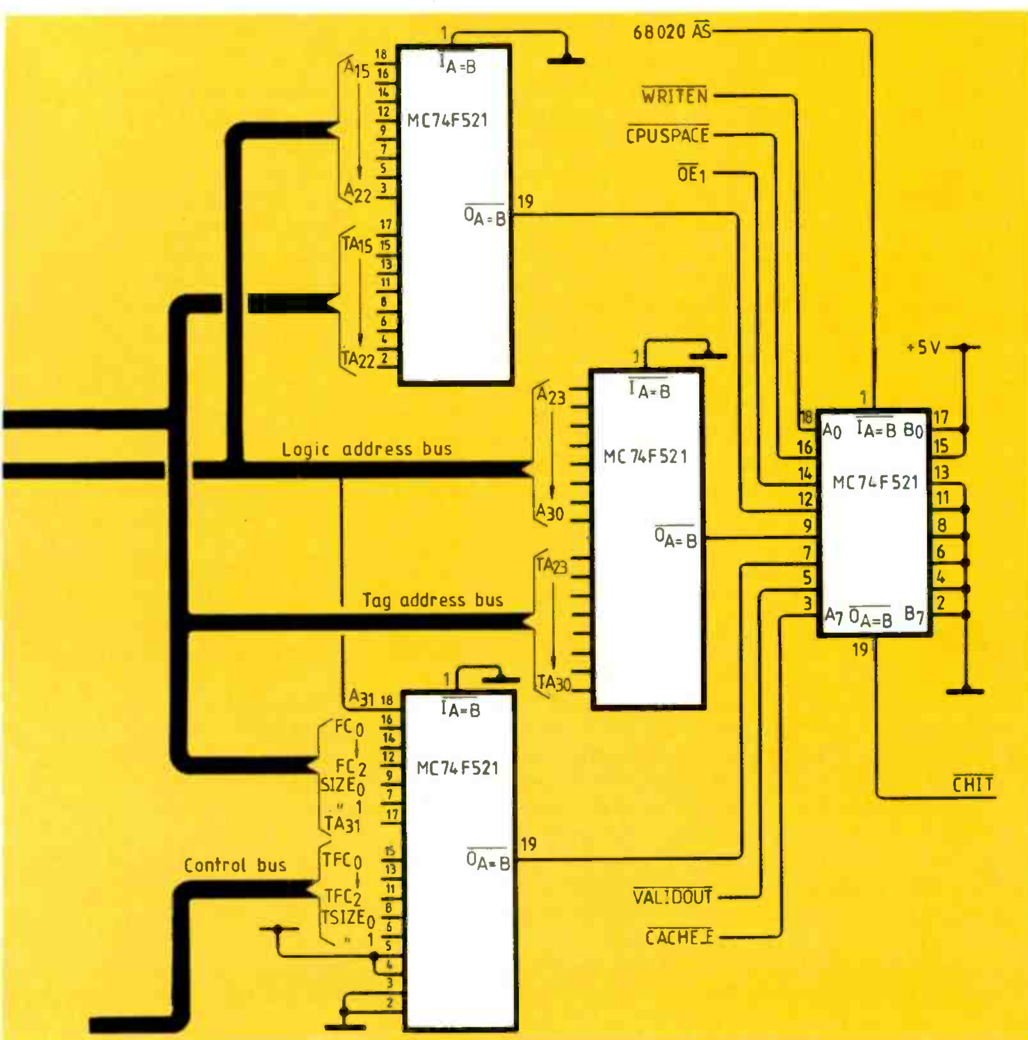
By using the whole of the address bus as a tag there is no interdependence between the data items, unlike direct mapping, and so the hit rate of this type of cache will be very high and related closely to the physical size of the cache.

When a miss occurs, i.e. there are no tag matches, the cache must have some means of updating the entry so that it will be valid the next time that that address is accessed. To do this a 'least recently used' algorithm determines which entry when overwritten will least affect overall performance. When this item is updated, the tag field becomes the information currently on the address bus and the valid bit is set. The next time that the address is accessed a hit will occur.

Performance of this type of cache depends on efficiency of the replacement algorithm and relies on the fact that there is no interdependence betwen entries. On the other hand, fully-associative caches are expensive because of the number of comparators required and the complexity of the replacement algorithm.

Set-associative caches are cheaper. Instead of holding the whole of the address in the tag field, the set-associative caches use a number of low-order address bits as an index to a block of tag and data items, Fig.3. This index selects a tag from each group and compares it with the current access address. If one of these entries hits, the associated data entry is extracted.

The advantage of this type of cache over the fully-associative type is that the number of comparators required is only equal to the



number of groups (or sets) and not the number of entries. Size of the index field, and hence the number of entries per group, is thus a trade-off between the number of comparators and the cache hit rate. A replacement algorithm is still necessary for set-associative caches but a simpler round-robin type algorithm can be applied instead of the least-recently-used one.

In a direct-mapped cache the index field produces a block size that is the same size as the cache itself so there is only one group, Fig.4. As a result, only one comparator is used and replacement algorithms are unnecessary so this is the easiest type of cache to implement and the cheapest.

Hit rates of direct-mapped caches are still quite high (proportional to the number of entries) but their performance is degraded by address interdependence. This interdependence is caused by the fact that the index field produces an offset into the cache which remains the same for addresses which are modulo with this index, i.e. they have the same index but a different tag field.

In execution this means that an entry can actually be replaced on the next cycle if the next access happens to have the same index; there is no way of determining when the entry was last used or how frequently it was used.

CACHE DESIGN EXAMPLE

A direct-mapped cache for data, supervisor and user accesses to and from memory is easiest to implement. Cache size depends on the hit rate required and how much you are prepared to spend on fast static rams but is typically 4, 8 or 16Kbyte; in practice, 32Kbyte is usually the upper limit.

Since the direct-mapped cache can be used for data accesses it should be designed to avoid stale-data retention. Stale data is data held in the cache from a previous read cycle; it represents data in memory that has been modified by an external processor write cycle. To prevent stale data, data from the processor is written simultaneously to both the cache and external memory on every write cycle. Data read from the cache is then always the latest data. This method is called write allocation.

Consider a 32Kbyte cache for the 68020 organized in 8K long words (32-bit words), Fig.5. Cache entries are held in 32Kbyte of data ram and tag data with the valid bit is held in tag ram. The tag field could be 22 bits wide consisting of 17 high-order bits for addressing an individual entry in the 8K long-word block of memory, three function-code bits to distinguish between the types of memory access, and two size bits for accommodating misaligned data transfers (misaligned data is 32bit data not resident on a 32bit boundary in memory). The valid bit is set each time an entry is made in the cache.

On a cache hit, associated data is read from the cache data ram and placed on the bus. Logic i.cs control the data transfer direction to and from the tag and data rams. Address lines A_{15-31}, function codes FC_{0-2} and size values $SIZE_{0,1}$ update the tag field and information on the data bus is placed in the data rams.

Ideally, cache updating should occur while the read cycle is executing. For this purpose, if there is a cache miss during a read cycle a signal must be produced early enough in the cycle to be fed back to the control logic. This signal places the tag and data rams in write mode, allowing data presented on the buses to be routed directly to the tag and data rams as well as to the processor.

This entry-update method is practical for processors operating between 8 and 10MHz but for a 68020 operating at between 20 and 25MHz with no wait states, the time available for entry updating may be too small. An alternative method could be to use the 68020 late-retry facility during cache misses as follows.

When a cache miss occurs the cache-control logic sends halt and bus-error signals to the 68020 simultaneously. This causes the processor to retry the previous cycle, allowing enough time to enable the tag and data rams for writing. On execution of the retired read cycle, data read from memory is written into the data rams and information on the address and control lines is written into tag ram, Fig.6.

IMPLEMENTATION

The faster the 68020 becomes, the more difficult it is to design a system operating with no wait states. Therefore to gain any noticeable performance improvement from an external cache, very fast static memories are essential. Fast and ALS logic families make it possible to design a 68020 cache using 25ns memories without resorting to custom or application-specific (asic) devices.

Logic required for the cache divides into four parts for entry updating, general control, tag-ram operation and data-ram operation. Figure 7 shows tag-ram logic with 16K by 4bit 25ns rams. During a read cycle, addresses presented by the processor are used for indexing into tag ram, output of which is the previously described 22bit tag field. Provided that certain other conditions are met, if the 32bit comparator indicates that tag ram output matches the current address and control lines the cache-hit signal $\overline{\mathrm{CHIT}}$ is asserted.

Conditions that must be met before $\overline{\mathrm{CHIT}}$ can be asserted are the true states of the valid bit and cache-enable signal and the untrue states of the i/o enable, cpu-space and ram-write signals. These conditions feed the last comparator stage.

On detecting a cache miss the control logic causes data presented on D_{0-31} to be placed in the tag rams. During the cache hit the F244 latch outputs are high impedance, thus isolating the address and control bus from the rams to prevent bus contention. Data-ram logic is similar except that four F245 bidirectional buffers are used for both isolating and directing ram data for writing/reading; data direction is controlled by $\overline{\mathrm{CHIT}}$.

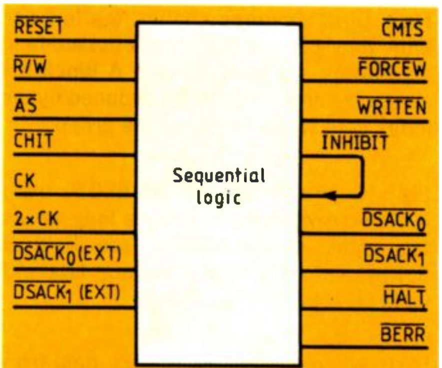
Signals produced by the entry-update logic are described in the panel. This logic can be implemented using simple two-input gates and D-type bistable devices from fast or ALS families.

Control logic can be implemented using the same simple i.cs; its complexity depends on the cache facilities required. For example, consider logic providing cache enable, disable and clear facilities. The valid bit is held in ram with a clear facility which allows all cache entries to be cleared.

In its simplest form, the control logic contains a bistable device which can be addressed by the supervisor when performing a c.p.u. access to an otherwise unused c.p.u. function (that is not access levels, breakpoints, interrupt-acknowledge or co-processor space). This access is treated just like a normal memory cycle. One c.p.u.cycle causes the bistable device to enable the cache through $\overline{\mathrm{CACHE\_E}}$. Another location clears entries in the cache by clearing the contents of valid-bit ram and a third location causes the bistable device to disable the cache.

Figure 8 is a simplified control-logic diagram. Signal $\overline{\mathrm{CACHE\_E}}$ is used in the comparator section as VALIDOUT; both signals must be asserted before a cache hit is considered valid.

When the cache is first enabled or a cache clear command is issued, the valid-bit ram is cleared. Using the address lines shown, cache clear is initiated by a memory cycle at address 1070000_{16}, cache enable at address 2070000_{16} and cache disable at 4070000_{16}. When reading or writing to any of these addresses, $DSACK_{0,1}$ are returned to terminate the cycle but data on the bus is irrelevant.



ENTRY-UPDATE LOGIC SIGNALS

CMISS. Active when $\overline{\mathrm{CHIT}}$ from the tag comparators is inactive, this signal indicates a cache miss. It should be sampled during the middle of the 68020 S_3 clock cycle. For this the 2×CLK input is used since it is twice that of processor clock CLK.

$\overline{\mathrm{DSACK(EXT)}}_{0,1}$. These are $DSACK_{0,1}$ signals returned from the external device during a read cycle ($R/\overline{W}$ high) when there is a cache miss.

RESET. Connecting the processor reset line into the entry-update logic ensures that the cache operates in its correct mode after reset.

$\overline{\mathrm{DSACK}}_{0,1}$. Cache control logic sends these signals to the processor on assertion of address strobe $\overline{\mathrm{AS}}$ so the entry logic assumes a cache hit on each cycle.

HALT, BERR. On detection of a cache miss, CMISS is asserted then these signals are simultaneously sent to the 68020 to make it perform a retry cycle.

$\overline{\mathrm{WRITEN}}$. Feeding the ram write-enable pin ($\overline{W}$) directly, this signal allows data to be written during the retried cycle. It is produced from $\overline{\mathrm{DSACK(EXT)}}_{0,1}$ and asserted on or close to the falling edge of S_4 of the processor clock. During S_4 the processor latches data.

FORCEN. Data ram isolation buffers are enabled by this signal to allow them to route data during the update cycle.

$\overline{\mathrm{INHIBIT}}$. Produced within the update logic, this signal inhibits $\overline{\mathrm{DSACK}}_{0,1}$ during the retry cycle for a cache miss.

David Burns and David Jones are applications engineers at Motorola's East Kilbride plant.

TELECOMMS TOPICS

Monitoring the Atlantic Ocean Intelsat

Intelsat has awarded a contract to Mercury Communications Ltd for the monitoring of IBS transponder usage on one of its satellites.

It will monitor the 11/12GHz beam received in Europe from the Atlantic Ocean Intelsat V satellite and forward the data obtained to Intelsat's Washington headquarters. The major service carried on this satellite is the Intelsat Business Service (IBS) which is a totally integrated digital service allowing carriers to offer voice, data, facsimile and video transmission. Mercury is the largest user in the world of IBS and its parent company, Cable and Wireless, is the largest operator of international communications satellite earth stations in the Intelsat system.

Toshiba to enter UK telecoms market

As part of its expansion plans, Toshiba has announced that it is to enter the UK telecommunications market. It will be launching Group 3 (sub 1-minute) facsimile machines and hopes to receive approval in the Autumn to sell the first of its small key telephone systems in the UK.

When announcing his company's entry into the UK business facsimile and key telephone market, Mr Shunki Yatsunami, chairman of Toshiba Information Systems (UK) Ltd, forecast a turnover of £100 million ($150m) by 1990 for its full range of office automation products.

Home banking network for Australia

Two UK companies are to supply their products to the giant Westpac bank in Australia to enable it to provide its customers with full home and office banking facilities. Known as Handyline, the service allows Westpac's customers to transfer funds, pay credit cards, obtain a statement and the balances in their accounts using a digitized voice delivery service.

The complete 132-port network incorporates Micro Scope Videogate network concentrators and Langston's P111 software, and has been supplied by their Australian agents, Thorn EMI Information Technology.

The Royal National Lifeboat Institution (RNLI) is to replace its traditional call out devices, such as explosive flares, with radiopagers. British Telecom Mobile Communications has devised a suitable system and is supplying 2000 specially adapted radiopagers over the next two years. The first batch of 1000 is being delivered to lifeboat stations which are, at present, hampered by poor communications or cumbersome call out procedures.

World record 565Mbit/s opto link

Telephone Cables Ltd (TCL) has installed, on behalf of Mercury Communications Ltd, what is claimed to be the longest, operational, unrepeatered, single-mode optical-fibre network in the world, working at 565Mbit/s and 1300nm using standard production fibre.

TCL installed the 10-fibre to provide a 51km two-way link from Wolverton to Mercury's Whitehall Satellite Earth Station, via Bicester in Oxfordshire. Even though it was expected to need a repeater at its midpoint, attenuation test results suggested that this would not be necessary. As Mercury wished to operate the cable at 565Mbit/s, further tests were carried out which provided necessary confirmation.

Not only has this assisted Mercury on this route by avoiding the need for a repeater site, it is now possible that most future routes can be planned without the need for repeaters, thus reducing costs and increasing reliability.

Renaults by packet switching

Renault, the French state-owned car company, is to extend its Direct Vehicle Ordering System (DVOS) throughout Europe. The system, developed in Paris by the company itself, has been serving the company's French dealer network for the past two years. Now, at a cost in excess of £1 million, the 300 Renault dealers in the UK have gone on the system which will now also be taken up in Germany, Italy and other European territories.

The total investment by Renault in DVOS runs into several million pounds so far. This includes two Amdahl mainframes in Paris and a Tandem computer in London. Major connections are made via X.25 packet-switched networks – Transpac in France and British Telecom's PSS in the UK.

In Britain, it represents just the first phase of extensive computerized communications being built into the company's UK operations during the next two or three years, aimed at putting the Renault network into the forefront of communications advances being made in the automotive industry over the coming decade.

Small-dish satellite trials

Trials of a small-dish satellite business communications service were started by British Telecom in May. The service will allow users at terminals at many distant locations in Europe as well as the UK to exchange data easily and cheaply by satellite with their company's central computers.

The trial service is based on the Very Small Aperture Terminals (VSATs) and uses dish antennas of 1.2m (4ft) or 1.8m (6ft) diameter installed on customer premises. It will enable links to be set up quickly, even when terminals are moved to new locations.

It is centred on BT's London Teleport, its central satellite communications earth station in London's dockland, where equipment from Comsat Technology Products has been installed to act as the network hub for the service. Any remote site may communicate with the hub, or to any other VSAT via the hub.

Applications to be evaluated during the six months trial include the distribution of news and images for information services, internal company electronic mail and other interactive corporate data communications.

First all-opto laser amplifier repeater

The first field trial of a laser amplifier repeater has been successfully carried out in a 120km fibre link installed in the British Telecom network. All optical systems, when developed commercially, promise considerable savings in the cost of optical communications links, especially for undersea systems. By avoiding the need to convert the optical signal to an electrical one and then back to light, they will be significantly cheaper and more simple to make, and their power

TELECOMMS TOPICS

requirements will be reduced.

Still in the experimental stage, it is the optical equivalent of the travelling-wave tube used as a microwave amplifier. When held below threshold, it emits an amplified light pulse at one end in response to an incoming trigger pulse at the other.

It has been further demonstrated in the laboratory that, using wavelength-division multiplexing, it can simultaneously simplify separate sets of pulses at different light frequencies. It can also amplify such pulses when they are travelling in the device in opposite directions at once. These lab. tests were carried out over 50km of fibre with wavelengths of 1525 and 1506nm and data rates of 280 and 565Mbit/s. The light sources were distributed feedback lasers while, at the receiving end of the system, channel filtering was achieved using fixed-wavelength interference filters.

The amplifier is a laser, modified by having its end faces coated to reduce their reflectivity 500 times, thus destroying the lasing action. A steady voltage is superimposed between the upper and lower surfaces to establish an electric field across the cavity. As a result, when a pulse of light enters the cavity at one end, it stimulates the production of extra photons which leave the cavity at the far end.

Expansion in second phone service

Residential customers and small businesses in the Nottingham and Derby areas will take part in test marketing of the new Mercury 2300 telephone service. In addition, the company has extended its local call services for its directly connected customers in the Birmingham and Manchester areas.

The two Midlands cities are key locations in the Mercury "Figure of Eight" network, and have been selected to gauge the impact of the service with residential and smaller businesses. It will offer cost savings averaging 15 per cent on long-distance calls, and up to 10 per cent on selected international routes including USA, Canada, Hong Kong and Bermuda. Mercury will monitor the trial closely, carefully evaluating customer reaction and the degree of take-up as part of its plans for a nationwide service to complete with British Telecom.

To use the new service, customers will need to purchase a special Mercury Telephone at a cost of £51.99 (inc. vat) and pay an annual fee of £8.62 (again inc. vat) for an Authorisation Code. Calls are made using the customer's existing exchange line so that, to place a Mercury connected call, the trunk or international call is dialled in the usual manner except that, prior to commencing dialling, the M (Mercury) button on the phone must be pressed.

The local call service, which will be most beneficial to those companies with more than 30 exchange lines, was previously only available to directly connected customers in London. It will enable business customers to make savings of up to 30 per cent on local calls.

Fax expansion for British Telecom

With facsimile growing at an average of 100 per cent each year for the past six years and forecasts suggest that next year a further 75,000 terminals will be added to the 90,000 currently in operation. British Telecom has added two new machines to its range. They are a personal computer based machine providing store and forward features for fax, linked with test processing for the high volume user and compact, low-cost, desk-top machine incorporating an integral feature phone. The former, the MerlinFax PC100 provides the user with an icon-based menu display for ease of operation. At each stage, help information is available on request to guide the inexperienced user.

The latter, the HS20, is a joint product of British Telecom and Televerket, the Swedish PTT, and has already been launched on the Swedish market. Looking rather like a sophisticated feature phone it is claimed to incorporate sufficient features to satisfy most users.

Prudential approach to telecommunications

Prudential Corporation, the insurance and financial services group, has taken delivery of the one-millionth line of Plessey's ISDX digital p.a.b.xs as part of the process of implementing one of the country's largest and most sophisticated private digital networks. Based on ISDXs of various sizes it will extend from Scotland to the West Country.

To date, the number of extensions at Prudential's five London and Reading head office establishments and another selected nine offices around the country is 4,250 in the network featuring the latest d.p.n.s.s. (digital private network signalling system) technology. This allows many features such as call diversion and call-back when free to be available between offices. In addition, Direct Dialling In (DDI) routes an incoming call directly to the called internal extension. At the present time, the company's 24 regional offices are being equipped with smaller ISDX-SN exchanges on a stand-alone basis. In due course, when this replacement programme is completed, they will be connected to create one of the largest and most sophisticated private digital telephone networks.

Since being launched as the IDX (Integrated Digital Exchange), and now offered with ISDN features, Plessey has sold over 3,000 of these switches worldwide and achieved a sales revenue of around £250 million.

Packet switching cuts bank security costs

Largest clearing bank, National Westminster, is to use its private X.25 packet data communications network to carry alarm data from branches all over the UK. This will enable it to dispense with the central alarm monitoring stations of security company Chubb Alarms Ltd. Chubb is responsible for the security of 350 out of the banks 2000 branches.

Chubb engineers and NatWest d.p. experts worked together on the system developed by Chubb and already in use by two other European banks.

Under the programme, bank branches are being equipped with a specially developed interface unit which accepts signals from intruder alarm systems and the electronic security devices protecting Automatic Teller Machines (ATMs). When regularly polled by one of the seven central monitoring stations around the UK, an interface inserts encrypted data packets into the private network. Chubb claims to have reduced the necessary data traffic by 90 per cent without sacrificing the level of security.

Telecomms Topics is written by Adrian Morant.

RESEARCH NOTES

Intensive care biofeedback

What is probably the most sophisticated biofeedback system ever invented has been developed by John Packer of the Department of Electrical and Electronic Engineering at the University of Melbourne. It's an automatic, computer-based device for stabilizing the blood pressure of seriously ill patients. This is normally achieved manually by regulating the infusion of different drugs, a task that involves taking blood pressure readings usually every 30 seconds.

An obvious electric alternative would be to have a continuous blood-pressure sensor and connect it to a dispenser for two drugs, one to increase blood pressure and one to lower it. This would in theory eliminate any need for manual intervention by nurses. It isn't as simple as that, however.

Mr Packer says that there are several reasons why researchers in Britain, the USA and Australia have found difficulty in implementing such a biofeedback system for blood pressure control. One is noise from the blood pressure transducer caused by movement or by coughing; another is the variation in patients' response to a drug at different blood pressure levels.

These problems have now been taken care of by the development of a computer program that can distinguish significant changes and convert them into an appropriate response. The system adapts to variations in patient sensitivity and incorporates a wide range of safety alarms. Patient data is displayed graphically on a v.d.u. and stored on disc for subsequent analysis by medical staff. Doctors and nurses can interact with the program through a standard keyboard.

Clinical trials involving more than 80 patients have been successfully carried out in intensive care and cardiac surgical units.

How the brain is wired

Speculation about how the human brain works has been a preoccupation since time immemorial and never more so since the advent of the computer. But whilst nerve cells or neurons behave in some ways like silicon switching elements, the similarities are in other ways quite limited. The switching rate of a neuron is, for example, thousands of times less than that of a typical c-mos gate. Neuronal architecture is also markedly different from that pioneered by von Neumann, being massively parallel. But of course, it isn't quite as simple as that or we would already be well on the way to suitcase-sized computers with human intelligence and consuming only a few tens of watts of power.

One of the most puzzling aspects of the brain is how it wires itself up in the first place during foetal development. Obviously hidden away in the genes there must be a sort of wiring diagram written in molecular code. But it can't be just like a computer circuit diagram because there simply isn't enough space on the genes for all the data. This has led molecular researchers to speculate that the brain must in some way 'self wire' itself.

Dr Adrian Aitken of the University of New South Wales has now provided a little more evidence that this is exactly what does happen. His first achievement was to make a preparation of an intact foetal rat brain without disturbing the structure. Hitherto brain researchers have relied on making microscope slides from thin slices of tissue. In computer terms, Dr Aitken has discovered how to take the lid off whilst others are attacking the innards with a chain saw.

Having got inside the foetal brain, the next step was to follow the growth of the neuronal axons, the links or wires by which neurons connect themselves into the circuit matrix. The precise method employed was detailed and complex but it led Dr Aitken to some fascinating and significant conclusions.

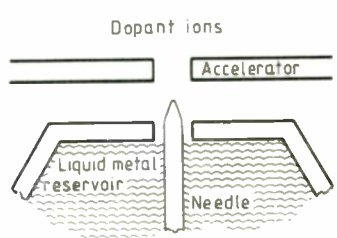
Neurons, it seems, have molecules that cause the growing axons to follow a sticky trail in the brain tissue. It's as if the pin of an i.c. were to sniff out another i.c. and begin growing a wire link. Dr Aitken says that the 'stickiness' of the top of a growing nerve fibre governs the direction in which it will grow. In this way the nerves do not necessarily have to 'know' which other cells of the developing brain to connect to. All they have to do is follow the adhesive trail.

These findings, recently presented in a paper to the Australian and New Zealand Society for Cell Biology are significant theoretically and also clinically. In future research, Dr Aitken intends to examine more closely the mechanism of nerve-fibre guidance and he hopes that, with additional information, it may be possible to direct the growth of nerve fibres and ultimately determine their network architecture. This has application in the treatment of several nerves and also in the understanding of degenerative neurological conditions such as multiple sclerosis and Parkinson's Disease. Conceivably it might also facilitate brain transplants!

Unmasked chips

Implanting dopants directly into a silicon substrate is an attractive proposition for the manufacture of v.l.s.i microcircuits. Apart from avoiding the need for a mask such a technique would permit variations, either in the location or degree of doping.

A research programme involving Manchester University, the University of Manchester Institute of Science and Technology (UMIST) and IBT-Dubilier is currently looking at practical ways of implementing the Culham-Dubilier liquid metal ion source,



shown in the diagram. The ion source consists of a positively-charged needle of less than 10μm diameter placed near an ion accelerator electrode. Liquid dopant is fed by capillary action from a reservoir behind the needle and is then emitted as a beam. Focussing is achieved by electrostatic or electromagnetic lenses.

For the system to work properly, the dopant material must meet certain tight constraints. It must flow over the needle without dissolving it. It must also have a suitable low vapour pressure. Unfortunately neither arsenic nor boron, the most common dopants, meet these criteria.

What the group have found is that certain alloys of the dopants do meet the criteria and that once the alloy has been ionized, the unwanted component can be separated by a technique analogous to mass spectroscopy. (Remember the ion traps on old cathode ray tubes?)

Where arsenic is concerned, an alloying material that works well is platinum together with a tungsten needle. With boron, platinum is also employed though rhenium is the preferred needle material. Computer studies are now going on at Manchester University to try and find three-component alloys that perform even better.

Flying power station

A new slant on power generation is a flying windmill being developed by Associate Professor Bryan Roberts at the University of Sydney. The Gyromill, as it's called, is a cross between a windmill and an autogyro and flies tethered by steel cables to the ground. These cables not only provide anchorage but also contain power cables and control circuits for ground command signals.

If the whole idea of putting a power station in the sky seems a little eccentric, Professor Roberts explains that there are two major advantages from this approach compared to the use of ground based windmills. Conventional windmills of the sort now springing up around the shores of Britain are so close to the ground that the wind is both slower moving and more turbulent than higher in the atmosphere. Since the extractable power is related to the cube of the windspeed, the advantages of a few extra mile/h are obvious. Turbulence is a different and altogether more serious problem and has led to at least one windmill in the USA breaking up completely. If you doubt the im-

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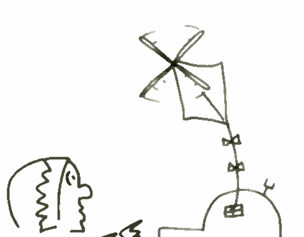
pact of turbulence on large structures near the ground, just recall how bumpy it gets as an aircraft is landing.

The Gyromill prototype has two contra-rotating blades, each 4 metres in diameter and each driving a 3kW generator. Professor Roberts has already done the sums to show that this can easily be scaled up to several megawatts at least. Tests on the prototype have also shown that there are no serious problems.

When the windspeed exceeds about 25km/h, the Gyromill will take off from the ground and hover like a kite, generating electricity as it does so. If the windspeed near the ground isn't quite strong enough for an unassisted take-off, then the generators can be employed in reverse as motors until the Gyromill is airborne. The motors then revert to their normal role as generators.

The mechanics of the machine are extremely complex, to ensure that it will fly stably in all wind conditions up to gale force. If the wind does become dangerously gusty, then the Gyromill can adjust its blades so as to land safely and switch off. Professor Roberts hopes eventually to build a fully automatic version that will take off and land under full computer control. The computer would respond not only to the prevailing wind conditions but also to the needs of the electricity utility. Gyromills could be kept on the ground and then launched automatically at periods of peak demand.

At the moment, flying power-stations on this grand scale may be a little way off, even in Australia. But Professor Roberts believes that the idea may have immediate applications in areas like Antarctica where the problem of ground turbulence is exacerbated by icing and where diesel generators pose difficulties of their own. Flying at about 300 metres above the icy waters, a Gyromill would be fed by a steady stream of air, largely free from drifting snow.



Major research grants for antennas

Over the past few years the Antennas Group in the Electronic Laboratory at the University of Kent has been awarded substantial research grants from the Science and Engineering Research Council and British Aerospace for work on satellite antenna systems. Recently the group has received two further grants, from the SERC and the Royal Signals and Radar Establishment, each of more than £100,000. The work of the group, surpervised by Dr Ted Parker, Reader in Radio Communications, and Dr R.J. Langley, Lecturer in Electronic Engineering, is concerned with studies of frequency-selective surfaces.

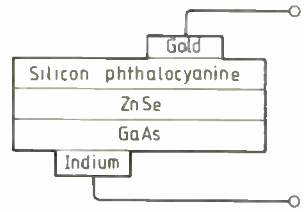
These can be used to construct component parts ('subreflectors') of communications antennas, which can then become capable of operating on several wavebands simultaneously, thereby improving the efficiency and cost effectiveness of the system. In some of these applications, the surfaces have to be quite tightly curved, and the aims of the project funded by RSRE are to improve the design procedures for curved surfaces and to develop manufacturing techniques.

In other applications, two or more surfaces are stacked together in cascade, or the subreflectors have partly metallic and partly frequency selective surfaces. The grant from SERC is supporting a study of these more complex structures.

Electroluminescent blues

A paper published jointly by a team of applied physicists at Durham University and a group of chemists from UMIST describes what they claim is the first ever room-temperature blue luminescent device based on metal-insulator-semiconductor (m-i-s) technology. This offers an alternative configuration to the more common p-n junction used in opto-electronic devices.

The latest m-i-s diode employs



zinc selenide (ZnSe) as a II-VI semiconductor. This is on a gallium arsenide substrate fabrication using metal organic chemical vapour deposition (m.o.c.v.d.) at room temperature.

The 'insulator' part of the m-i-s structure is a Langmuir-Blodgett (molecular thickness) film made of a silicon phthalocyanine compound. At an applied voltage of around 2V, a current of approximately 1mA flows; this is thought to be limited by the internal resistance of the silicon phthalocyanine layer. Under such conditions the researchers report a blue-white emission from beneath the gold contact layer. Such light is said to be clearly visible under normal indoor lumination.

Further research is now in progress to establish the optimum thickness of the 'insulator' layer.

Magnetohydrodynamics to beat pollution

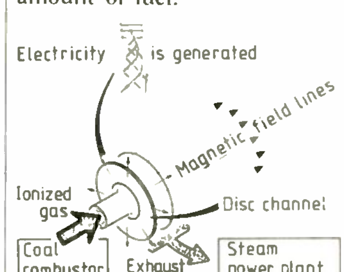
A research team at the University of Sydney has developed a practical means of improving the efficiency of existing coal-fired power stations, using a novel magnetohydrodynamic converter. Magnetohydrodynamics is the process whereby hot gases from the burning fuel can be used to generate electricity directly.

In essence, the m.h.d. generator works by taking the hot gases and ionizing them with a seed material to make them electrically conducting. The gases then pass through a magnetic field in which charge separation occurs, resulting in a current flow between pairs of collector plates and an external circuit.

The Sydney m.h.d. generator differs from the usual approach of feeding the gases along a straight channel; instead it employs a disc structure in which the flow is radial. This makes the system more compact and enables it to produce much more power per unit volume than linear designs. It is also substantially cheaper because the magnet used is simpler in design. Where the researchers, led by Dr Steve Simpson, have made substantial advances is in the development of insulating materials capable of withstanding temperatures of around 2000°C.

The disc m.h.d. generator, one of only three of its kind in the world, has now been running successfully for almost a year at White Bay power station in New South Wales. Tests show that it is performing beyond expectations. The team is particularly pleased with the generator because they claim that the other two disc m.h.d. generators at Stanford University in the USA have not produced such encouraging results. Also encouraging are the results of a computer study which predicts that it should be possible to scale the design up.

Although m.h.d. is still in its infancy in terms of development, many countries are now looking at the technology as a means of reducing pollution and getting more electricity from a given amount of fuel.



Where m.h.d. scores is that it makes use of very high temperatures at which conversion efficiency is high. And because the exhaust gases are still extremely hot by normal standards they can be re-used to boil up water and drive a turbine in the conventional way. The most practical way of employing an m.h.d. machine is therefore as a sort of 'front end' to an existing station. But whether extensive use of m.h.d. would improve efficiency to the point where coal-fired power stations are as competitive and free from acid rain as nuclear stations remains to be seen.

Research Notes is written by John Wilson.

Minimal eprom programmer

Special protocols devised to suit last month's hardware allow software to take over all the tasks in reading or writing eproms.

B.J. SOKOL

The simple hardware described in the June article can be controlled by any computer with a serial interface capable of communicating at 9600 baud. Creating the necessary software is not an enormous task, but is made vastly easier by the help of a high-level language such as Basic, Pascal, or C. Most of the procedures needed are available from such languages, with the exception of a few low-level functions which may require either machine code or system calls depending on the operating system in use. I have used the C language to implement the procedures for two different computers and three different operating systems and found the source code was portable in all cases with only the need for a few different assembly language routines to be bound in at link time.

Features of the program break down into three classes: the necessary, the fairly essentially useful, and the nice. Necessary are the features required to write and read eproms from and to disc files. The useful features add the capacity to display eprom contents, to verify eprom contents against files and to display informative screens and warning messages. The nice features may include provision of progress reports during programming, verifying and copying, differentiation during verification between reprogrammable and erasure-requiring faults, and file name and file size buffers to eliminate the need to retype the file identification if multiple copying and/or verification is required.

The *necessary* features are built from the following software functions:

1. initialize serial communication to 9600 baud, no parity, two stop bits, eight data bits;
2. open a disc file for reading or writing, and close it again;
3. flush the computer's and/or uart's serial receive buffer;
4. output an eight-bit character through the serial port with no handshake;
5. wait for an eight-bit character to arrive through the serial port, input it, with no handshake;
6. do nothing for 50 milliseconds (± 5ms).

Some of these functions may not require programming; for example, on my CP/M machine dip switches set up the serial port parameters. Some functions may come as part of your language, and some may require machine code or assembly language programming.

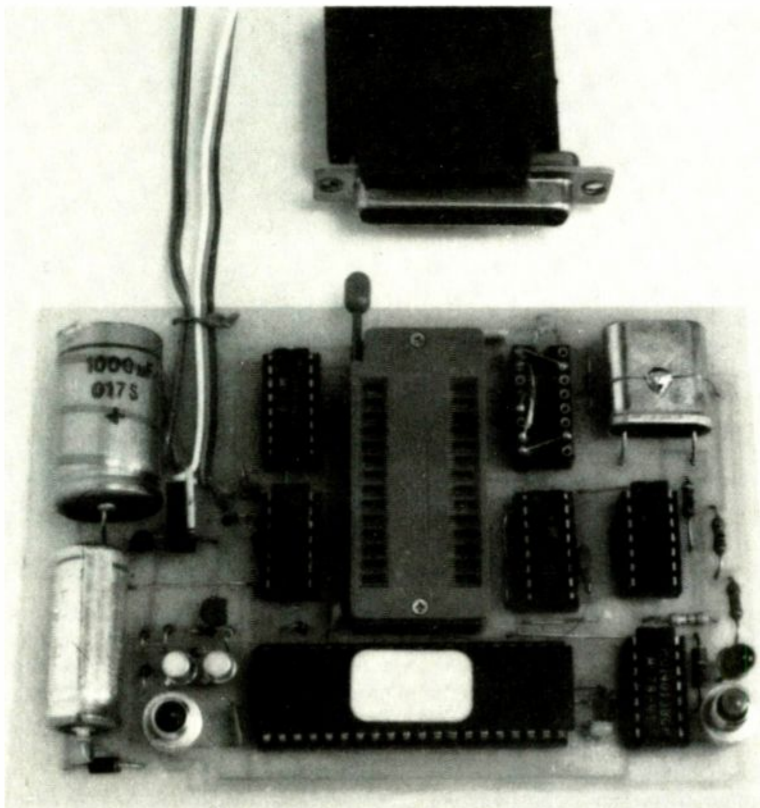


Table 1. Hardware settings for different communication parameters (uart type 6402, 8017 8502 etc.)

Pin	High	Low
35	No parity	Parity enabled
36	Two stop bits	One stop bit
39	Even parity	Odd parity

A detailed discussion of these functions will follow, but first let us assume they are provided, and consider the program from the top down. The two essential functions of the eprom maker are transfer of rom contents to and from disc files. These use the following program flows.

For reading: initialize, flush the buffer, open a disc file to read into, then repeat the following as many times as there are bytes to be read:

send a dummy byte (say, 0),
input a byte and store it as next in the file,
send another dummy byte,
input a byte and discard it.

After all bytes are read close the input file.

For writing: initialize, flush the buffer, open a disc file to write from, then repeat the following as many times as there are bytes to write:

fetch the first/next byte from the file and output it,
unless the fetched byte is FF_{16}, delay 50ms
input a byte and discard it,
output the fetched byte again,
input a byte and discard it.

Finally inform the user writing is done and close the output file.

CREATING PROCEDURES

If serial communication parameters are not available as listed above you may use different parameters and change the hardware in accordance with Table 1, perhaps with more dividers after the 4520 in the bit-rate generator.

Opening and closing disc files are functions of any high-level language, and with most you can use buffered file i/o to save considerable execution time.

If a serial communication flush function is not provided it can be implemented by a software loop that repeats as long as there is a byte to be read from the serial port – reading in a byte, discarding it, and trying again.

Outputting and inputting with no handshake may require an interface directly to the hardware of your uart, as operating system calls (for example under MS-DOS) may scan DTR or other signals before sending or receiving serial bytes. The (not recommended) alternative to taking the trouble with software is to wire up a special DB25 serial plug involving pins 4,5,6 and/or 20 and perhaps others with the right combination of shorting links.

On a simple computer, like my CP/M machine, the delay procedure is implemented by simply entering a loop to count up to a constant number, uselessly. This is not practical with IBM p.c.-type machines for several reasons. One is that processor speeds vary greatly. Some machines use two or even three different processor speeds selectable by the user, and some turbos don't even have the standard 4.77MHz as one of their options. Added to this is the difficulty that the various members of the Intel and NEC families of processor used in p.c.s queue instruction in an internal pipeline in differing ways, so that the time required to run a delay loop is not proportional to processor speed from one machine to another. Finally, a p.c. running DOS is not strictly a single thread machine, for the foreground task is stopped at intervals to allow d-ram refresh and for a system clock interrupt which may be trapped by memory-resident software.

The solution to these problems is to let the software figure out the delay parameters for itself. As in the simple case, a delay loop counter is used, but the counter goes up to a variable limit rather than a constant one, and the variable is adjusted each time the program is entered.

The assembler and C functions given in Table 2 show how this can be done. The delay(n) function is tested 50 times by the adjust( ) function using an initial value for n which is about right to produce a 50ms delay on an XT using a 4.77MHz clock. DOS system calls 2Ch and 2Dh to set and read the time are bound in using assembler routines zerosec( ) and readsec( ). These allow the number of seconds elapsed during the 50 in-line iterations of delay(n) to be measured. The resolution of these system calls is worse than 50ms, but repetition of the delay means the timing of each delay call is measured to about ±1ms, five times as accurate as is required for eprom programming.

Table 2 shows how time information obtained from readsec( ) can be re-formatted to an integer from the mixed binary and decimal format supplied by DOS (the high byte of the data word is seconds, the low byte is hundredths of seconds), then cast into a floating point form, and then divided into the expected number of 2.5 seconds to

Table 2. Two C and two assembler functions to adjust the delay function del(newfac) to 50ms. Functions zerosec and readsec should be declared –public, assembled and then linked to the C program.

```
delay(timer)
        int timer;
        {
        int n;
        for (n=1; n<=timer; n++) ;
        }

adjust()
        {
        int timer,readsec(),factor,timfac,newfac;
        float correct,timff;
        factor=2200;

        zerosec();     /*zeroes seconds, leaves minutes & hours*/

        delay (factor);
        delay (factor);
        delay (factor);

   .....and etc to fifty times ...

        timer= readsec();
               /*returns sec in hi byte, hundreths in lo byte*/
        timfac=(100*(timer/256) + (timer&0xff));
               /*corrects this to an integer*/
        timff=timfac;
               /*casts this to a float*/
        correct = (250/timff);
                newfac = (correct * 2200.0);

        printf ("The speed factor of your PC is %f.\n",correct);
        return (newfac);
}
```

```
zerosec_:       push bp
                push dx
                push cx
                mov  ah,2ch
                int  21h    ;read time
                mov  dx,0   ;zero secs
                mov  ah,2dh
                int  21h    ;set time
                pop  cx
                pop  dx
                pop  bp
                ret
```

```
readsec_:       push  bp
                push dx
                push cx
                mov  ah,2ch
                int  21h
                mov  ax,dx
                pop  cx
                pop  dx
                pop  bp
                ret
```

obtain a correction factor for the original guess at the delay constant. A corrected constant is then returned to the calling main progam for use in the 50ms delay loop when required. The entire process takes 2.5 seconds at most, and (for the sake of simplicity) resets the seconds counter of the system clock once to cause a 'loss' of at most 59 seconds.

Now we turn to *useful* aspects of the software. Menu screens can be designed to control of the various modes of operation. It is also useful to add a mode to display the contents of an eprom while they are being copied to a disc file.

A verify function is very helpful. It reads sequential bytes from the eprom but opens a file for reading rather than writing, and compares the eprom contents with sequential bytes from the file and displays any differences found.

The first of the nice functions memorizes the identity and size of the last file used to allow the re-use of the same data. This feature has certainly saved me enough in time and temper (and typing errors) to have made the tussle with string processing in its implementation worthwhile.

Another function puts blobs on the screen in blocks indicating 1Kbyte processed, to give a progress report. One blob per 64 bytes gives just enough information during programming to give comfort that something is happening without wasting too much time doing screen writes. It is also useful that the number of bytes to be programmed can be selected to be less than the full eprom length, allowing partial programming where this is suitable. To program the popular 2764 eprom fully takes eight minutes (less if there are 'blank' areas with FFs in them). A 27256 can take half an hour to program.

A final *nice* feature is an addition to the verify function that reports whether eprom erasure is required when there is a mismatch between a file and the eprom contents. Erasure is required when an eprom bit is low that should be high. The software reports each such mismatch with a message and an audible signal. This makes checking the suitability of an eprom for *overwriting* with a given file a matter of listening rather than careful watching. Silence during the verify function means overwriting is possible because all mismatched bits are high.

The author can supply executable software, a brief manual on disc, and a program useful for comparing two binary files. The basic version is available for a Morrow MD2 or MD3 CP/M system, or a Morrow with SWP coprocessor under CP/M86 or PC-DOS for £10 plus s.a.e. disc mailer from B.J. Sokol, 47 Grafton Road, London NW5 3DX. The fully featured program as described here is available for PC compatibles with a COM1: serial port for £15 plus mailer.

Jerry Sokol started his design consultancy in the U.S. in the early 1960s. He also lectures in renaissance literature at London University.

More out of MAC

A new way of getting more television signals through a given satellite transponder bandwidth for tv signal distribution or d.b.s. has won an international prize for a British researcher. Called D-SMAC, the system is the work of W.H. Dobbie of British Telecom Research Laboratories, Martlesham Heath, Suffolk. Mr Dobbie has won the $10,000 Piero Fanti international prize for 1986 given by the Italian company Societa Telespazio S.p.A. It honours the late Dr Piero Fanti, who was Telespazio's first director general, and is awarded to the winner of a competition open to all students and researchers in countries which are members of INTELSAT. The prize was presented at a Washington, DC meeting of INTELSAT signatories in April this year.

The new D-SMAC system allows four tv signals to be carried by a 36MHz transponder channel, compared with the current maximum of two signals using the PAL standard. It is based on the existing D2-MAC system which has already been proposed for d.b.s. and cable tv in Europe. In the name D-SMAC, the 'D' indicates that data is multiplexed with the video signal at baseband, the 'MAC' is the accepted abbreviation for multiplexed analogue components, while the 'S' means that these analogue components are subsampled.

Basically the four tv signals are transmitted through a 36MHz transponder by frequency division multiplex (f.d.m.) – that is, one tv signal in 9MHz. The techniques used to achieve good bandwidth efficiency include a non-linear pre- and post-filtering process, the subsampling mentioned above (called modified quincunx subsampling) and a method of adaptive interpolation which allows for practical analogue transmission. The system uses samples in the current tv field for interpolation and so avoids an immediate requirement for frame delay/stores and motion information.

Apart from signal distribution, Mr Dobbie's prizewinning paper states that the same technique could be used in d.b.s. to allow a doubling of broadcasting capacity "without significant loss of quality compared with PAL in the short term, with the option of trading the increased capacity in a compatible manner for enhanced definition and aspect ratio in the future." The subsampling method "allows the enhancement information to be overlaid in an effective and simple manner."

Mr Dobbie works in a group concerned with terrestrial interfaces and baseband processing within the Radio and Satellite Communications Division at Martlesham. This outfit is now building a prototype codec based on the D-SMAC principle. It will be used for signal distribution trials over a typical satellite link probably later this year, to include subjective comparisons with current distribution systems.

This antenna at British Telecom International's Goonhilly earth station, Cornwall, is to be used for the BTI Skyphone service – a satcom scheme allowing air travellers to make in-flight telephone calls from aeroplanes. The scheme follows from INMARSAT's 1985 decision to offer aeronautical mobile satcom services through its L-band maritime satellite network (January issue, p. 32). BTI Skyphone is one commercial system set up to exploit this new form of public telecommunications and will operate initially on transatlantic routes through INMARSAT's Atlantic Ocean satellite (MARECS B2) at 26° W. International direct dialling will be possible for passengers. Voice signals will be digitally encoded, initially at 9.6kbit/s, and data transmission will be available through the system, initially at 600bit/s. Standard airborne equipment will have up to four telephone channels per aircraft (four simultaneous calls). Avionics manufacturers are at the moment considering wall-mounting cordless units and integral seat-back units. Eventually the BTI Skyphone service could be extended to work through the INMARSAT comsats over the Indian and Pacific Oceans.

Advanced communication through Olympus

Digital television, high-definition tv, telecommunications to aircraft, adaptive channel coding, correlative phase modulation, simulated on-board processing and countermeasures against fading are among the many advanced radiocommunication experiments booked for the ESA Olympus satellite after it is launched next year.

This large multi-purpose comsat, weighing about 1.5 tonnes and measuring 26 metres from tip to tip of its solar arrays, is really an orbiting test-bed for anything that the European Space Agency and other organizations may want to try out for the future. In geostationary orbit at 19° W, the first flight model will carry four distinct payloads. One is for direct broadcasting projects, another is for specialized services (such as education, newsgathering, business), a third is for advanced communications experiments at 30/20GHz, while the fourth is for propagation studies.

At a recent IEE colloquium on 'Satellite communications above 18GHz' an overall picture of the expected utilization of these payloads was given by C.D. Hughes of ESA, Noordwijk, Netherlands. Probably of most interest to *E&WW* readers is the intended advanced communications work at 30/20GHz – which of course is on the verge of the millimetre-wave region. The payload for this comprises three 30W t.w.t. transmitters and two independently steerable spot beams with a beamwidth (to the 3dB contours) of 1°. The e.i.r.p. at beam centre is about 54dBW, allowing the use of small diameter antennas for earth stations.

Altogether this payload provides one wideband channel of 700MHz bandwidth and two narrow-bank channels of 40MHz each. Uplinks are at 30GHz and downlinks at 20GHz.

ESA will use this payload for data relay experiments. These will be to and from the Eureca orbiting scientific platform due to be launched in 1989. This low-orbit vehicle will carry an inter-orbit communications module which will send and receive signals to and from the geostationary Olympus transponders. Eureca will be tracked by the steerable antennas of Olympus and the data originating from the platform will be transmitted and received by an ESA earth station in Europe.

In broadcasting, said Hughes, there is a plan to demonstrate the ability of Olympus to relay high-quality television pictures and sound from remote parts of the world to European locations for broadcasting. In particular, using the steerable spot beams and ESA's air transportable earth stations, it will be possible to relay items of topical interest from, say, South America to a station in Europe, from where the Olympus d.b.s. payload can be employed to distribute the programmes. The European Broadcasting Union has shown interest in doing high-definition tv experiments using the 30/20GHz payload.

The wideband capability of this payload will be used to make measurements of phase correlation in very wide band transmissions at millimetre-wave frequencies. There will also be a number of scientific experiments concerned with countermeasures for fading. These will include experiments with diversity, both in frequency and space, and with digital techniques for alleviating the effects of fading. Most of the more general experiments, for example a British Aerospace video conferencing project, will investigate fade countermeasures as a necessary part of radiocommunications at 30/20GHz.

Many of the planned experiments are in the field of business communications using small earth stations, continued Hughes. The Canadian Communications Research Centre will set up an experimental network of stations for such business communications. It will also investigate the potential of on-board processing systems, using double-hop techniques and equipment on the ground to simulate a future satellite signal processor.

British Aerospace and the ESA are to run a business communications experiment in the UK involving data, voice and video conferencing. Initially the ESA's TDS-6 earth stations will be used for this experiment at three UK locations. Telespazio, in collaboration with the Politecnico di Milano and other Italian organizations, have also said they want to carry out business communications and teleconferencing experiments.

In data transmission, a number of European scientific organizations including the University of Graz (Austria), Rutherford Appleton Laboratory (UK) and CNUCE (Italy) will operate an inter-networking experiment. This will link together computer networks in the various countries to demonstrate the possibilities of high-speed operation of such systems. A further experiment called CODE (Cooperative Olympus Data Experiment) has been devised by an earth station working group consisting of representatives from universities and sceintific establishments. This will involve linking together scientific and educational establishments using very small aperture terminals (February issue, p. 160, on v.s.a.ts) throughout Europe.

Also using near mm-wave frequencies is the Olympus payload for propagation studies mentioned above. The general idea here is that the satellite provides a platform for source of electromagnetic radiation in space. These are in the form of beacon transmitters. Olympus carries three such transmitters, with frequencies of 12, 20 and 30GHz. They are all linearly polarized and accurately aligned with each other in polarization.

The 20GHz beacon can be switched by telecommand between two orthogonal polarizations or made to switch automaticaly between polarizations at a rate of about 1kHz. This feature allows accurate measurements to be made of differential polarization. The 12GHz beacon has a global converage with a minimum e.i.r.p. within coverage of 10 dBW. The 20 and 30GHz beacons have European coverage, each with a minimum e.i.r.p. of 24dBW. They are mutually coherent, being derived from a single oscillator source within the satellite which is duplicated to ensure long-term reliability.

These beacon transmissions, said Mr Hughes, not only allow absolute measurements of attenuation and cross-polar effects at 20 and 30GHz but also permit direct comparison simultaneously between 12-, 20- and 30GHz phenomena. He felt this to be very valuable because it will enable the considerable amounts of propagation data already collected at 12GHz to be scaled to the higher frequencies.

Offshore multi-channel satcoms

Winds in the North Sea often reach speeds of over 100 knots (185km/h), so the dishes of any satellite earth terminals used there have to withstand hefty wind loadings which can deflect their radiation beams away from the satellite position. In a new offshore terminal, claimed to be the first multi-channel satellite system used in the UK section of the North Sea oilfields, this problem is dealt with by sophisticated position-control servos which respond to the wind buffetings.

The new satcom terminal, built by Ferranti, is installed in a floating production vessel working at the Balmoral oilfield, 225km north-east of Aberdeen. A very demanding specification meant that a radome could not be used for protection. To achieve the required pointing accuracy of 0.05° for the antenna tracking and pointing system in the fierce wind conditions the antenna mount is made very rugged and position-controlled by a servo system using multiple processors.

This system receives error signals from two sources. Dynamic variations are sensed by an attitude and heading reference unit while slow drifts are obtained from a step-track pattern. An input to the step-track system is provided by a receiver picking up signals from a beacon on the satellite. The two corrections obtained through these detection systems are combined and then used to control the antenna's azimuth and elevation motor drives.

Overall the floating satcom terminal provides voice and data communications at Ku band through the European ECS-2 space segment to a British Telecom shore station at Bridge of Don, Aberdeen. Transmitter r.f. power is 250 watts. Multiple channels are obtained by the s.c.p.c. (single channel per carrier) transmission method, a system widely used in satcoms for sending a large number of different voice or data signals through a single transponder. Modulation is by companded f.m.

Ten voice channels are initially available, with an option for expansion to 25 channels without alteration to the equipment. Data is transmitted in 64Kbit/s circuits but with a Viterbi system of coding which results in an actual transmission rate of about 132Kbit/s. Considerable use is made of voice digitizing and statistical multiplexing to achieve the highest possible transmission efficiency. Equipment redundancy is applied throughout.

It seems that the Balmoral oilfield is a 'marginal' one from the business point of view, with a prospect of high recovery costs and small returns. Combined with the recent oil price drop, this makes a difficult situation for the suppliers of communications equipment, as the oil companies don't have much money to spare for capital investment at the moment.

International appointments

INTELSAT has elected His Excellency Susanta De Alwis, the Sri Lankan ambassador to the USA, as the new chairman of the international cooperative. He is supported by Juan Ciminari of Argentina, who was elected vice-chairman at the same time. Mr Ciminari, who has a degree in electronic engineering, has worked for Motorola in Argentina and served as that country's Secretary of Communications.

After the somewhat dramatic dismissal of its previous director general (and his deputy) following an audit, INTELSAT has now appointed Dean Burch of the USA to this important post for a term of six years. A lawyer by profession, Mr Burch has had 30 years' experience in telecommunications, including chairmanship of the FCC and leadership of the US delegation to the 1985 WARC at Geneva.

Newly elected chairman of the council of INMARSAT is a British communications engineer, Geoff Hall. He is currently head of satellite systems (planning and policy) in British Telecom International. In 1966 Mr Hall was in charge of the early UK satcom services operated through the country's first earth station at Goonhilly. Later he worked for the Comsat Corporation in the USA and was involved in the establishment of the INTELSAT organization. After his return to the UK, Mr Hall was given responsibility for all BT earth stations in this country.

He served as the INMARSAT council vice-chairman in 1986. Taking over this position now is Hideo Nagata, director of the satellite and radio communications department of Kokusai Denshin Denwa of Japan.

Satellite Systems was written by Tom Ivall.

Crossover distortion in class B amplifiers

Detailed tests on three modes of amplifier operation, including a non-switching class B type, using the same basic circuit produce a few surprises.

E. MARGAN

Ever since the publication of my circuit idea[1] I have received questions as to what extent the circuit was an improvement over the traditional arrangement. Nearly every question emphasized the subjective sensation of distortion reduction achieved[2].

At the time I had measured the circuit performance and found that the circuit definitely posessed certain advantages to justify publication, but enough data was collected to give a precise answer (other than "come and listen for yourselves").

Now I can give some answers regarding electrical performance and offer some hints on what can be perceived. There are still unknowns however and further experiments are encouraged to throw more light on the subject.

MEASUREMENT TECHNIQUES

Historically, crossover distortion was the first distortion mechanism encountered in transistorized audio amplifiers ("transistor sound"). It was considerably reduced by employing the now common bias technique[3] and it is surprising how little attention it has received in literature since. By the discovery and explanation of other distortion mechanisms it eventually faded into the background until the famous feedback vs feedforward error-correction debate, followed by the subjective evaluation debate. Although subjective evaluation was recognised to produce statistically unusable results[1], there remained an impression that not everything could be measured to correlate with the descriptions of what has been perceived by the "golden eared" ones. In fact there are many works that stress the output stage non-linearities as the major source of problems (refs 5,7,8,10,12).

Various methods have been developed to evaluate amplifier distortion. Most of them use steady-state signals to aid analysis. Several forms of distortion, however, have their origin in conditions that are variable by definition ("What have sine waves to do with music?").

Having experimented with different methods I finally decided that the 'subtraction' method[6] could offer most in flexibility as it requires no precision signal reference and can be used with both steady-state and transient signals.

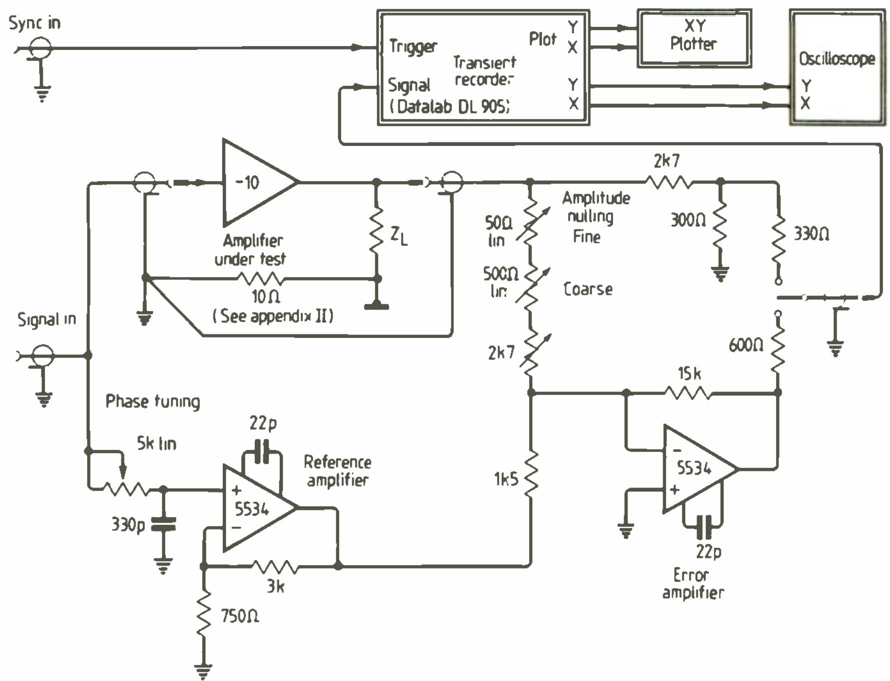


Fig.1. The "subtraction" test set-up due to Baxandall can be used with both steady-state and transient signals and does not require a precision reference.

Fig. 1 shows the test circuit, while Fig. 2 shows the experimental amplifier built to enable comparative measurements between standard class A and class B circuits and the circuit proposed[1] which will be referred to as class NSB (non-switching B). The circuit shown in Fig. 2 has the advantage of using the same devices in all the three modes, thus enabling direct comparison of test results. The front-end was built around a 5534 operational amplifier with open-loop gain of 60dB, unity-gain compensated by 22pF, a 20dB closed-loop gain, 40dB overall feedback and 200kHz closed-loop roll-off. The experimental amplifier performance is compared to another 5534 as its basic performance was considered acceptable by power amplifier standards. This amplifier has also a high-frequency single-pole network which matches its high-frequency roll-off and phase to the experimental amplifier. The output signals of both amplifiers are summed together by a resistive network. Being of opposite phase, the output signals are effectively subtracted, leaving only noise and distortion at the nulling point. A further 5534 is used to prevent nulling point loading by other test equipment and to amplify the error signal (×10) to increase the level as required by the input sensitivity of the test equipment.

Using a sine-wave generator at first to test the class B performance it was noted that if the level of distortion was changed the high-frequency single-pole control had to be readjusted to give minimum output from the subtraction amplifier (Fig. 3). To investigate the pattern of the change the generator was replaced by the circuit shown in Fig. 4, consisting of a square-wave generator driving two tunable band-pass filters both with independent Q-factor adjustment. At high Q settings the filters produce exponentially decaying sine waves simulating a real-life transient (Fig. 5, top trace). Such a signal offers the advantage of looking simultaneously at both distorted and undistorted amplifier response and make direct comparison.

By trying to get minimum output from the error amplifier it was noted that if the phase was nulled in the high signal level region where crossover spikes occured there remained considerable phase error in the low-level region where no switching distortion was being produced (Fig. 5, middle trace). And *vice versa*: if the phase was nulled in the undistorted region a lot of uncompensated phase error appeared, broken by the crossover spikes (Fig. 5, bottom trace). This means that only when the output signal amplitude falls below the level of transistor cut-off both amplitude and phase effects can be cancelled completely. Increasing quiescent current considerably reduced both phase error and crossover spikes, but they could not be entirely eliminated until the quiescent current was greater than the peak output current (essentially class A operation).

The obvious explanation is that when the class B output stage generates distortion the voltage gain stage is having a hard job to rebalance the error sensed by feedback, but it can only react with its own open-loop bandwidth and gain[7]. Also, the output impedance, being not near-zero under distortion conditions, forms an attenuator, together with the load which becomes part of the feedback loop. This is confirmed by Fig. 6 which shows error increase under capacitive load.

The degree and nature of distortion in class B configuration was a real surprise for it was expected that high distortion would show up at levels where the inactive output device becomes unbiased and eventually reverse biased (Fig. 7, top trace). That is also why it was expected that class NSB bias mode (Fig. 7, bottom trace) could be a better solution. In fact, in Fig. 8, where voltages across the output emitter resistances are recorded, the distortion threshold is reached when the output level falls below 100mV (on 4 ohm load, 0.4 ohm emitter resistances and 100 mA quiescent current).

It was also found that distortion falls as the voltage gain stage bandwidth rises, which was expected[8]. This throws a bit more light to schemes of alternative frequency compensation networks[9] and local error correction techniques[10,11]. While those methods reduce the errors considerably, the proposed circuit eliminates them in principle, enabling the overall feedback to be always effective. Comparing the recorded class B performance with class NSB recorded in Figs 9 & 10 shows the distortion generated with class NSB operation is very close to the noise floor. These figures are the same as can be achieved with class A

Fig.3. Class B operation: Output signal, top trace, 2V/div. Error signal, middle trace, 10mV/div. Decreasing quiescent current from 100 to 20mA increases crossover spikes and phase must be readjusted: bottom trace, 10mV/div. Recorded with resistive load, timebase 2ms full scale.

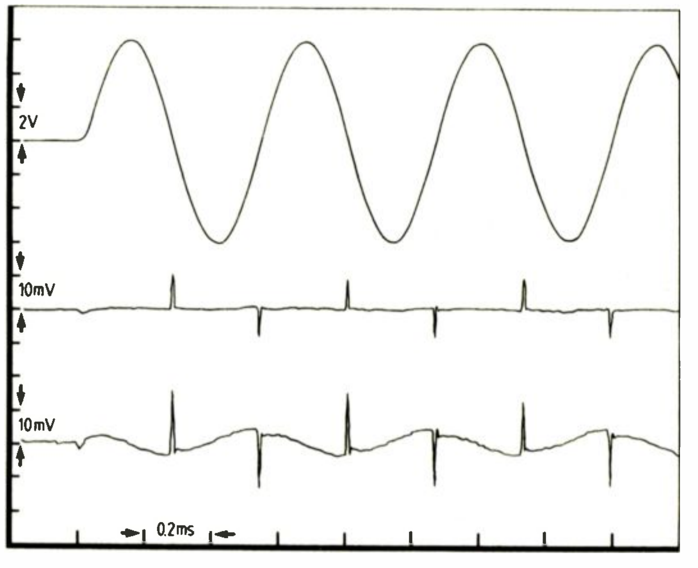
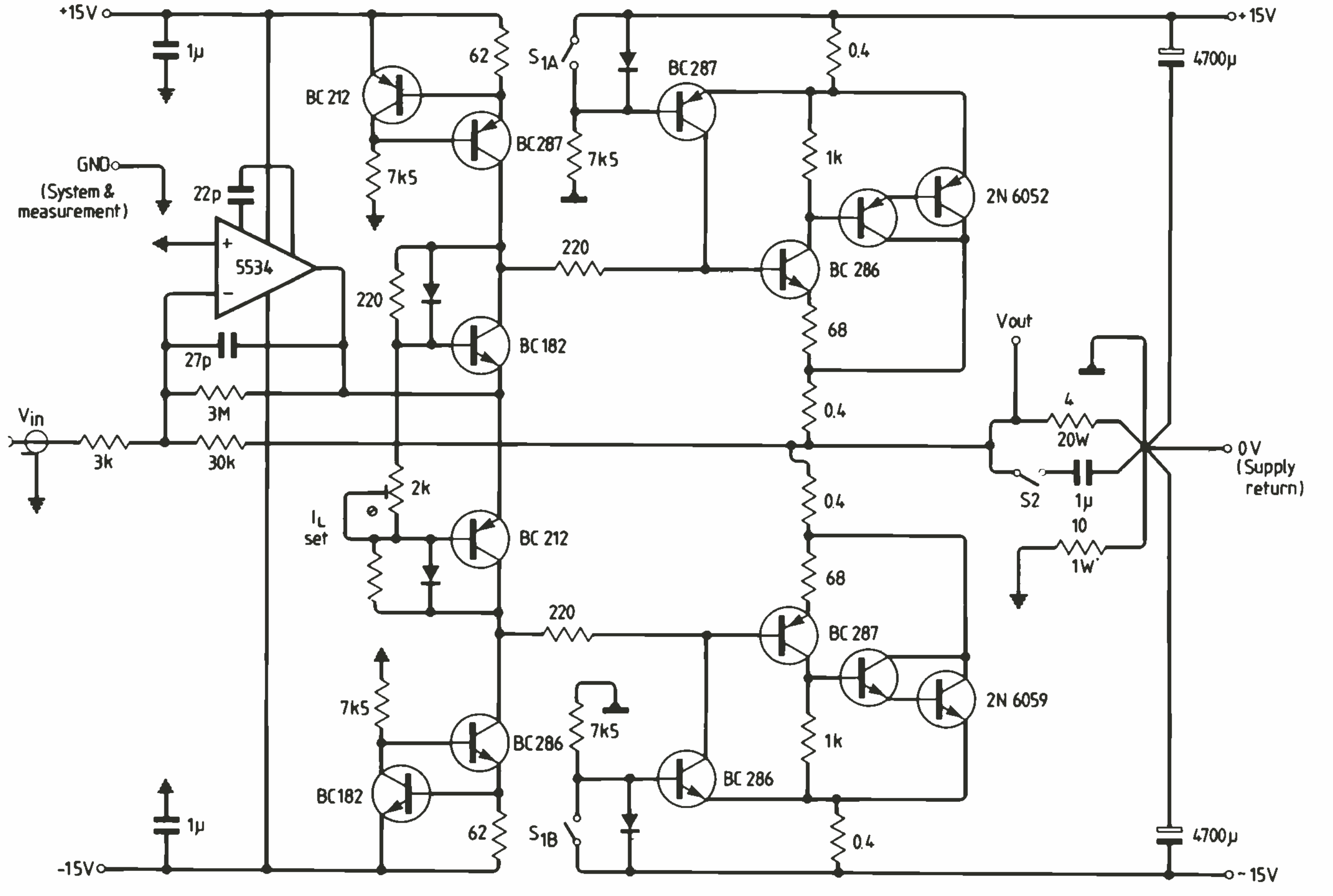


Fig.2. The experimental amplifier circuit diagram function in three modes, A, B and non-switching B.



operation. Such performance speaks for itself.

The proposed class NSB circuit has several distinct advantages over similar circuits presented before[12]. First, it uses only negative feedback (in contrast to positive or combined positive and negative in similar circuits) to sense and prevent switching off (Fig. 7, bottom trace). Secondly, the quiescent current is sensed directly, thus no thermal feedback is needed to achieve thermal stability. Third, thermal stability of the circuit does not rely mainly on high value of emitter degeneration resistance, so those resistances can be made small (less than 0.1 ohm) and so improve output impedance linearity in dependance of output current.

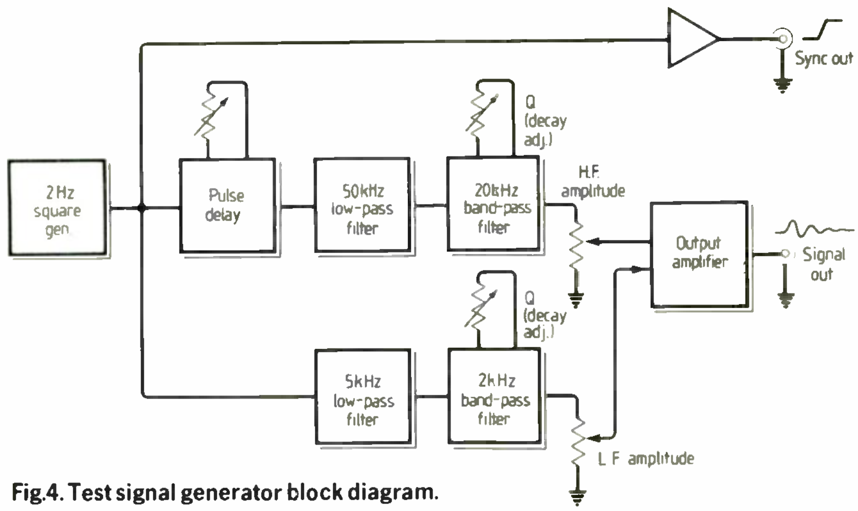
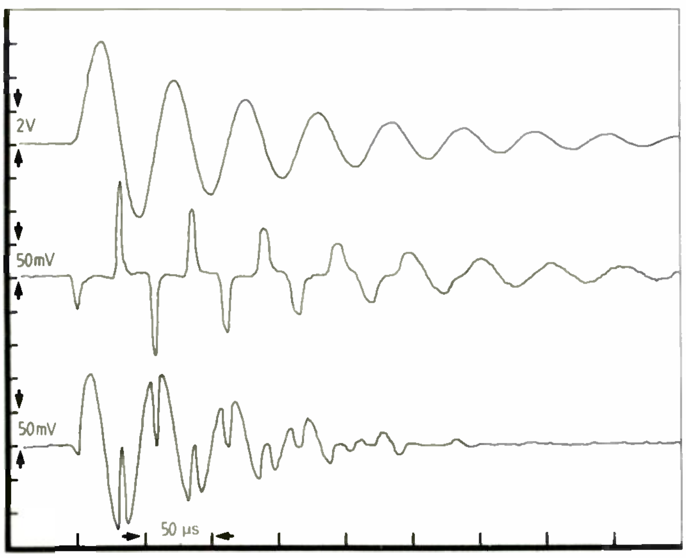


Fig.4. Test signal generator block diagram.



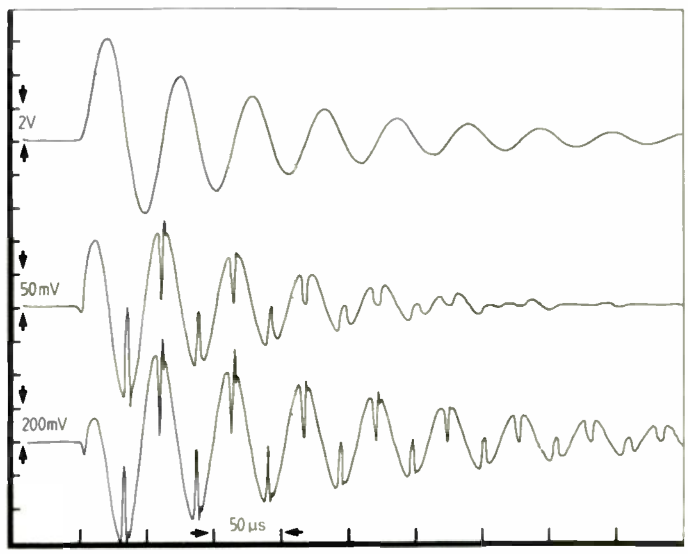
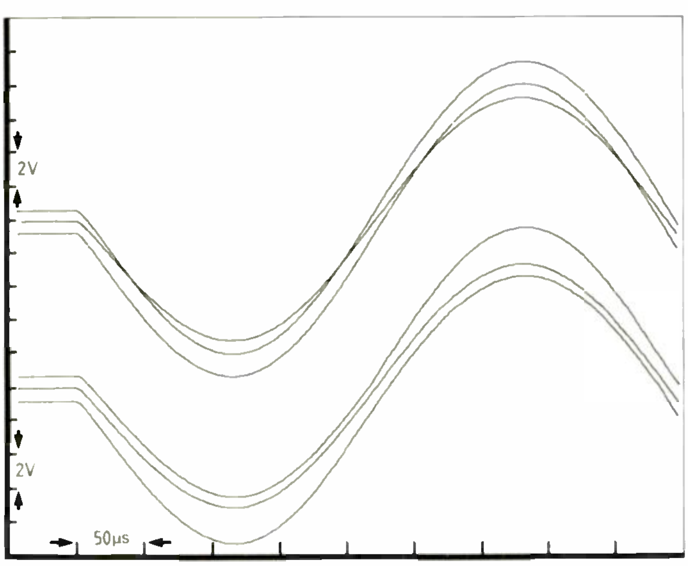


Fig.5. With exponentially decaying sine wave both distorted and undistorted class B response can be compared simultaneously. Top trace: test amplifier output, 2V/div. Middle trace: phase nulled in distorted region shows uncompensated phase in undistorted region, 50mV/div. Bottom trace: correct phase nulling, 50mV/div. Resistive load, timebase 0.5ms full scale.

Fig.6, above. Same as in Fig. 5, except bottom trace recorded with capacitive load, showing increased phase error.



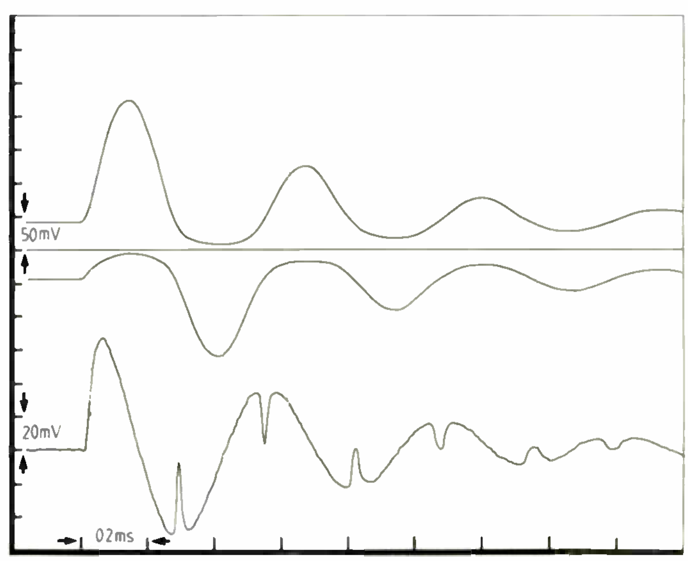


Fig.7. In class B operation the inactive output device becomes reverse biased: the output voltage is compared to the bias voltage under quiescent condition and with input signal applied, top traces, 2V/div. No such condition is allowed in class NSB operation, bottom traces, 2V/div. Resistive load, timebase 0.5ms full scale.

Fig.8. Class B output transistor currents (recorded as voltages across the emitter resistors) with zero current level shown for comparison. Vertical sensitivity 50mV/div., R(e) = 0.4ohm, R(L) = 4.0ohm, I(q) = 100mA. Bottom trace shows the error signal at 20mV/div. Time base: 2ms full scale.

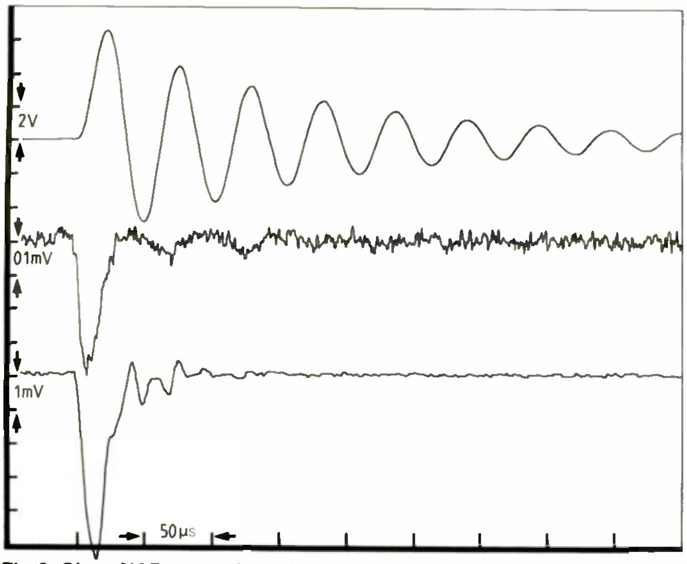


Fig.9. Class NSB operation with 100mA quiescent current shows no trace of phase error and no crossover spikes. Top trace: 2V/div., middle trace: 0.1mV/div., resistive load, bottom trace: 1.0mV/div., capacitive load, timebase: 0.5ms full scale.

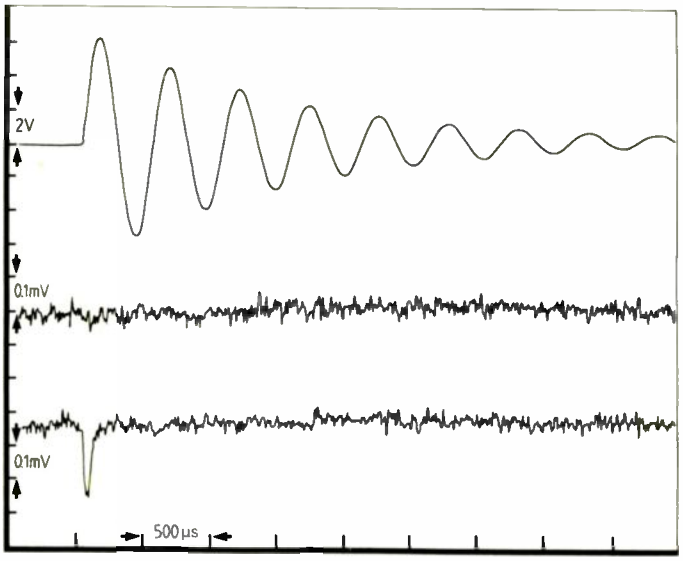


Fig.10. Same as Fig.9 except bottom trace 0.1mV/div. recorded with capacitive load; timebase 5ms full scale.

CONCLUSIONS

Although further investigation is needed several conclusions can be readily drawn from the data presented:

- Class B amplifier generates crossover distortion until the output signal current falls below the level determinated by the ratio of load impedance to emitter degeneration resistances and quiescent current setting.
- When crossover spikes are present a phase error is also generated[7].
- Phase error is inversely proportional to the open-loop bandwidth of the voltage gain stage.
- Phase error is also dependent on the ratio of the amplifier output impedance to the load impedance.
- The envelope of the phase error signal stays in fixed proportion to the output signal envelope until a threshold is reached and it suddenly disappears (switching phase modulation).
- In complex signals the individual components are differently affected: the higher the frequency, the greater the phase error. This, and the previous point mean that phase coherence is lost during that part of a musical signal which bears dominant localization and 'definition' information.
- A cost and bias level compromise combined with thermal stability requirement has forced many designers of commercially equipment to underbias the output stage (for comparison, see ref. 8).

As a consequence, comparing amplifiers of different design shows differences that depend on open-loop bandwidth and gain as well as on output impedance and quiescent current setting. Also, using the same loudspeaker load doesn't guarantee freedom from load-induced differences.

Regarding audibility of the described performance bear in mind that many subjective evaluation sessions have reported objections which could be attributed to lost phase coherence. Unfortunately, I have no means of performing a well-controlled listening session; someone with more experience in this field is invited to contribute. Of course, when listening to some digitally recorded piano I could definitely express my preference for classes A and NSB performance, even though not belonging to the "golden eared" category, but the opinion of a single person (and a strongly biased one who also knows what to listen for) can hardly have statistical meaning.

In fact, the phase errors recorded are of the order of 0.05 degrees at middle frequencies increasing up to several degrees at the top of the audio range, measured with a resistive load. Reactive loads and/or reduced open-loop bandwidth produces even greater phase error but to standardize measurement a reference reactive load and bandwidth are required to be defined.

But equally important, a statistically meaningful definition of the audibility threshold to switching phase modulation would be welcome. Only in regard to this threshold can the data presented here undergo relevant evaluation.

Finally, it has been demonstrated that both class A and class NSB are free from the effect described, thus highlighting the inherent quality of the NSB principle as a solution for crossover distortion.

References

1. E. Margan, Add-on current dumping, *Electronics & Wireless World*, 1985, October, p.40.
2. G. Nalty, Feedback letter, *Electronics & Wireless World*, 1986, February, p.42.
3. M. Glogolja, "Biasing circuit for the output stage of a power amplifier – the V_{be} multiplier", RCA application note AN 6297.
4. S. P. Lipshitz and J. Vanderkooy, "The great debate: subjective evaluation", *Journal of the Audio Engineering Society*, 1981, July – August, p.482.
5. P. Blomley, New approach to class B amplifier design, *Wireless World*, 1971, February, p.57, March, p.127.
   G. C. Haas, Design factors and considerations in full complementary symmetry audio power amplifiers, *Journal of the Audio Engineering Society*, 1968, July, p.321.
   N. S. Pass, Active bias circuit for operating push-pull amplifiers in class A mode, US Patent 3 995 228, 1976, November 30.
6. P. J. Baxandall, Audible amplifier distortion is not a mystery, *Wireless World*, 1977, November, p.63.
7. M. Otala, Nonlinear distortion in audio amplifiers, *Wireless World*, 1977, January, p.41.
8. J. Lohstroh & M. Otala, An audio power amplifier for ultimate quality requirements, *IEEE Transactions on audio and electro-acoustics*, 1973, December, vol. AU-21, no. 6, p.545.
9. E. M. Cherry, Nested differentiating feedback loops in simple audio power amplifiers, *Journal of the Audio Engineering Society*, 1982, May, p.295.
10. M. J. Hawksford, Distortion correction in audio power amplifiers, *Journal of the Audio Engineering Society*, 1981, January-February, p.27.
11. M. J. Hawksford, Distortion correction circuits for audio amplifiers, *Journal of the Audio Engineering Society*, 1981, July-August, p.503.
    M. J. Hawksford, Optimisation of the amplified-diode bias circuit for audio amplifiers, *Journal of the Audio Engineering Society*, 1984, January-February, p.31.
12. S. Tanaka, New biasing circuit for class B operation, *Journal of the Audio Engineering Society*, 1981, March, p.148.
13. E. M. Cherry, a new distortion mechanism in class B amplifier, *Journal of the Audio Engineering Society*, 1981, May, p.327.

Appendix 1 - Phase error calculation

The error signal undergoes phase modulation during the first rising edge of the output signal, Fig 5, whereupon a fixed phase relationship is established. If we neglect the exponential amplitude decay term as it is present in both the input and output signal as well as in the error signal, and label the input signal as sine, then the error signal is clearly a cosine. Looking at the amplitude nulling network under the correct nulling condition:

reference signal	$x = A \sin \omega t$
output signal	$y = B \sin (\omega t + e)$
error signal	$z = C \cos \omega t$

turn to page 709

NEW PRODUCTS

Synthesized function generator

A fully programmable 2MHz synthesizer/function generator with high 30V peak-to-peak output and eight-digit resolution has been introduced by Philips Test & Measurement.

High output accuracy and repeatability is guaranteed in the PM5191 by direct synthesis of an output signal from a crystal oscillator reference, ensuring that the stability is as good as that of the crystal. Phase noise is less than 80dBc/Hz.

Sinewaves, triangular signals, pulse trains and positive and negative ramps are the five outputs provided, with amplitude modulation being possible both internally and externally. The high output voltage can be set in r.m.s. peak-to-peak or dBm. a.c. and d.c. settings are completely independent within the ±15V window.

Manual operation is designed to be simple, with logical grouping of front panel controls and clear led readout of waveform, frequency and output setting. Frequency-related settings can be made precisely with numeric keys while preset frequency and level steps can be accessed by up/down buttons. The instrument can be operated remotely through a GPIB an incorporated into an automatic test system. Pye Unicam Ltd, York Street, Cambridge, CB1 2PX. Tel: 0223 358866.

Spectrum and logic analysers for hire

Instrument Rental now have two of the newest offerings from Tektronix. The 2710 is a low cost high performance spectrum analyser covering the range 10KHz to 1.8GHz. Due to the user-friendly display and no less than five separate parameter menus, the instrument's operation and set-up procedure is both quick and easy. Features include a marker mode to give direct readout of frequency and amplitude, automatic signal centering, user definable key steps, and waveform storage of up to three separate traces.

The Tektronix 1225 is a new logic analyser. It consists of 48 channels running at speeds of up to 100MHz in asynchronous mode. Like the 2710, the 1225 is extensively menu driven with the bare minimum of controls for data entry and function selection. Features include glitch capture, multiple time bases, 2K of memory per channel, built in battery backed, real-time clock and non-volatile storage for eight front-panel set ups. Instrument Rentals (UK) Ltd, Dorcan House, Meadfield Road, Langley, Berks, SL3 8AL. Tel: 0753 44878.

Static tester reaches 25kV

Schaffner EMC's latest electrostatic discharge tester, the NSG 432, will give test voltages of up to ±25kV. Part of the expanded NSG 430 series of test equipment, the new tester has a multi-turn potentiometer to enable setting the voltage with better resolution, from a minimum value of 2kV; but rather than rely on the potentiometer's linearity, the designers of the 432 have incorporated a digital voltmeter. All major test standards are catered for by the increased output available.

The instrument is supplied with a human-body model simulation to IEC801-2 (150 ohms, 150pF), but other models can be simulated on request. The purchaser may specify positive or negative polarity (positive is standard), an E-field adaptor or an H-field generator which produces an associated burst of electromagnetic radiation. For semi-automatic testing, there is an optional counter which produces a preset number of discharges in succession. The NSG 432 has been designed so that future changes in standards can be met by simple modifications. Schaffner EMC Ltd, Headley Park Area 10, Headley Road East, Woodley, Reading, RG5 4SW. Tel: 0734 697179.

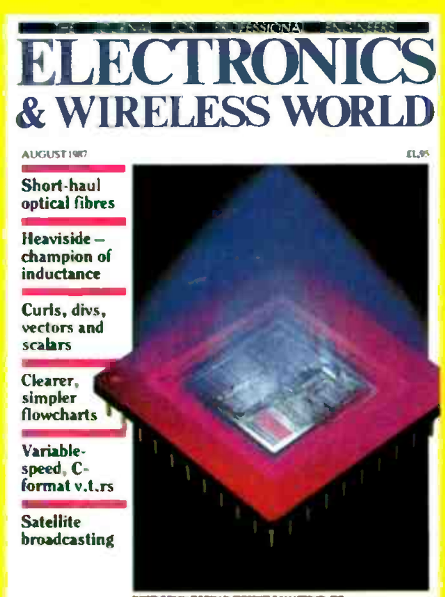
NEXT MONTH

Optical fibres. Short-haul optical-fibre data communication is an essential part of modern communications systems. This feature presents an overview of the techniques employed and the hardware available.

Pioneers. Next in this gallery of the founding fathers of electrical communication is Oliver Heaviside, the irascible genius whose insight into the physics of cables made long-distance telephone calls a practical possibility.

Tone generation system. A microcomputer scans two electronic organ keyboards and a pedal board, controlling up to 15 generators, which contain eproms holding the waveforms corresponding to 16 different stops. Attack and decay times are appropriate for each frequency and tone colour.

Q and stability. A further look at Q, with reference to the stability of oscillators used in timekeeping.



Curls and divs. Having mentioned Maxwell recently, JW finds himself taken to task for not explaining vector fields. It turns out to be not too difficult and certainly not stodgy.

A new look at gain/bandwidth product. The received wisdom is that the gain/b.w. product of a feedback amplifier is a constant, with reduced bandwidth at high gains. Is this true, or is it simply a matter of circuit design?

Variable-speed video. In the three years since our original series of articles on this subject appeared, the technique of replaying C-format professional v.t.rs at variable speed has advanced. John Watkinson deals with the new developments.

Image localization. Using the wavefront reconstruction approach to predict image position in stereophonic sound systems with interchannel phase difference.

NEW PRODUCTS

BRITISH ELECTRONICS WEEK

Credit card memory

The Aston Card has been given many additional applications. This credit-card sized memory plugs into equipment designed to use it or into a special adaptor to provide addition ram, rom or eprom to a computer or other digital device. An adaptor and plug-in p.c.b. has made it suitable for the IBM PC in addition to the adaptors already available for a number of other computers including the BBC, Commodore and Amstrad micros. Originally founded around eproms, the range has now been extended to include lithium-backed static ram (up to 1Mbyte) and eproms, either of which can be used as a removable, solid-state, disc-like storage medium. Software provided with the system allows the cards to be formatted and the computer will treat them as if they were discs. Masked roms for specific applications can be produced.

Some applications are security access, remote data capture and event recording, font and character changing in printers, software for programmable machines and so on. Further details from Cumana Ltd, The Pines Trading Estate, Broad Street, Guildford, Surrey GU3 3BH. Tel: 0483 503121.

1Mbit dynamic rams

High speed and low power are the latest developments in Toshiba rams with packaging in standard dual-in-line, plastic SOJ and ZIP formats for applications flexibility.

The new TC511000P/J85 features an access time of 85ns and a page-mode cycle time down to 50ns. The device is suitable for high-speed microprocessors operating at up to 16MHz.

The TC514256PL has an operating power figure of 358mW reducing to 5.5mW on standby. Access time is 100ns. As the standby current is less than 100μA this device can replace c.mos rams in large battery-backed memory arrays. Toshiba (UK) Limited, Semiconductor Division, Frimley Road, Frimley, Camberley, Surrey, GU16 5JJ. Tel: 0276 62222.

Spectrum analyser from Rohde & Schwartz

The FSA (Frequency Spectrum Analyser) from Rohde & Schwartz offers a dynamic range of 150dBm in a 6Hz resolution bandwidth. Covering a frequency range 100Hz to 1.8 or 2GHz, the FSA meets most requirements for the measurement of spectral distribution of signals. The quasi-continuous i.f. resolution and synthesiser tuning render the instrument suitable for both swept and fixed frequency analysis. All functions can be remotely controlled via the GPIB bus; thus ensuring simple integration into larger test systems.

The FSA facilitates the highest available frequency accuracy by the use of synthesisers throughout the instrument. With bands above 5MHz; synchronized start and stop techniques are employed – smaller bands use phase synchronized frequency steps. The FSA offers an intermodulation-free range of >100dB together with low s.s.b. phase noise of <−114dBc at 1KHz from the carrier. The resolution bandwidths: typically 6Hz to 3MHz; the frequency span 100Hz to 2GHz and the level display range of 175dB (−145 to 30dBm) make the FSA ideal for all applications of selective level measurement.

The FSA offers high operating convenience with parameter variation via step keys, direct entry, spinwheel or menu-dependent softkey operation. Automatic test routines include correction routines for level, frequency and bandwidth, internal self-test, adjustable automatic coupling for resolution bandwidth, video bandwidth and sweep time, help functions, autozoom and autoranging. The FSA incorporates a 9in (228mm) colour monitor with free choice of colours for traces; graticule; softkey labelling and background. Further features of the FSA are a.c./d.c. coupling; integrated a.m./f.m. demodulator and loudspeaker; Centronics interface and user port. Also connectors for external monitor; headphones and keyboard. Rohde & Schwarz UK Ltd, Roebuck Road, Chessington, Surrey KT9 1LP. Tel: 01 397 8771.

Tailor-made connections

Flexicon have set up a full-time special-projects team for bespoke connectors. Among their recent products is a low-profile chip-carrier socket which uses elastomeric interconnections to provide up to 224 ways. The socket projects only 2mm above the surface of the p.c.b. and can be surface mounted. Holes are needed for the fixing and orientation of the socket. Mounting the chip exerts a minimum of stress and distortion to the p.c.b. The design ensures correct polarity and orientation during assembly.

Other specialist connectors have been a zero-insertion-force interconnection system for flat-screen display panels and a high-density low-profile connector for the expansion modules of the Cambridge Computer's (Sir Clive Sinclair's) Z88 computer.

The company believes that there is an increasing market for bespoke connectors which are designed into a system rather than being added as an afterthought. Flexicon Systems Ltd, Hitchin Street, Biggleswade, Beds SG18 8BH. Tel: 0767 312086.

GTO snubber capacitors

Snubber capacitors are designed to carry the full load during the turn-off period in gate-turn-off thyristors. The capacitors produced by LCR Components have a peak current rating of 2000A. The very short turn-off phase of some applications requires the capacitors to have a low inductance of about 30nH, high r.m.s. current carrying capacity of 75A and a high dv/dt pulse rating of 2000V/μs. The capacitors are available in the range 1.5 to 4mF with tolerances of ±5 and ±10%. LCR claims to produce the largest range of capacitors in the UK. LCR Components, Woodfield Works, Tredegar, Gwent NP2 4BH. Tel: 049525 3131.

Surface-mounted resitors and inductors

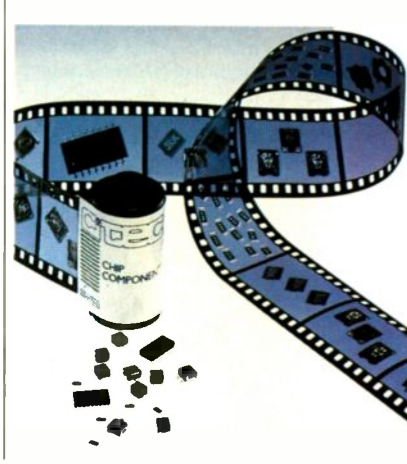
BICC Citec have produced a number of surface-mounted resistive and inductive components.

The 3204 is a fully sealed chip potentiometer, suitable for dip or wave soldering. Range available is from 500Ω to 1MΩ, with a power rating of 0.1W at an operating voltage of 20V.

Resistance in the 3305 trimmer potentiometer ranges from 10 to 2MΩ. It is believed to be the first fully 0-ring sealed chip trimmer. It has a power rating of 0.25W at 70°C with an input voltage of 20V. Temperature stability is within 100p.p.m.

Also available on 12mm-tape reels is the 3600 range of chip inductors, with a range from 0.22μ to 220mH, with an operating temperature from −25 to +85°C. A tolerance of 10% is offered on values above 3.3mH.

Citec has also produced chip resistors and resistor networks for surface mounting. BICC-Citec Ltd, Westmead, Swindon, Wilts, SN5 7YT. Tel: 0793 478301.



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AAZ15	0.30
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AC107	0.55
AC125	0.35
AC126	0.35
AC127	0.40
AC128	0.35
AC141	0.35
AC141K	0.45
AC142	0.40
AC142K	0.45
AC176	0.35
AC187	0.35
AC188	0.35
ACY17	2.25
ACY18	1.55
ACY19	1.80
ACY20	1.50
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AF114	3.50
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AF186	0.75
AF239	0.65
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ASY26	1.40
ASY27	1.00
ASZ15	2.20
ASZ16	2.00
ASZ17	1.60
ASZ20	4.50
ASZ21	4.75
AUY10	3.50
BA115	0.13
BA148	0.15
BA154	0.06
BA155	0.11
BA156	0.06
BAW62	0.05
BAX13	0.05
BAX16	0.06
BC107	0.12
BC108	0.13
BC109	0.13
BC113	0.12
BC114	0.12
BC115	0.12
BC116	0.19
BC117	0.24
BC118	0.30
BC125	0.25
BC126	0.25
BC135	0.18
BC136	0.18
BC137	0.22
BC147	0.12
BC148	0.12
BC149	0.12
BC157	0.12
BC158	0.13
BC159	0.12
BC167	0.10
BC170	0.09
BC171	0.11
BC172	0.09
BC173	0.09
BC177	0.15
BC178	0.28
BC179	0.15
BC182	0.11
BC183	0.09
BC184	0.11
BC212	0.11
BC213	0.11
BC214	0.11
BC237	0.09
BC238	0.09
BC300	0.36
BC303	0.36
BC307	0.09
BC308	0.09
BC327	0.09
BC328	0.09
BC337	0.09
BC338	0.09
BCY30	7.50
BCY31	7.50
BCY32	7.50
BCY33	7.50
BCY34	7.50
BCY39	3.60
BCY40	3.00
BCY42	0.32
BCY43	0.45
BCY58	0.25
BCY70	0.21
BCY71	0.21
BCY72	0.21
BCZ11	3.50
BD115	0.35
BD123	2.30
BD124	2.50
BD131	0.42
BD132	0.42
BD135	0.27
BD136	0.27
BD137	0.30
BD138	0.30
BD139	0.30
BD140	0.30
BD144	2.00
BD181	0.75
BD183	0.75
BD237	0.35
BD238	0.35
BDX10	0.91
BDX32	2.00
BDY10	2.40
BDY20	1.50
BDY60	1.50
BF115	0.30
BF152	0.16
BF153	0.19
BF154	0.17
BF159	0.20
BF160	0.20
BF166	0.35
BF167	0.30
BF173	0.45
BF177	0.30
BF178	0.30
BF179	0.35
BF180	0.35
BF181	0.35
BF182	0.30
BF183	0.30
BF184	0.30
BF185	0.30
BF194	0.15
BF195	0.15
BF196	0.15
BF197	0.15
BF200	0.33
BF224	0.15
BF241	0.12
BF244	0.35
BF257	0.30
BF258	0.30
BF259	0.30
BF336	0.30
BF337	0.30
BF338	3.00
BFS21	4.00
BFS28	2.50
BFS61	0.30
BFS98	0.30
BFW10	1.04
BFW11	1.01
BFX84	0.28
BFX85	0.28
BFX87	0.28
BFX88	0.28
BFY50	0.28
BFY51	0.28
BFY52	0.28
BFY64	0.36
BFY90	0.65
BSX19	0.27
BSX20	0.27
BSX21	0.27
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BTY79-400R	3.00
BU205	1.20
BU206	1.20
BU208	2.00
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BY126	0.15
BY127	0.15
BZX61 Series	0.17
BZY88 Series	0.10
BZY91 Series	8.00
BZY93 Series	0.12
BZY95 Series	1.64
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CRS3-40	0.75
CRS3-60	0.90
GEX66	3.00
GEX541	6.50
GJ3M	3.00
GM0378A	1.75
KS100A	0.45
MJE340	0.79
MJE370	0.73
MJE371	1.05
MJE520	0.75
MJE521	0.73
MJE2955	2.25
MJE3055	2.00
MPF103	0.55
MPF104	0.55
MPF105	0.55
MPSA06	0.17
MPSA56	0.17
MPSU01	1.11
MPSU06	1.33
MPSU56	1.71
NE555	0.45
NKT401	4.00
NKT403	3.50
NKT404	4.00
OA5	1.75
OA7	0.75
OA10	0.55
OA47	0.15
OA70	0.22
OA79	0.21
OA81	0.21
OA85	0.21
OA90	0.08
OA91	0.08
OA95	0.08
OA200	0.15
OA202	0.15
OA211	1.00
OAZ200	1.50
OAZ201	1.50
OAZ206	1.50
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OC16	5.00
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OC22	4.50
OC23	10.00
OC24	3.00
OC25	1.75
OC26	1.50
OC28	5.50
OC29	4.40
OC35	4.00
OC36	4.00
OC41	1.20
OC42	1.50
OC43	1.50
OC44	1.25
OC45	0.85
OC71	0.65
OC72	2.20
OC73	1.45
OC74	1.40
OC75	1.40
OC76	1.60
OC77	2.75
OC81	0.90
OC81Z	4.00
OC82	0.95
OC83	1.40
OC84	1.40
OC122	6.50
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OC139	12.00
OC140	18.00
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OC170	4.40
OC171	4.40
OC200	4.00
OC201	5.50
OC202	5.50
OC203	5.50
OC204	7.00
OC205	10.00
OC206	8.50
OC207	18.00
OCP71	2.50
ORP12	2.40
R2008B	1.95
R2009	2.25
R2010B	2.00
TIC44	0.48
TIC226D	1.20
TIP29	0.29
TIP29A	0.35
TIP30A	0.35
TIP31A	0.25
TIP32A	0.25
TIP33A	0.53
TIP34A	0.60
TIP41A	0.38
TIP42A	0.42
TIP110	0.40
TIP117	0.45
TIP125	0.35
TIP130	0.45
TIP131	0.45
TIP132	0.48
TIP135	0.45
TIP137	0.48
TIP140	0.85
TIP142	0.85
TIP2955	0.60
TIP2955I	0.45
TIP3055	0.60
TIP3055I	0.45
ZS140	0.25
ZS170	0.20
ZS178	0.54
ZS272	0.23
ZS278	0.57
ZTX107	0.12
ZTX108	0.12
ZTX109	0.12
ZTX300	0.13
ZTX301	0.14
ZTX302	0.14
ZTX303	0.14
ZTX304	0.14
ZTX311	0.13
ZTX314	0.25
ZTX500	0.14
ZTX501	0.14
ZTX502	0.14
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ZTX504	0.20
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ZTX550	0.25
1N914	0.03
1N916	0.03
1N4001	0.04
1N4002	0.04
1N4003	0.04
1N4004	0.04
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1N4006	0.04
1N4007	0.05
1N4009	0.30
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1N5400	0.10
1N5401	0.11
IS44	0.04
IS290	0.10
IS921	0.12
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2G302	1.20
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2N404	1.50
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2N930	0.35
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2N1132	0.35
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2N1303	0.90
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2N1305	1.00
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2N1307	1.20
2N1308	4.00
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2N1613	0.30
2N1671	5.00
2N1893	0.30
2N2147	8.00
2N2148	2.75
2N2218	0.32
2N2219	0.32
2N2220	0.22
2N2221	0.22
2N2222	0.20
2N2223	7.50
2N2368	0.23
2N2369	0.23
2N2484	0.24
2N2646	0.75
2N2904	0.30
2N2904A	0.30
2N2905	0.30
2N2906	0.22
2N2907	0.22
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2N3441	0.75
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2N3614	5.00
2N3702	0.11
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2N3773	1.60
2N3819	0.50
2N3820	0.60
2N3823	0.80
2N3866	1.00
2N3904	0.10
2N3905	0.10
2N3906	0.10
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2N4062	0.15
2N4124	0.13
2N4126	0.13
2N4248	0.25
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2N4400	0.12
2N4401	0.12
2N4402	0.12
2N5457	0.45
2N5458	0.40
2N5459	0.40
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ECL82	1.50
ECL83	3.00
ECL84	1.50
ECL85	1.50
ECL86	1.75
EF37A	5.00
EF39	2.75
EF40	5.00
EF41	3.50
EF42	4.50
EF50	2.50
EF54	5.00
EF55	3.50
EF80	1.75
EF83	4.00
EF85	1.75
EF86	3.50
EF89	2.50
EF91	2.95
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EY84	9.24
EY86	1.75
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GXU4	44.50
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GZ33	4.75
GZ34	4.00
GZ37	4.75
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KT77 Gold Lion	12.00
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M8079	12.34
M8080	8.25
M8081	9.82
M8082	9.69
M8083	10.25
M8091	10.43
M8096	6.80
M8097	8.10
M8098	8.15
M8099	8.00
M8100	10.30
M8136	11.75
M8137	12.25
M8140	6.00
M8141	6.50
M8142	8.75
M8144	7.50
M8149	6.50
M8161	9.35
M8162	11.75
M8163	8.25
M8190	5.00
M8195	10.85
M8196	7.50
M8204	7.05
M8212	11.37
M8223	6.00
M8224	6.30
M8225	4.50
M8248	14.03
MD2901	115.00
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MX123	86.00
MX145	61.50
MX151	18.30
MX152	150.00
MX161	175.00
MX163	19.50
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OA2	3.25
OA3	2.50
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OC2	4.35
OC3	2.50
OD3	2.50
OZ4	3.50
PC86	2.50
PC88	2.50
PC95	1.75
PC97	1.75
PC900	1.75
PCC84	1.50
PCC85	1.50
PCC88	2.00
PCC89	1.75
PCC189	2.50
PCC805	1.60
PCC806	1.60
PCL82	2.00
PCF80	2.00
PCF82	1.50
PCF86	2.50
PCF87	2.00
PCF200	3.25
PCF201	3.25
PCF801	2.50
PCF802	2.50
PCF805	1.70
PCF806	1.70
PCF808	1.70
PCL82	2.00
PCL83	3.00
PCL84	2.00
PCL85	2.50
PCL86	2.50
PCL805/85	2.50
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PFL200	2.50
PL36	2.50
PL81	1.75
PL81A	2.00
PL82	1.50
PL83	2.50
PL84	2.00
PL504/5	2.50
PL508	5.50
PL509	6.00
PL519	6.00
PL801	1.50
PL802	6.00
PY33	2.50
PY81	1.50
PY82	1.50
PY83	1.25
PY88	2.00
PY500A	4.00
PY800	1.50
PY801	1.50
QE451	82.50
QQV02-6	38.00
QQV03-10	26.25
QQV03-20A	48.38
QQV06-40A	46.00
QQV07-50	76.65
QQZ06-40A	62.20
QU37	12.50
QV03-12	6.80
QV04-7	3.50
QV08-100	197.40
QY3-65	63.24
QY3-125	78.48
QY4-250	74.00
QY4-400	87.20
QY5-500	208.00
QY5-3000A	566.80
QZ06-20	46.00
R10	6.00
R17	3.00
R18	3.00
R19	9.24
R20	2.50
RG3-1250	59.50
RG3-250A	32.68
RG4-1250	61.60
RG4-3000	99.45
RR3-250	40.00
RR3-1250	45.75
S130	6.00
S130P	6.00
STV280-40	14.00
STV280-80	21.00
SU41	5.00
SU42	10.00
TD03-10	35.00
TD03-10F	35.00
TT15	50.00
TT21	37.50
TT22	37.50
TT100	60.00
TY2-125	78.75
TY4-400	88.20
TY4-500	124.26
TY5-500	272.50
TY6-800	231.00
TY6-5000A	632.20
TY6-5000B	395.00
TY6-5000W	523.00
TY7-6000A	632.00
TY7-6000W	579.00
TZ40	25.00
U18/20	3.50
U19	13.75
U25	2.50
U26	2.50
U37	12.00
UABC80	1.25
UAF42	2.50
UB41	3.00
UBC41	2.25
UBF89	1.50
UCC84	1.75
UCC85	1.85
UCF80	2.00
UCH42	2.50
UCH81	2.50
UCL82	1.75
UCL83	2.75
UF41	2.00
UF42	2.10
UF80	1.75
UF85	1.75
UF89	2.00
UL41	5.00
UL84	1.75
UM80	2.00
UY41	4.00
UY85	2.25
VLS631	15.00
XG1-2500	100.00
XG5-500	30.00
XG2-6400	185.00
XR1-1600A	53.75
XR1-3200	81.97
XR1-3200A	
XR1-6400	165.00
YD1120	395.00
YD1240	588.60
Z803U	25.00
Z759	25.00
ZM1001	8.00
ZM1020	9.00
ZM1020	9.00
ZM1022	9.00
ZM1023	9.00
ZM1040	19.36
ZM1041	16.66
ZM1042	17.77
1B3GT	3.00
1B24	25.00
1B35A	48.00
1B63	64.00
1R5	1.75
1S5	1.75
1T4	1.75
2AS15	11.50
2C39A	60.00
2C43	70.00
2D21	3.25
2E26	8.25
2J42	98.00
2J55	265.00
2J70A	383.00
2J70B	336.00
2K25	125.00
3400Z	115.00
3500Z	100.00
3A5	3.00
3B24	11.00
3B28	15.35
3B29	20.05
3B240M	17.50
3B241M	17.50
3C23	25.00
3C24	12.00
3CX100A5	47.00
3E29	45.00
3S4	2.00
3V4	1.75
4-65A	60.00
4-125A	60.00
4-250A	80.00
4-400A	87.00
4B32	20.00
4C35	120.00
4CX250H	58.00
4CX350A	105.00
4X150A	60.00
4X150D	56.00
5HE12	65.00
5B254M	35.00
5B255M	35.00
5C22	160.00
5J180E	2500.00
5R4GY	5.50
5U4G	3.00
5U4GB	2.50
5V4G	2.50
5Y3GT	2.50
5Z3	4.00
5Z4G	2.50
5Z4GT	2.50
6-30L2	1.75
6AB4	1.75
6AB7	3.00
6AC7	3.00
6AF4A	4.25
6AG7	3.00
6AH6	5.00
6AK5	5.99
6AK6	2.50
6AL5	1.50
6AM4	4.00
6AM5	9.69
6AM6	6.02
6AN5	4.75
6AN8A	3.50
6AQ5	3.25
6AS6	8.66
6AS7G	8.75
6AT6	1.25
6AU5GT	5.00
6AU6	2.50
6AV5GA	4.50
6AV6	1.50
6AX5GT	3.00
6B7	3.25
6B8	3.25
6BA6	1.50
6BA7	5.00
6BA8A	4.00
6BC4	4.00
6BE6	1.50
6BH6	2.50
6BJ6	2.25
6BK4	4.50
6BL6	125.00
6BL7GT	4.50
6BM6	115.00
6BN6	2.00
6BQ7A	3.50
6BR7	6.00
6BR8A	3.50
6BS7	6.00
6BW6	6.00
6BW7	1.50
6BX7GT	5.00
6BZ6	2.75
6C4	1.25
6CB6A	2.50
6CD6GA	5.00
6CG7	2.50
6CH6	13.00
6CL6	£3.75
6CW4	8.00
6D2	1.50
6DK6	3.00
6DQ6B	4.75
6EA8	3.00
6EB8	2.50
6EW6	2.25
6F6	3.00
6F23	1.60
6F28	1.60
6F33	33.50
6H1	14.00
6H3N	2.75
6H6	3.00
6J4	5.50
6J6	8.93
6J7	4.75
6JE6C	7.50
6K6GT	2.75
6K7	3.00
6K8	3.00
6KD6	8.00
6L6G	5.00
6L6GA	3.50
6L6GC (GE)	5.75
6L6GT	3.00
6L7	2.50
6N2P	2.50
6N3P	2.50
6N7	3.00
6P25	4.00
6Q7	3.75
6R7	3.25
6RHH8/6KN8	10.00
6SA7	3.00
6SC7	2.75
6SF7	2.50
6SH7	3.00
6SJ7	3.25
6SK7	3.50
6SL7GT	3.00
6SN7GT	3.00
6SQ7	3.40
6SR7	4.00
6SS7	2.75
6U5G	3.50
6U8A	2.25
6V6GT	4.25
6X4	3.00
6X5GT	1.75
7B7	2.50
7C5	4.00
7C6	2.50
7H7	4.00
7R7	4.25
7S7	3.50
7Y4	2.25
7Z4	2.00
12AH8	5.00
12AT6	1.50
12AT7	1.75
12AU6	2.50
12AU7	1.75
12AV6	2.50
12AV7	3.50
12AX7	1.75
12AY7A	4.00
12B4A	3.50
12BA6	2.50
12BE6	2.50
12BH7	2.75
12BY7	3.00
12E1 ITT	28.00
12E14	65.00
12E1	20.00
13E1	170.00
19H5	47.50
24B9	67.25
30C15	2.00
30C17	2.00
30C18	2.00
30F5	1.60
30FL1/2	1.38
30FL12	1.80
30FL14	2.00
30L1	1.50
30L15	2.00
30L17	2.00
30P4	2.50
30P19	2.50
30PL1	3.00
30PL14	1.80
30PL15	1.80
35W4	1.00
50C5	1.50
75B1	6.05
75C1	4.50
85A1	7.50
85A2	6.45
90AG	20.00
90AV	20.00
90C1	6.00
90CG	14.54
90CV	15.45
92AG	20.00
92AV	20.00
95A1	8.45
150B2	6.50
150B3	8.35
150C2	3.25
150C4	6.00
211	35.00
723AB	125.00
803	25.00
805	45.00
807	3.75
811A	18.33
812A	47.50
813 valve	65.00
833A	193.16
866A	35.00
872A	20.00
922	6.00
931A	18.50
1624	4.00
1625	3.50
2050	7.50
4212L	300.00
4212H	300.00
5544	110.00
5545	150.00
5551A	120.00
5552A	165.00
5642	9.00
5654	3.00
5651	4.45
5670	4.50
5675	28.00
5687	6.00
5696	4.50
5718	7.50
5725	5.50
5726	11.37
5727	7.05
5749	2.50
5751	4.00
5763	4.50
5814A	4.00
5840	4.00
5842	12.00
5876A	31.50
5879	5.00
5886	17.50
5963	2.50
5965	3.50
6005	2.25
6021	4.50
6057	12.25
6058	12.34
6059	6.00
6061	6.00
6063	3.75
6064	10.25
6067	11.75
6072	6.00
6080	14.00
6097A	235.00
6097B	200.00
6146A	12.00
6146B	12.00
6159B	19.00
6189	9.50
6201	11.40
6412	20.00
6550	10.00
6883B	12.50
6973	7.50
7025	4.50
7027A	8.00
7551	6.25
7586	15.00
7587	23.00
7609	56.00
7868	6.00
7895	12.00
8068	16.50
8136	2.50
8417	6.00
18042	11.53
18045	10.49
18046	11.53

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Ex-Equipment
4CX250B 8.50
CV Devices
Large stocks
Prices on application

BASES

B7G Unskirted	0.40
B7G Skirted	0.50
B9A Unskirted	0.40
B9A Skirted	0.50
B9D	0.55
Int. Octal	0.40
Loctal	0.55
Nuvistor base	2.00
Valve screening can all sizes	0.40

CRTs

2AP1	8.50
2BP1	9.00
3BP1	20.00
3DP1	5.00
3EG1	10.00
3FP7	6.00
3GP1	6.00
3JP1	8.00
3JP2	8.00
3JP7	10.00
3KP1	15.00
3RP1	35.00
3WP1	20.00
5ADP1	55.00
5CP1	10.00
5CP1A	40.00
5FP15A	15.00
5UP7	25.00
DG7-5	63.32
DG7-31	58.07
DG7-32	58.07
DG7-36	65.00
DH3-91	56.83
DH7-11	113.12
VCR138	12.00
VCR138A	12.50
VCR139A	8.00
VCR517B	10.00
VCR517C	10.00

CRT sockets
Prices on application

IC sockets
Texas
low profile

8	pin	10p
14	pin	10p
16	pin	10p

INTEGRATED CIRCUITS

7400	0.16
7400	0.35
7401	0.36
7402	0.36
7403	0.36
7404	0.42
7405	0.42
7406	0.48
7407	0.55
7408	0.36
7409	0.36
7410	0.36
7411	0.40
7412	0.42
7413	0.36
7416	0.48
7417	0.48
7420	0.48
7422	0.36
7423	0.36
7424	0.36
7427	0.36
7428	0.36
7430	0.36
7432	0.36
7433	0.55
7437	0.36
7438	0.36
7439	0.36
7440	0.36
7441	0.48
7442	1.25
7450	0.30
7451	0.30
7453	0.30
7454	0.30
7460	0.30
7470	0.48
7472	0.30
7473	0.48
7474	0.36
7475	0.65
7476	0.48
7480	0.32
7483	0.48
7484	0.72
7486	0.54
7490	0.72
7491	0.36
7492	0.54
7493	0.54
7494	0.78
7495	0.65
7496	0.60
7497	3.00
74100	0.81
74107	0.36
74109	0.54
74110	0.48
74111	0.51
74116	1.50
74118	1.20
74119	1.50
74120	0.75
74121	0.54
74122	0.70
74123	0.60
74125	0.60
74126	0.54
74128	0.55
74130	0.70
74141	0.46
74143	1.30
74145	0.72
74147	1.50
74148	1.40
74150	1.60
74151	0.36
74154	1.40
74155	0.60
74156	0.48
74159	1.75
74170	1.20
74172	4.00
74173	0.72
74174	0.60
74175	1.00
74176	1.00
74180	1.48
74190	1.20
74191	1.20
74192	1.10
74193	0.60
74194	1.10
74195	0.72
74196	1.00
74197	1.00
74198	2.20
74199	2.20
FAA570	1.75
FAA630S	1.75
FAA700	3.00
TBA480Q	1.50
TBA520Q	1.50
TBA530	1.50
TBA550Q	1.75
TBA560Q	1.75
TBA673	1.75
TBA700	1.50
TBA700Q	1.75
TBA750Q	1.50
TBA800	1.00
TBA920	1.75
TBA990	1.50
TCA270Q	1.00
TCA760A	1.25

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NEW PRODUCTS
BRITISH ELECTRONICS WEEK

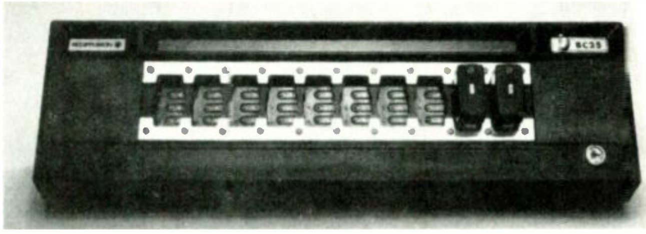
Piezoelectric film

Polyvinylidene fluoride (pvdf) in a polarized form, with metallic conductive surfaces applied, offers remarkable piezoelectric properties and may be used for a seemingly unlimited number of applications in transducers. It acts as a self-charging capacitor with the signal taken from the metal electrodes. Like piezo-ceramic material, it produces an output voltage when stressed and will change its physical dimensions when a voltage is applied across it; so it can be used both for microphones and loudspeakers. As a load cell it can be used in pressure, strain, vibration and impact measurement, and in accelerometers. It has been used to provide touch sensors for experimental robots, and respiration and heartbeat sensors for babies. The simplest example is its use as a switch and with 20 times the output of a ceramic transducer, proportional to the applied stress, it can drive a liquid-crystal display directly. The film can be incorporated into keyboards where the switches have the advantage of dirt and moisture resistance, bipolar output and the ability to be used in battery-powered equipment. One specific successful application has been in its incorporation into a pressure-sensitive graphics input tablet with an x-y accuracy of 0.1mm.

The film also responds to infra-red radiation and can be used for temperature measurement. It is sensitive enough to detect a human body at 16 metres and be incorporated into intruder alarms. Further details, samples, experimentation kits and the film itself are available from the Pennwalt Corporation, 74 Great King Street, Edinburgh EH3 6QU. Tel: 031 558 1144.

Solder rework station

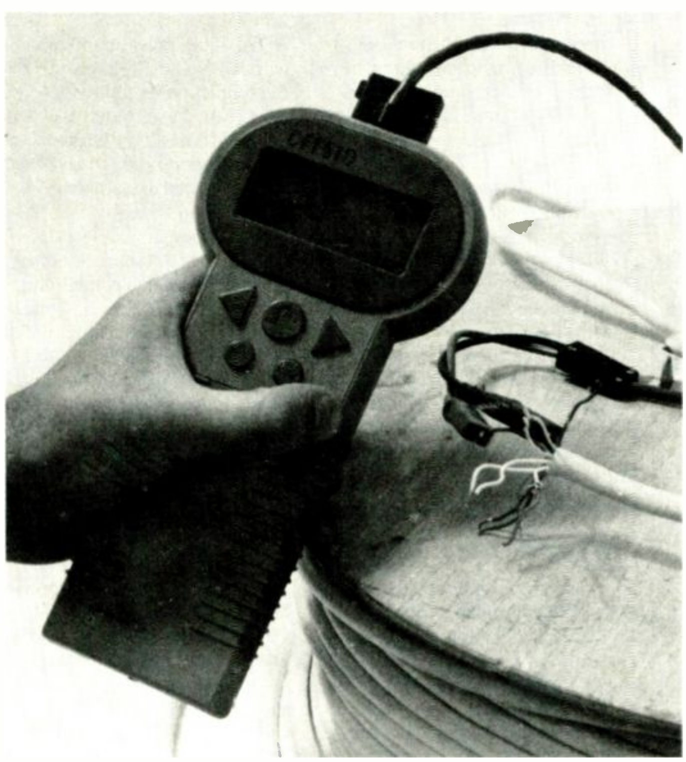
A new Weller multi-function hot gas workstation is suited to rework and reflow soldering/desoldering of micro components. The AH 1700 station features a hot-gas pencil, giving a variable rate of gas flow, the temperature of which is adjustable between 10°C and 450°C. Gas flow is turned on and off by means of a footswitch. A hand-held vacuum pick-up tool, connected to the work station, enables components to be positioned or removed during reflow or desoldering. A temperature controlled hot plate, adjustable between 30 and 250°C provides pre-heating for ceramic or other components with poor heat conductivity. Weller equipment comes from Cooper Tools Ltd, Sedling Road, Wear, Washington, Tyne and Wear N38 9BZ. Tel: 091 416 6062.



Fast charging of NiCads

After extensive research into the behaviour of nickel cadmium batteries under various pulsed charging conditions, Rediffusion radio systems have developed a processor-controlled battery charger that is capable of sensing the condition of the battery and recharging it accordingly. It is intended for use with the smaller NiCd batteries commonly used in hand-held radios and other battery-operated equipment as used by public and emergency services.

At the heart of the BC25 charger is a patented system for recognizing the fully charged state of a battery. Having this ability, the charger can be used to rapidly charge each battery safely with no risk of overcharging. It can also be used to trickle-charge batteries only partly discharged. A full condition charge, i.e. a controlled discharge followed by a rapid recharge, is used for batteries that have failed or may be suspect. Leds are used to indicate the status of each battery under charge and, in the condition mode, the capacity of the battery as a percentage of its rated capacity. The BC25 is fully automatic and only needs the batteries to be loaded and removed. A manual switch alternates between normal or condition charging. Rediffusion Radio Systems Ltd, Newton Road, Crawley, West Sussex, RH10 2PY. Tel: 0293 518855.



Pulse/echo cable fault locator

The first truly hand-held, battery-powered, pulse-echo cable fault locator with l.c.d. read-out is claimed by Cossor. It has been designed to be comfortable and easy to use by any operator. The CFL 510 uses microprocessor technolgy and the l.c.d. is a dot matrix type with four ranges: 100m, 300m, 1000m and 3000m full-scale, with 1.6% resolution and a nominal 3% accuracy

The pulse width is selected with each range and velocity factor set to 0.67 at switch-on and is adjustable between 0.01 and 0.99. With a weight of only 1 kg, the CFL 510 is powered by six AA cells with a battery life of up to three months normal usage. Cossor Electronics Ltd, The Pinnacles, Harlow, Essex CM19 5BB. Tel: 0279 26862.

Graphic chip set

New from Hi-Tek Electronics is the National Semiconductor advanced graphics chip set, a v.l.s.i. system which utilizes parallel processing techniques to enable handling of an unlimited range of colours with no reduction in performance.

The chip set comprises individual modules which enable the user to design a system to meet specific requirements. Modules can be integrated with a general-purpose microprocessor for black and white display or used to support unlimited colour planes for a high performance, high resolution colour graphics workstation, plotter, or printer.

Modules in the chip set include a 20MHz raster graphics processor (r.g.p.) which has line drawing speeds of 10 million pixel/s in any direction and a powerful instruction set, enabling the user to incorporate proprietary graphics algorithms into the system; a 20MHz 'bitblt' processing chip which, dedicated to a single parallel memory plane, enables additional planes of colour to be added without degrading system performance; a video clock generator which uses a low-frequency crystal oscillator and an on-chip digital phase-locked loop to produce a pixel frequency of up to 225MHz; and a 225MHz video shift register which has a 4-word 16-bit fifo buffer to ease timing problems. Hi-Tek Electronics, Ditton Walk, Cambridge, CB5 8QD. Tel: 0223 214722.

Low-profile toroids

To meet a demand for compact power supplies and audio equipment, Drake Transformers have developed a range of low-profile toroidal transformers. The PWL range has about half the height of conventional toroids with equivalent ratings but have a greater outside diameter. They have polyester tape insulation and sleeved flying leads. The PWL transformers are offered in a range from 100 to 800VA.

Drake is now an independent company, having bought itself from its former parent, Blagden Industries. This has resulted in maintaining employment for 76 skilled workers, while moving to a new address near their former factory in Billericay. Drake Transformers Ltd, Bruce Grove, Wickford, Essex SS11 8BT. Tel: 0268 560040.

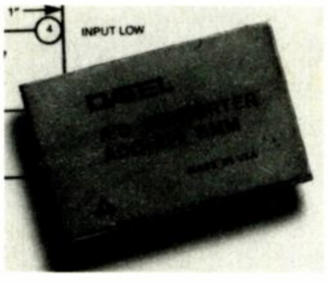
NEW PRODUCTS

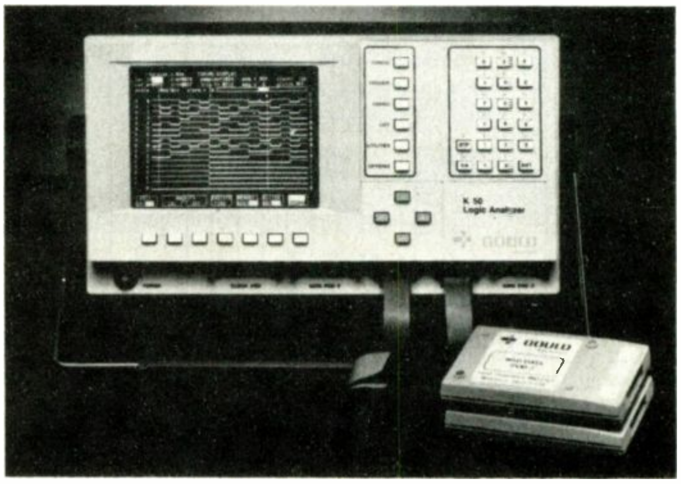
BRITISH ELECTRONICS WEEK

High-speed 10-bit d-to-a

Two ultra-high-speed digital-to-analogue converters have been produced by Datel. The ADC-510 and 515 can complete a 10-bit conversion in 425ns and 650ns, giving sampling rates of 2.35 and 1.54MHz respectively.

Features include initial errors of 3 l.s.b. maximum for offset and 5 l.s.b. maximum for gain errors, different coding selections, indication of signals below and above the full-scale range and the means to improve throughput by putting a sample-hold back into the sample mode before the existing conversion is finished. There is a facility to programme the input voltage range. Other specifications include a maximum nonlinearity of ±0.5 l.s.b, a minimum harmonic distortion below full scale of 60dB, and high temperature stability. More information from: Datel UK, Intec 2 Business Park, Wade Road, Basingstoke, Hants, RG24 0NE. Tel: 0256 469085.





Multi-purpose logic analyser

The Gould K50 can be configured from the front-panel keyboard from 32 channels at 25MHz (1k samples per channel) to eight channels at 100MHz (4k samples per channel). It can capture complex timing, state and microprocessor- oriented software events, including glitches down to 5ns, which are stored in a seperate memory and can be unambiguously displayed alongside timing data.

Three external clock inputs with qualifiers are provided to allow the demultiplexing of complex events, while Gould's 'Trace Control' feature offers four levels of complex-event definition with four trigger words plus one glitch word.

The K50 features a high-resolution, non-glare 7-inch (178mm) c.r.t. which can show up to 17 channels across the complete memory or be expanded for detailed viewing.

Channels or channel groups can be labelled, and two independent on-screen cursors and a trigger marker are used to indicate absolute and relative data position and value. The major instrument functions are controlled by dedicated front-panel keys, while soft keys guide the set-up of individual parameters. The 'search' and 'compare' functions display their results as highlighted events.

The K50 is supplied with eight-channel, high-impedance probe pods (1 megohm, 5pF), which each provide a t.t.l. or ±9V variable-threshold range and are protected to +50V.

The analyser is supplied complete with IEEE-488, RS-232 and Centronics ports, plus trigger, re-start and video outputs. Also included is a battery-backed non-volatile memory which saves the current stored data, three reference data sets and 16 set-up configurations.

A range of microprocessor analysis packages is available, including disassembler software and interface adaptors for the Z80, 8085, 6502, 6809, 8086/8 and 68000 processors. Price of the K50 is £2950 (plus tax). Gould Electronics Ltd., Instrument Systems, Roebuck Road, Hainault, Ilford, Essex, IG6 3UE. Tel: 01-500 1000.

Maths on a personal computer

A new software package (MathCAD) allows the entering and solution of mathematical equations exactly as they would be written or printed in a maths text. In addition it can be used like a programming language to compute with variables, and to produce graphs and tables and add text. Greek characters can be used as well as all mathematical symbols. The software handles real and complex numbers and computes unit conversions and dimensional analysis. Functions not provided can be defined by the user, although some advanced functions such as integration, differentiation, Fast Fourier transforms, cubic spline interpretation and statistical analysis are already included. MathCAD checks for errors before it processes the equations, looking for undefined variables, mismatched units, missing parentheses and the like.

MathCAD runs under MS-DOS 2.0 or higher and is therefore suitable for IBM PC (XT or AT) and compatibles. It requires 512K of ram and IBM colour or enhanced graphics or a Hercules monochrome card. Output is to a dot-matrix or laser printer. MathSoft International Ltd. Tamworth, Staffs, B79 7BR. Tel: 082786 239.

Contact cleaners

Used to clean, lubricate and protect contacts and edge connectors plated with precious metals (gold, silver, palladium etc) gold Electrowipes are lint-free pads impregnated with a blend of contact-cleaner fluid and safety solvent. Packed in sachets, the disposable pads use a non-flammable solvent which is claimed to be safe on delicate components and 'sensitive' plastics. As well as removing contamination from contact surfaces, the pads leave a residual trace of lubricant which increases contact area and reduces contact resistance to a low and stable level. Another advantage is that with the lubricating properties of the wipes, it is possible to reduce the thickness of the precious metal plating. Electrolube Ltd, Blakes Road, Wargrave, Berks, G10 8AW. Tel: 073 522 3014.

Eraseable programmable logic array

An eeprom-based programmable logic device from Exar is claimed to have logic capabilities comparable with gate arrays and allows the use of multi-layer logic. The XR-78C800 contains the equivalent of 600 to 800 gates. Advanced logic architecture permits umlimited Boolean levels with up to ten flip-flops at any level without using i/o pins. Term sharing at any level and logic-controlled input latching are other features. The devices are designed to integrate a wide variety of user-defined logic functions onto a single package and offer a fast turnaround to save time and board space. The device is added to a wide range of electrically eraseable proms including two high-speed c.mos eeproms. Exar Corporation, 43 Moorbridge Road, Maidenhead, Berks, SL6 8PL. Tel: 0628 783066.

Image processing on a PC

A two board plug-in for the IBM PC (AT or RT) can create an image processing workstation ideal for applications such as machine vision, image enhancement, scientific, medical, sonar and geophysical image analysis, high-end graphics arts systems and simulation/training systems. Design innovations incorporated into the MVP-AT include 'area-of-interest' processing, real-time image operations, non-interlaced output and a 32-bit plane image buffer comprising four flexible 512 by 512 by 8 image buffers which can be used in all possible combinations. When combined with the capacity to perform convolutions, averaging and subtraction, pattern matching and morphological transforms, this will give the user performance previously available only at a much higher price. Other functions offered by the board are pan, scroll and zoom, real-time colour frame grab from a variety of input sources such as RGB or NTSC Colour, RS 170 monochrome, and multiple input and output look up tables.

The optional Matrox Imager-AT package is specifically designed to complement the MVP-AT and provides a cost-effective solution for o.e.m's planning to develop their own software. This package contains over 150 library routines and is callable from 'C', Fortran and Pascal Microsoft compilers. Densitron Computers Ltd, Unit 4, Airport Trading Estate, Biggin Hill, Kent TN16 3BW. Tel: 0959 76331.

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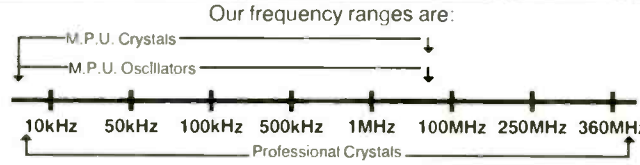

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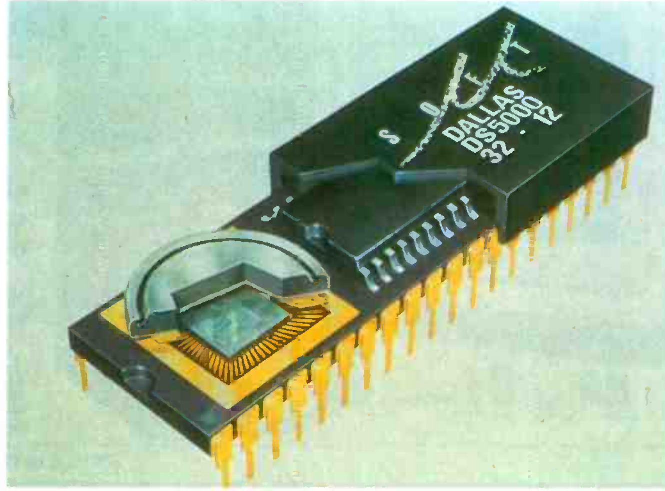
Two processors in one

Arguments between engineers over whether to use 6502 or Z80 expertise in company projects are resolved at once with Rockwell's dual processor chip. More seriously, the dual architecture c.p.u. combines the fast i/o handling of the 6502 architecture with the versatile block move instructions of the Z80 onto one chip, the two processors communicating through tri-port ram at locations 0020 on the 6502 and FE00 on the Z80. This ram is accessible externally to allow multiple dual c.p.us to be connected together; bus contention arbitration is executed with an algorithm that accesses the tri-port ram to read preset device numbers. To keep the number of pins down the data bus is multiplexed with the lower eight bits of the address bus, leading to 32 pins for each c.p.u. rather than the more usual 40, and the two-sided structure requires an upper and a lower p.c.b. Rockwell's specialist single-chip distributor is RCS Microsystems Ltd 141 Uxbridge Road, Hampton Hill, Middx TW12 1BL. Tel: 01-979 2294.

Sealed rechargeable batteries

Eight batteries have been added to the Power-sonic range of sealed lead-acid batteries. The new versions range from an 80Ah 12V model down to a 500mAh 6V battery which is only 58mm long.

The advantages of these batteries is that they need no topping-up and can be used in any position. They offer leak-proof cases, suspended electrolyte, overcharge protection, cycle or float applications, high discharge rate and extended shelf life. Power-Sonic Europe Ltd, Cornwallis House, Howard Chase, Basildon, Essex SS14 3BB. Tel: 0268 293353.



Soft-centred controller

Latest in a series of innovative products from Dallas Semiconductor is what they call a soft microcontroller. Superficially the DS5000 resembles a c-mos 8051, but the package also contains an 8K or 32K-byte static ram (64K is promised) and a ten-year lithium battery. These and some tricks built into the processor make the unit proof against power failure, whether for a few instants or for much longer. When the supply is restored the processor simply resumes execution from where is left off, with all data and registers intact – a feature which also makes the device very suitable for use in portable data gathering.

Software updates can be downloaded to the DS5000 from remote sources, over the telephone if need be. The built-in memory can be partitioned dynamically into program and data areas by the user.

In addition, a software protection feature makes it possible to save and load programs in encrypted form. If an unauthorized user tries to reset the lock bit, the 40-bit keyword is automatically erased.

Initial 1000-off price of the 12MHz, 32K-byte version is $80. Details from Joseph Electronics in Birmingham on 021/643 6888.

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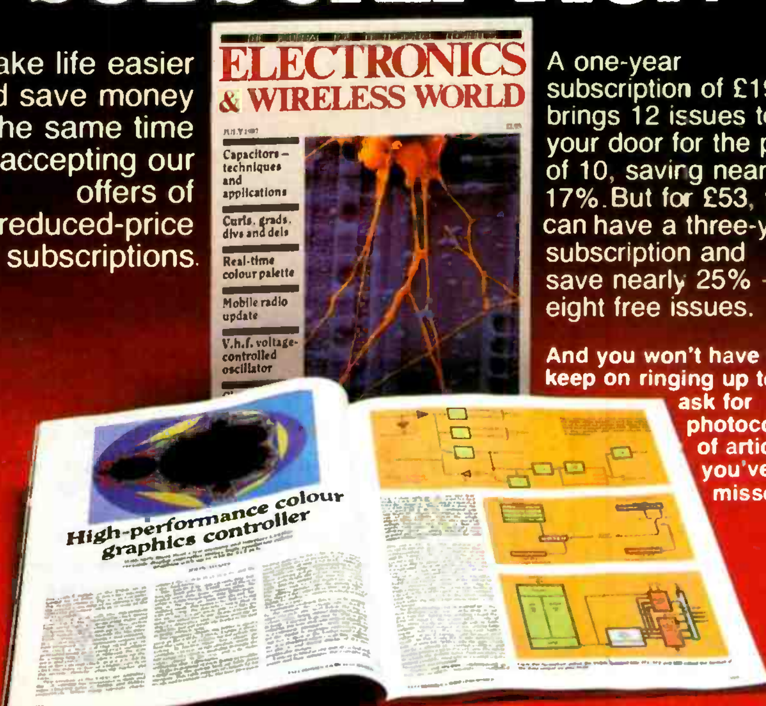

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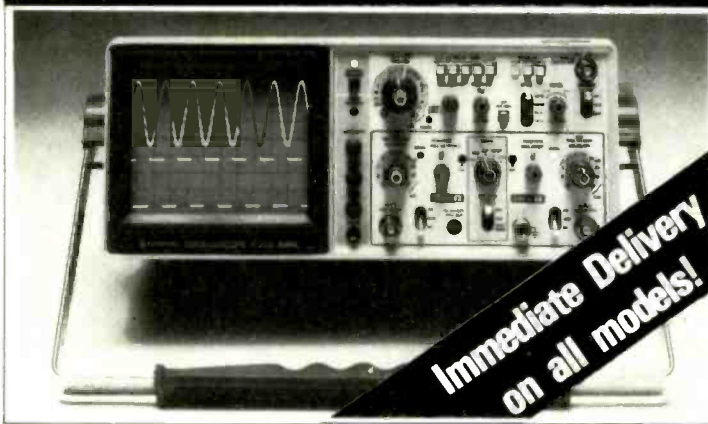

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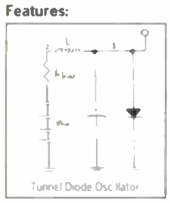

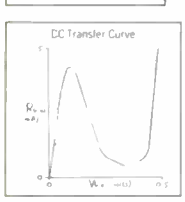

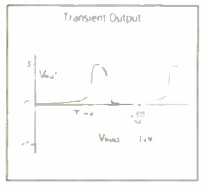

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ENTER 39 ON REPLY CARD

Digits – not without tears

Digital audio is rapidly infiltrating into both radio and television broadcasting, although not without experiencing difficulties seldom foreseen by the early advocates of "rugged go/no-go, hands-off operation." Indeed, it is the abrupt change from go to no-go, that replaces the more-certain but more-gradual degradation of analogue signals, that is tending to cause unexpected headaches for transmission engineers. British Telecom engineers have reported encountering unexpectedly severe problems during the rare occasions when multipath tropospheric-propagation conditions exist right down to the levels of microwave towers.

In an ICAP87 paper, M.C.D. Maddocks and J.H. Stott of BBC Research describe problems experienced on a new digital u.h.f. link between Stockland Hill, Devon and Alderney intended to carry a multiplex of radio programmes from the UK to the Channel Islands radio transmitters, replacing existing analogue links. This was designed to provide reliable, high-quality audio, despite there being at least a 50dB fading range on this long, over-the-horizon sea path. Propagation data were available from the existing analogue television links over this path, received on the IBA's adaptive antenna and (for diversity) a large parabolic dish reflector antenna.

Predictions suggested that signal-to-noise values should be sufficient for the digital link to be open for 99.85 per cent of the time, free of objectionable co-channel interference 99.7 per cent of the time, indicating a total predicted performance of 99.55 per cent of time and a link operational time of 99.4 per cent. In practice, measurements on the experimental link taken over several months indicated a link operational time of 97.8 per cent with 89.5 per cent error-free seconds.

The BBC engineers noted that although the majority of link failures lasted less than ten seconds, there were a significant number of longer failures, subjectively more damaging and increasing in frequency in early afternoon and late-night periods, both recognised as important radio broadcasting times. The link failures also posed the problem that they were neither so short as to be disguised in the signal decoding, for example by muting, nor so long as to be very rare. While it is hoped to identify the reasons for the unexpectedly poor performance of the experimental link, it seems likely that a considerably more complex digital modem may prove necessary. No doubt all will come right in the end but it is another indication that digital transmission can throw up new problems.

Digital broadcasting

Some years ago the BBC conducted a programme of experimental terrestrial broadcasting of digital signals using the Band 1 v.h.f. transmitter at Pontop Pike. Although this was found to provide excellent quality reception at most, though not all, domestic locations, portable and mobile reception proved extremely dicey owing to the destructive effects of short-term multipath propagation – a condition that can still cause digital teletext to display "garbage" (error-prone) pages in some urban standing-wave situations. But teletext is not expected to have to cope often with the severe multipath of mobile reception.

Although both the BBC and IBA are planning to use digital stereo (plus the conventional analogue channel) for television sound in the fairly near future, direct transmission of signals in digital form for terrestrial radio broadcasting in the UK seems to have been put on the back-burner for the time being.

However, according to the Russian engineer F.I. Vlasov in a 1986 article in the OIRT journal *Radio and Television*, an experimental digital sound broadcasting system was established in 1983 in Leningrad, and then in 1985 in both Leningrad and Tallin using the "newly available" frequency of 102.656-MHz (until recently East European v.h.f. broadcasting has tended to use frequencies around 70 MHz). No details are given of the results achieved and the extent of any multipath problems but it is suggested that while the band 100 to 108 MHz would be suitable for only three analogue stereo networks, six stereo digital programmes could be accommodated as a multiplex within a 4-MHz band, provided that all transmitters used the same carrier frequency and each sound signal (mono or one of a stereo-pair) is coded in a floating-point code with 10-bit mantissa and 3-level codes. With a sampling frequency of 32 kHz, the bit-rate would be 4.096 Mbit/s with double phase-shift modulation.

F.I. Vlasov concludes that "at the present time we are participating in a revolutionary process of a radical change in sound broadcasting technology. Digital sound engineering is the technology of the 21st century; in our days it is making its first steps and conquering ever new fields."

It is clear from this paper that the Russian engineers are carefully following developments in digital audio engineering outside of the USSR. F.I. Vlasov regrets that standardization of encoding parameters has not been achieved with 48 kHz sampling used in digital studios, 44.1 kHz for laser (CD) sound, and 32 kHz for transmission links, with repeated rate-conversions increasing costs and, unless adequate measures are taken, reducing the quality of programme sound. Bit numbers and coding laws also differ: 16 bit linear coding has been standardized for CD, but 14 bit linear and 10 and 9.5 bit non-linear codes are used on transmission channels. Every attempt, he believes, should be made to avoid increasing still further the divergence between coding parameters.

He notes that CD records have created a need for improved reproduction systems and lists as suitable for monitoring purposes analogue loudspeakers having about 110 dB dynamic range and capable of maximum sound pressure levels of about 128 dB, in which category he puts the Technics B-10, Mitsubishi DS-505 and Junior (Kreisler) loudspeakers, adding "The monitor units of the English firms Tannoy (M-1000 and M-3000 units) and Bowers & Wilkins (B&W-801 and B&W-868) also approach meeting the requirements of digital."

But he also looks beyond the analogue systems, noting that Bell Laboratories have developed a system for immediate conversion of a digital signal with the decoding effected directly on the diaphragm. As a third possibility he notes the potential of adaptive systems such as that demonstrated by Acoustical Research in 1982 which includes adaptation to the acoustic characteristics of the listening room by the use of microprocessors, adding "In our opinion the development of adaptive sound reproduction systems constitutes the main trend of development in the near future, as it will be possible to create sound reproduction systems satisfying all requirements of the prospective digital sound channel."

Data broadcasting

The use of digital data carried on sub-carriers of v.h.f. broadcast stations seems likely to increase in the near future. Telerate (UK) Ltd have now launched their subscriber radio teletext service on the 97.3 MHz LBC channel in London, with the similar Telemet system on the Capital transmitter due later this year. The BBC has launched full test transmissions of the EBU Radio Data Service (RDS) in preparation for an official launch of the system in September, providing automatic location of the strongest signal, display of station name, alternative frequencies of a given service, time and date. This service is due to be available from all BBC v.h.f. transmitters in England by the autumn, and RDS may also soon be available on IBA transmitters. The successful introduction depends to a marked extent upon the willingness of semiconductor manufacturers to develop special purpose l.s.i. chips, with the usual chicken-and-egg quandary of firms being reluctant to incur heavy development costs until they have some evidence of a market demand; while broadcasters find it difficult to start a new service until receivers are available.

Radio Broadcast is written by Pat Hawker.

RADIO COMMUNICATIONS

Packets on the move

While the Royal Signals are still striving to come to terms with organizational and management requirements for the Ptarmigan tactical C^3I line and radio battlefield communications system, a team at the Royal Signals & Radar Establishment at Malvern has been busy investigating the possibility of introducing store-and-forward digital packet-switching technology into combat net radio systems operating on a single narrow-band channel. Following the use of a small number of experimental units, the team intends to expand its work with the acquisition by commercial procurement of an experimental 25 station unit. With this, it is planned to develop and further refine the distributed algorithms so far developed based on the need for the packet switching to operate effectively in a highly mobile and hostile environment.

The current RSRE work is described by B.H. and T.R. Davies in some detail in an invited paper in a special issue (January, 1987) of *Proc. IEEE*. This issue devotes over 150 pages to the use of packet-switching technology for mobile-radio networks, mostly for military-type applications. The guest editors apologize for the preponderance of military-sponsored papers, explaining "This is due to the unfortunate lack of success that we experienced in including a paper on the application of this technology to the commerical and amateur sectors. This absence, however, should not undermine the importance of these areas of applications. In fact, some commercial systems are in use, including communications to field engineers and support of package delivery services."

Meanwhile, the UK Royal Signals officers are still seeking to learn from early field experience of Ptarmigan and its radio-relay sector, Treffid, following its role in the 1986 "Exercise Summer Sales" in West Germany, which witnessed the first large-scale use of Ptarmigan at Corps level.

It is recognised that the Royal Signals faces the challenge of managing an area system superimposed on a hierarchical command structure, a friction-provoking situation that is not proving easy to solve. Major G.R. Leach has written (*J. Royal Signals Institution*) "successful deployment of Ptarmigan relies on a close understanding of the difference between command of the trunk system and its electronic managements." He stresses that the success of Ptarmigan is reliant on good-quality radio-relay links and that the burden of providing these depends on the ability of junior commanders, including the radio-relay detachment commanders, the Recce sergeants and the trunk-network commanders. Differences of opinion between these on such matters as the siting of the radio-relay units can jeopardize the effective operation of a whole Ptarmigan battlefield system.

Such large-scale military exercises are having increasingly to recognise that Warsaw Pact forces have developed a sophisticated concept of offensive electronic warfare (radio electronic combat support) and would certainly attempt to intercept, exploit and disrupt the communications of their enemy.

Supercool diodes?

The recent marked upsurge of R&D interest in superconductivity has followed the discovery, initially by Bednorz and Miller of IBM Zurich but now apparently with Japanese scientists in the lead, of a completely new family of "high-temperature" oxide-ceramic superconductors and seen by some observers as "an invention comparable to that of the transistor." For the communications engineers, it raises the possibility of improved low-noise devices for microwave, millimetre-wave and optical communications. The way seems open for improved diode detectors and mixers by means of super-Schottky diodes with junctions having a hybrid superconductor/semiconductor structure used with the relatively inexpensive liquid nitrogen coolant.

Superconductivity, first discovered by the Dutch physicist Heike Kamerlingh-Onnes in 1911, is the curious property of many electrical conductors to change abruptly to a state of no measurable resistance when their temperature closely approaches absolute zero (0K, −273°C). It was not until 1957 that a comprehensive theory of superconductivity was formulated by J. Bardeen, L.N. Cooper and J.R. Schrieffer (the "BCS" theory). This led to a gradually increasing exploitation, or at least investigations into the many potential applications in the 1960s, including the confirmation of some aspects of the "Josephson effect" predicted by Brian Josephson in 1962 and which is seen as providing the key to the application of superconductivity for super-fast computers as well as for low-noise electronics.

Most of the R&D on the Josephson effect has been targeted on the development of computers, with IBM concentrating on its use as a switching device (though reportedly largely abandoning this project a few years ago) and Bell Laboratories seeking ways of using Josephson junctions to increase the speed and capacity of central computer memories.

But until the recent ceramic-oxide breakthrough, superconductivity could only be achieved with the use of costly liquid helium (boiling point 4K) as the coolant. With the transition to a superconductive state of barium-yttrium-copper oxide found by Mitsubishi scientists to be over 90K, the much cheaper and easier to handle liquid nitrogen (boiling point 77K) can be used as the coolant.

It could, however, be low-noise communications that may benefit before computers. Temperature of the coolant is not the only problem in using Josephson-junction devices in computers. It has yet to be shown that it is possible to combine large numbers of such devices on to a single chip, because of the tendency for different stability problems to be found in each junction. This, however, would not necessarily prevent their use as discrete devices in low-noise applications. NEC have reported the development of a functioning Josephson device based on two layers of single-phase yttrium-barium copper oxide.

It may be recalled that the original low-noise receiver at Goonhilly Downs in the early 1960s was based on a helium-cooled maser having extremely low-noise parameters but, apart from expense, this proved to have too narrow a bandwidth for the later generations of communications satellites.

ICAP87

Among the near-950 pages of the IEE's two-part Conference Book No 274 covering the recent International Conference on Antennas and Propagation (ICAP87) at Sheffield University are no less than 179 papers and 47 poster presentations – formidable tomes indeed. However, they include not only the usual esoteric and highly mathematical analyses favoured by specialists in these fields but also quite a number of more down-to-earth (if that is the appropriate expression) and practical papers. These range from interesting historical surveys of 100 years (dating from Heinrich Hertz) of antenna development and propagation research to practical engineering papers on the design of microwave towers with emphasis on wind hazards. The BBC has also come up with some lessons from the past, including explanations of how they tackled such unexpected problems as the Penge effect, "ghosts" in Preston, hazard-lamp hazards and the rusty-bolt effect that can give rise to spurious intermodulation products. It is also interesting to note that Marconi Research have been doing new design work on the 50-year-plus Bruce rhombic antenna relating bandwidth to apex angle. Reception of v.h.f. signals in urban areas, including an improved Swedish model for hilly woodland from which it seems that a forest may theorectically be treated as a dissipative, lossy dielectric slab lying on a half-space ground. There is also an illuminating paper on height-gain at v.h.f. in urban, rural and oversea paths. The computer has made possible the use of the "Method of Moment" technique to predict antenna performance.

Radio Communications is written by Pat Hawker.

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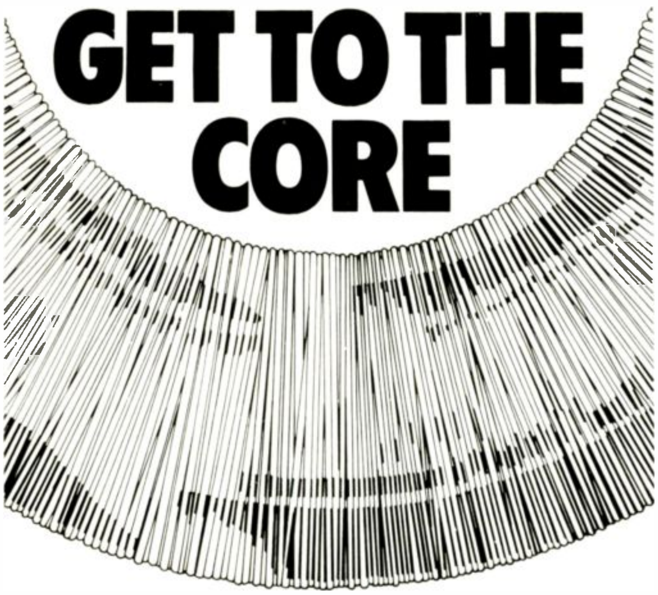

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Editorial Feature List

AUGUST 1987

Short-haul optical-fibre data communications is an essential part of modern communications systems. This feature presents an overview of the techniques employed and the hardware available.

SEPTEMBER 1987

Microwave semiconductor devices. These specialised components retain an air of mystery for many engineers. We present a feature on the physics of these devices and characterize the types now is use.

For further advertising details please ring Martin Perry on: 661 3130 or Michael Downing on 661 8640

TELEVISION BROADCAST

Systems proliferate

At the height of the PAL/NTSC/SECAM controversy in the 1960s, at least one large organization issued a firm edict that its engineers should not attempt to develop any new colour-encoding systems, but instead should concentrate on solving the problems of one of the three proposed systems which were showing an alarming tendency to proliferate new versions. Judging by the number of systems now emerging in the field of direct-broadcasting from satellite and for wide-screen h.d.tv, perhaps it is time that a similar ban should be imposed. The basic problem is to decide whether "compatibility" with existing standards is or is not an essential requirement for possible world standards.

There is at least still time for consideration, with American broadcasters at the moment more concerned with financial than engineering aspects of future television, partly resulting from the financial difficulties that have followed company take-overs or from fighting off such take-overs, in which the process of issuing "junk bonds" seems to have led to over-capitalization and sparked off a drastic round of cost-cutting. Yet the increasing practice of using electronic production rather than film for some of the major American drama series and subsequent up-conversion to 625 lines does underline the need for an improved electronic production standard, whether or not this is the 1125-line 60Hz standard that has been opposed by European broadcasters, (although German broadcasters, but not the German Bundespost, have committed themselves to support of 1125 as a production standard).

William Dobbie of British Telecom Research is proposing a new MAC system, designed for optimum bandwidth efficiency, which would allow two programmes of conventional quality to be transmitted in a single DBS channel, or alternatively would provide options for a single wide-screen h.d.tv transmission. In the USA, Faroudja Laboratories have developed a technique for improving the images of 525-line NTSC. Dr William Glenn is advocating an h.d.tv system compatible with NTSC which could be transmitted with the aid of an extra 3MHz channel on terrestrial networks. Richard Iredale (Del Ray Group) has a proposed HD-NTSC system that would be fully compatible, depends on a "TriScan" concept of smart scanning combined with digital processing in the receiver and would permit a change of aspect ratio to 14:9. Europe is still divided between support for the MAC variations including B-MAC, C-MAC, D-MAC (Eu-MAC), D2-MAC etc., with subsequent "evolutionary" progress to wide-screen h.d.tv.

Selling technology

1986 was a boom year for the High Street consumer-electronics shops, with no less than 3.9 million colour television sets reaching the retailers and rental chains; with video-cassette recorders recovering to the 2 million levels achieved a few years ago; and with CD record players up fourfold on 1985 to almost 640,000 units delivered to the trade. With so many major Japanese firms now having UK factories it is also not surprising that exports of the so-called "brown goods" are also running at record figures.

But the retail trade is far from happy, claiming that profit margins are far too low. Lord Chapple, chairman of BREMA, claims "I find it depressing that such an efficient and dynamic industry finds it impossible to hold prices at sensible levels which would allow reasonable margins to all involved." This reflects the row that broke out following an announcement earlier this year that some manufacturers were beginning to cut the £50-or-so price differential between sets fitted with the flatter, squarer picture tubes, now amounting to about 70 per cent of the production of large-screen sets, and those with conventionally shaped picture tubes.

The BREMA chairman believes that technological innovation should be used to induce the public to pay "more reasonable" prices, quoting the example of teletext. Yet my recollection of the early struggle to establish teletext as a viable operation is that it nearly died the death of public apathy until the Department of Trade & Industry stepped in, appointed Rex Foot to promote the system energetically and induce the Treasury to make, at least temporarily, financial concessions that enabled rental firms to charge virtually the same rentals as for remote-controlled sets not fitted with teletext decoders.

Then again, BSB, in planning to begin direct broadcasting from satellite by 1980, have widely publicized the figure of £200 as the likely "initial" cost of a suitable dish antenna plus the indoor unit including the MAC decoder, a decidedly optimistic figure that would not give much scope for "sensible margins", especially if the public came to expect that this would include installation costs.

Apart from the controversial digital audio recorders (DAT) which may finally appear in High Street shops later this year, another potential market that has yet to be developed is for consumer-priced electronic "stills" cameras. Casio have announced that they hope to launch the first such camera intended specifically for the consumer in the North American market very shortly. This camera uses the standard 2-in video-floppy as standardized for professional cameras. This can hold up to 25 full frames or 50 fields of colour pictures. The Casio camera has an m.o.s. image sensor capable of 280,000-pixel resolution, shutter speeds from one-eighth to one-thousandth of a second and the ability to take five fields continuously in one second. The camera will include the facility to playback on any television set (525-line models) without the need for a separate player unit.

The price in Japan is under £500.

Puzzles remain

The publication last November, coinciding with the many 50-year anniversary events, of the 500-page book British Television – The Formative Years, by Professor R.W. Burns – was clearly intended, and seems likely to remain, the definitive study of British television from the first Baird experiments in 1923 to the confirmation of the Marconi-EMI 405-line system as the UK standard for Alexandra Palace in February 1937. It covers in considerable detail the 1926 to 1934 struggle by Baird to make 30-line television broadcasting the basis of a viable industry, against the well-founded opposition of the BBC. At first the BBC were supported in opposing Baird by the Post Office engineers, who also formed the executive side of the regulatory body. But then, following the success of Baird in obtaining political support and the belief of the Post Office's legal advisors that the then Wireless Telegraphy Acts did not cover the transmission of visual images, the Post Office attitude became increasingly ambivalent and in the end they virtually forced the BBC, albeit reluctantly, to agree to provide transmitters for experimental 30-line transmissions.

Professor Burns has drawn widely, although at times rather selectively, upon the BBC and Post Office archives. But I wonder if I am alone in feeling that he has left a few important questions unaswered.

For example, how did Professor E. Taylor Jones come to write such an extraordinarily favourable report in the highly respected journal *Nature* (18 June, 1927) of the crude London/Glasgow land-line demonstrations, writing "The image was perfectly steady in position, was remarkably free from distortion and showed no sign of the streakiness which was, I believe, in evidence in the earlier experiments...My impression after witnessing these demonstrations is that the chief difficulties connected with television have been overcome by Mr Baird and that the improvements still to be effected are mainly matters of detail." It is extremely difficult to believe that this support fairly represented genuine results achieved in these hurriedly set up 1927 demonstrations. Was Professor Jones fooled? And if so who was responsible for "rigging" the demonstration?

Television Broadcast is written by Pat Hawker.

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74LS93 0.54
74LS95B 0.75
74LS96 0.90
74LS107 0.40
74LS109 0.40
74LS112 0.45
74LS113 0.45
74LS114 0.45
74LS122 0.70
74LS123 0.80
74LS125 0.50
74LS126 0.50
74LS132 0.65
74LS133 0.55
74LS136 0.45
74LS138 0.55
74LS139 0.55
74LS145 0.95
74LS147 1.75
74LS148 1.40
74LS151 0.65
74LS152 2.00
74LS153 0.65
74LS154 1.60
74LS155 0.65
74LS156 0.65
74LS157 0.50
74LS158 0.65
74LS160A 0.65
74LS161A 0.75
74LS162A 0.75
74LS163A 0.75
74LS164 0.75
74LS165A 1.10
74LS166A 1.50
74LS168 1.30
74LS169 1.00
74LS170 1.40
74LS173A 1.00
74LS174 0.75
74LS175 0.75
74LS181 2.00
74LS183 1.90
74LS190 0.75
74LS191 0.75
74LS192 0.80
74LS194A 0.75
74LS195A 0.75
74LS196 0.80
74LS197 0.80
74LS221 0.90
74LS240 0.80
74LS241 0.80
74LS242 0.90
74LS243 0.90
74LS244 0.70
74LS245 0.90
74LS247 1.10
74LS248 1.10
74LS249 1.10
74LS251 0.75
74LS253 0.75
74LS256 0.90
74LS257A 0.70
74LS258A 0.70
74LS259 1.20
74LS260 0.75
74LS266 0.60
74LS273 1.25
74LS279 0.70
74LS280 1.90
74LS283 0.80
74LS290 0.80
74LS292 14.00
74LS293 0.80
74LS295 1.40
74LS297 14.00
74LS298 1.00
74LS299 2.20
74LS321 3.70
74LS322A 3.90
74LS323 3.00
74LS324 3.20
74LS348 2.00
74LS352 1.20
74LS353 1.20
74LS356 2.10
74LS363 1.80
74LS364 1.80
74LS365 0.50
74LS366 0.50
74LS367 0.52
74LS368 0.50
74LS373 0.70
74LS374 0.70
74LS375 0.75
74LS377 1.30
74LS378 0.95
74LS379 1.30
74LS381 4.50
74LS385 3.25
74LS390 0.60
74LS393 1.00
74LS395A 1.00
74LS399 1.40
74LS445 1.80
74LS465 1.20
74LS467 1.20
74LS490 1.50
74LS540 1.00
74LS541 1.00
74LS608 7.00
74LS610 25.00
74LS612 25.00
74LS624 3.50
74LS626 2.25
74LS628 2.25
74LS629 1.25
74LS640 2.00
74LS640-1 3.00
74LS641 1.50
74LS642 2.50
74LS642-1 3.00
74LS643 2.50
74LS643-1 3.00
74LS644 3.50
74LS645 2.00
74LS645-1 4.00
74LS668 0.90
74LS669 0.90
74LS670 1.70
74LS682 2.50
74LS683 3.00
74LS684 3.50
74LS687 3.50
74LS688 3.50
74LS783 16.00

74S SERIES

74S00 0.50
74S02 0.50
74S04 0.50
74S05 0.50
74S08 0.50
74S10 0.50
74S11 0.75
74S20 0.50
74S22 0.50
74S30 0.50
74S32 0.60
74S37 0.60
74S38 0.60
74S40 0.50
74S51 0.60
74S64 0.45
74S74 0.70
74S85 5.50
74S86 1.00
74S112 1.50
74S113 1.20
74S114 1.20
74S124 3.00
74S132 1.00
74S133 0.60
74S138 1.80
74S139 1.80
74S140 1.00
74S151 1.50
74S153 1.50
74S157 2.00
74S158 2.00
74S163 3.00
74S169 5.50
74S174 3.00
74S175 3.20
74S188 1.80
74S189 1.80
74S194 3.00
74S195 3.00
74S196 3.50
74S200 4.50
74S201 3.20
74S225 5.20
74S240 4.00
74S241 4.00
74S244 4.00
74S251 2.50
74S257 2.50
74S258 2.50
74S260 1.00
74S261 3.00
74S283 2.70
74S287 2.25
74S288 2.00
74S289 2.25
74S299 4.50
74S373 4.00
74S374 4.00
74S387 2.25

74C SERIES

74C00 0.70
74C04 0.50
74C08 0.70
74C10 0.70
74C14 0.50
74C20 0.70
74C32 1.00
74C42 1.50
74C48 1.50
74C73 1.00
74C74 1.20
74C76 1.00
74C83 2.00
74C85 2.25
74C86 0.50
74C90 1.90
74C93 1.50
74C95 1.60
74C107 1.00
74C150 5.00
74C151 2.00
74C157 2.50
74C160 1.80
74C161 1.80
74C162 1.80
74C163 1.00
74C173 1.00
74C174 1.50
74C175 1.50
74C193 1.50
74C194 1.50
74C195 1.50
74C221 2.50
74C244 2.00
74C245 2.25
74C373 2.25
74C374 2.25
74C902 1.20
74C911 9.00
74C912 4.50
74C922 6.00
74C923 6.50
74C925 6.50
74C926 7.50

74ALS SERIES

74ALS00 0.45
74ALS02 0.45
74ALS04 0.50
74ALS08 0.50
74ALS10 0.45
74ALS20 0.45
74ALS32 0.45
74ALS74 0.70
74ALS138 1.50
74ALS139 1.50
74ALS244 4.00
74ALS245 4.75
74ALS573 2.60
74ALS574 4.50
74ALS580 2.60

4000 SERIES

4000 0.20
4001 0.24
4002 0.25
4006 0.70
4007 0.25
4008 0.60
4009 0.45
4010 0.60
4011 0.24
4012 0.25
4013 0.36
4014 0.60
4015 0.70
4016 0.36
4017 0.55
4018 0.60
4019 0.60
4020 0.80
4021 0.60
4022 0.70
4023 0.30
4024 0.48
4025 0.24
4026 0.90
4027 0.40
4028 0.60
4029 0.75
4030 0.35
4031 1.25
4032 1.00
4033 1.25
4034 2.50
4035 0.70
4036 2.50
4037 1.10
4038 1.00
4040 0.60
4041 0.55
4042 0.50
4043 0.60
4044 0.60
4045 1.00
4046 0.60
4047 0.60
4048 0.55
4049 0.36
4050 0.35
4051 0.65
4052 0.60
4053 0.60
4054 0.80
4055 0.80
4056 0.85
4060 0.70
4063 0.85
4066 0.40
4067 2.30
4068 0.25
4069 0.24
4070 0.24
4071 0.24
4072 0.24
4073 0.24
4075 0.24
4076 0.65
4077 0.25
4078 0.25
4081 0.24
4082 0.25
4085 0.60
4086 0.75
4089 1.20
4093 0.35
4094 0.90
4095 0.95
4096 0.90
4097 2.70
4098 0.75
4099 0.99
4501 0.36
4502 0.55
4503 0.36
4504 0.95
4505 3.60
4506 0.90
4507 0.35
4508 1.20
4510 0.55
4511 0.55
4512 0.55
4513 1.50
4514 1.10
4515 1.10
4516 0.55
4517 2.20
4518 0.48
4519 0.32
4520 0.60
4521 1.15
4522 0.80
4526 0.70
4527 0.80
4528 0.65
4529 1.00
4531 0.75
4532 0.65
4534 3.80
4536 2.50
4538 0.75
4539 0.75
4541 0.90
4543 0.70
4551 1.00
4553 2.40
4555 0.36
4556 0.50
4557 2.40
4560 1.40
4566 1.40
4568 2.40
4569 1.70
4572 0.45
4583 0.90
4584 0.48
4585 0.60
4724 1.50
14411 7.50
14412 7.50
14416 3.00
14419 2.60
14490 4.20
14495 4.50
145000 6.50
14599 2.00
22100 3.50
22101 7.00
22102 7.00
40014 0.48
40085 1.20
40097 0.36
40098 0.40
40100 1.50
40101 1.25
40102 1.30
40103 2.00
40104 1.20
40105 1.50
40106 0.48
40107 0.55
40108 3.20
40109 0.80
40110 2.25
40114 2.25
40147 2.80
40163 1.00
40173 1.20
40174 1.00
40175 1.00
40192 1.00
40193 1.00
40194 1.00
40244 1.50
40245 1.50
40257 1.80
40373 1.80
40374 1.80
80C95 0.75
80C97 0.75
80C98 0.75

LINEAR ICs

AD7581 12.00
ADC0808 11.90
AM7910DC 25.00
AN103 2.00
AN-1-5050 1.00
AY-3-1350 3.50
AY-3-8910 4.90
AY-3-8912 5.00
CA3019A 1.00
CA3020 3.50
CA3028A 1.10
CA3046 0.70
CA3059 3.25
CA3060 3.50
CA3080E 0.70
CA3085 1.50
CA3086 0.60
CA3089E 2.50
CA3090AQ 3.75
CA3130E 0.90
CA3130T 1.30
CA3140E 0.45
CA3140T 1.00
CA3146 2.25
CA3160E 1.50
CA3161E 2.00
CA3162E 6.00
CA3189E 2.70
CA3240E 1.50
CA3280G 3.00
D7002 6.00
DAC1408-8 3.00
DAC0800 3.00
DAC0808 3.00
DG308 3.00
HA1366 1.90
ICL7106 6.75
ICL7611 0.95
ICL7650 4.00
ICL7660 2.50
ICL8038 4.00
ICM7555 0.90
ICM7556 1.40
LC7120 3.00
LC7130 3.00
LC7131 3.50
LC7137 3.50
LF347 1.20
LF351 0.60
LF353 0.90
LF355 0.90
LF356N 1.10
LF357 1.00
LF398 4.00
LM10CLH 4.50
LM301A 0.30
LM307 0.45
LM308CN 0.75
LM310 2.25
LM311 0.60
LM318 1.50
LM319 1.80
LM324 0.45
LM334Z 1.15
LM335Z 1.30
LM336 1.60
LM339 0.40
LM348 0.60
LM358P 0.50
LM377 3.00
LM380N-8 1.50
LM380N 1.50
LM381AN 1.70
LM381N 3.00
LM383 3.25
LM384 2.20
LM386N-1 1.00
LM387 2.70
LM391 1.80
LM392N 1.10
LM393 0.85
LM394CH 4.00
LM709 0.35
LM710 0.48
LM711 1.00
LM723 0.60
LM725CN 3.00
LM733 0.65
LM741 0.22
LM747 0.70
LM748 0.30
LM1011 4.80
LM1014 1.50
LM1801 3.00
LM1830 2.50
LM1871 3.00
LM1872 3.00
LM1886 6.00
LM1889 4.50
LM2917 3.00
LM3302 0.90
LM3900 0.80
LM3909 1.00
LM3911 1.80
LM3914 3.50
LM3915 3.40
LM3916 3.40
LM13600 1.50
M51513L 2.30
M51516L 4.50
MB3712 2.00
MC1310P 1.50
1413 0.75
MC1458 0.45
MC1495 3.00
MC1496 0.70
MC3340P 2.00
MC3401 0.70
MC3403 0.65
MF10CN 4.10
MK50240 9.00
ML902 5.00
ML922 4.00
MM6221A 3.00
NE529 2.20
NE531 1.20
NE544 1.90
NE555 0.22
NE556 0.60
NE564 4.00
NE565 1.20
NE566 1.50
NE567 1.25
NE570 4.00
NE571 3.00
NE592 0.90
NE5532P 1.50
NE5533P 1.60
NE5534P 1.20
NE5534AP 1.50
OP-07EP 3.50
PLL02A 5.00
RC4136 0.55
RC4151 2.00
RC4195 1.50
RC4558 0.55
S50240 9.00
SAA1900 16.00
SFF96364 8.00
SL490 3.00
SN76013N 3.00
SN76023N 3.00
SN76033N 3.00
SN76115N 2.15
SN76489 4.00
SN76495 4.00
SN76660 1.20
SP0256AL2 7.00
SP8515 7.50
TA7120 1.20
TA7130 1.40
TA7204 1.50
TA7205 0.90
TA7222 1.50
TA7310 1.50
TBA231 1.20
TBA800 0.80
TBA810 0.90
TBA20 0.80
TBA820M 0.75
TBA920 2.00
TBA950 2.25
TC9109 5.00
TCA210 3.50
TCA220 3.50
TCA270 3.50
TCA940 1.75
TDA1004A 5.00
TDA1010 2.25
TDA1022 4.50
TDA1024 1.10
TDA1170S 3.00
TDA2002 3.25
TDA2003 1.90
TDA2004 2.40
TDA2006 3.20
TDA2020 3.20
TDA2030 2.50
TDA2593 5.00
TDA2653 7.00
TDA3560 7.50
TDA3810 7.50
TDA7000 3.50
TEA1002 7.00
TL061CP 0.40
TL062 0.60
TL064 0.90
TL071 0.40
TL072 0.70
TL074 1.10
TL081 0.35
TL082 0.55
TL083 0.75
TL084 1.00
TL094 2.00
TL430C 1.20
UA759 3.20
UA2240 1.20
UCN5801A 6.00
ULN2001A 0.75
ULN2002A 0.75
ULN2003A 0.75
ULN2004A 0.75
ULN2068 2.90
ULN2802 1.90
ULN2803 1.80
ULN2804 1.90
UPC575 2.75
UPC592H 2.00
UPC1156H 3.00
UPC1185H 5.00
XR210 4.00
XR2206 4.50
XR2207 3.75
XR2211 5.75
XR2216 6.75
XR2240 1.20
ZN404 1.00
ZN414 0.80
ZN419P 1.75
ZN423E 1.30
ZN424E 1.30
ZN425E8 3.50
ZN426E8 3.00
ZN427E8 6.00
ZN428E8 4.50
ZN429E8 2.25
ZN447E 9.00
ZN448 7.50
ZN449E 3.00
ZN450E 7.50
ZN459CP 3.00
ZN1034E 2.00
ZN1040 6.60
ZNA134H 23.00
ZNA234E 9.50

VOLTAGE REGULATORS

1A FIXED VOLTAGE PLASTIC TO220

+VE		−VE	
5V 7805	0.45	7905	0.50
6V 7806	0.50	7906	0.50
8V 7808	0.50	7908	0.50
12V 7812	0.45	7912	0.50
15V 7815	0.50	7915	0.15
18V 7818	0.50	7918	0.50
24V 7824	0.50	7924	0.50

1A FIXED VOLTAGE PLASTIC TO92

5V 78L05	0.30	5V 79L05	0.45
6V 78L06	0.30	12V 79L12	0.50
8V 78L08	0.30	15V 79L15	0.50
12V 78L12	0.30		
15V 78L15	0.30		

OTHER REGULATORS

FIXED REGULATORS
LM309K 1A 5V 1.40
LM323K 3A 5V 3.50
78H05KC 5A 5V 5.40
78H12 5A 12V 6.40
78P05 10A 5V 9.00

VARIABLE REGULATORS
LM305AH 2.50
LM317T TO-220 1.20
LM317K TO3 2.40
LM337T 2.25
LM350T 10A+VAR 4.00
LM396K 10A+VAR 15.00
LM723N 0.50
78HHO5KC 5A 5V 5.75
78HGKC 5A+VAR 6.50
78GUIC 1A+VAR 2.25
79HGKC 5A−VAR 6.75
79GUIC 1A−VAR 2.50

SWITCHING REGULATIONS
ICL7660 2.50
SG3524 3.00
TL494 3.00
TL497 2.25
78S40 2.50
RC4195 1.50

COMPUTER COMPONENTS

CPU
1802CE 6.50
2650A 10.50
6502 4.50
65C02-2MHz 12.00
6502A 6.50
6502B 8.00
6800 2.50
6802 3.00
6809 6.50
6809E 10.00
68B09 10.00
68B09E 12.00
68000-L8 36.00
8035 3.50
80C35 6.00
8039 4.20
80C39 7.00
8080A 7.40
8085A 3.00
80C85A 7.50
8086 22.00
8087-5 £120
8087-8 £160
8088 17.50
8741 15.00
8748 12.00
TMS1601 12.00
TMS9980 14.50
TMS9995 18.00
V20-8 10.00
V30-8 10.00
Z80 2.50
Z80A 2.90
Z80B 5.50
Z80H 7.50
TMS4500 14.00
TMS9901 5.00
TMS9902 5.00
TMS9911 18.00
TMS9914 14.00
Z80PIO 2.50
Z80APIO 2.75
Z80CTC 2.50
Z80ACTC 2.75
Z80DART 6.50
Z80ADART 7.00
Z80DMA 7.00
Z80ADMA 7.50
Z80ASIO/0/2/9 7.00
Z80BPIO 5.00
Z80BCTC 5.00
Z80BDART 9.00

SUPPORT DEVICES
2651 12.00
2816-30 20.00
3242 8.00
3245 4.50
6520 3.00
6522 3.50
6522A 5.50
6532 4.80
6551A 6.00
6821
68B21 2.50
6829 12.50
6840 3.75
68B40 6.00
6850 1.80
68B50 2.50
6852 2.50
6854 6.50
68B54 8.00
6875 5.00
8154 8.50
8155 3.80
8156 3.80
8205 2.25
8212 2.00
8216 1.60
8224 P.O.A
8226 4.25
8228 5.50
8243 2.60
8250 12.00
8251A 3.25
8253C-5 3.50
8255AC-5 3.20
8256 18.00
8257C-5 54.00
8259C-5 4.00
8275 29.00
8279C-5 4.80
8282 4.00
8284 4.60
8287 3.80
8288D 6.50
8755A 16.00

OTHERS
2N5777 0.50
BPX25 1.80
BPW21 2.80
OCP71 1.80
ORP12 1.20
ORP60 1.20
ORP61 1.20
SFH205 1.00
TIL32 0.55
TIL78 0.55
TIL31B 1.20
TIL81 1.20
TIL100 0.75

DISPLAYS
FND357 1.00
FND500/TIL730 1.00
FND507/TIL729 1.00
MAN71/DL707 1.00
MAN3640 1.75
MAN4640 2.00
MAN6610 2.00
NSB5881 5.70
TIL311 6.50
TIL729 1.00
TIL7300 1.00
MAN8910 1.50
MAN8940 2.50

DISPLAY DRIVERS
9368 4.50
9370 4.50
9374 3.50

MEMORIES
2101 4.00
2107B 5.00
2111A-35 4.00
2114 1.50
2114-3 2.50
2147 4.00
4116 2.00
4116-20 1.50
41256-15 3.00
4164-15T1 3.00
4416-15 3.50
4532-20 2.50
5101/5501 4.00
5514/5114 4.00
5516 4.00
5517AP 4.00
6116P-3 3.50
6116LP-3
6264LP-15 3.40
6514-45 4.40
6810 2.00
74S189 1.80
74S289 2.25
93415 6.00
93425 6.00

PROMS
28L22 4.00
24S10 2.50
18S030 2.00
18SA030 2.40
74S188 1.80
74S287 2.25
74S288 1.80
74S387 2.25
82S23 1.50
82S123 1.50
82S129 1.75

EE PROM
2816-30 15.00
2K+8 30.00
9306 256bits (16×16) 4.50

LEDs
0.125"
RED TIL209 0.12
GRN TIL211 0.16
YEL TIL212 0.20
Rect LEDs (R/G/Y) 0.30
CXQ (Bi colour) 1.00
10 LED Bar Graph
Red 2.25
Green 2.25

0.2"
TIL220 0.15
TIL222 0.18
TIL226 0.22

COUNTERS
74C925 6.50
74C926 6.50
74928 6.50
ZN1040 6.70

LM3914 3.50
LM3915 3.50
LM3916 3.50
UDN6118 3.20
UDN6184 3.20
ULN2003 0.90
ULN2004 0.90
ULN2068 2.90
ULN2802 1.90
ULN2083 1.80
ULN2804 1.90
75491 0.70
75492 0.70

EPROMs
2516+5V 3.50
2516-35 5.50
2532 4.50
2532-30 5.50
2564 11.00
2708 4.50
2716+5V 3.50
2716-35 5.50
2732 4.50
2732A-2 9.50
2732A-30 6.00
2732A-35 5.50
2764-25 2.00
27C64-25 6.00
27128-25 12.50
27256-25 4.00
27512 P.O.A
27512-25 14.00
TMS2716 5.00

CRT CONTROLLER
CRT5027 18.00
CRT5037 12.00
CRT6545 9.00
EF9364 8.00
EF9365 25.00
EF9366 25.00
EF9367 36.00
EF9369 12.00
MC6845 6.50
MC6845SP 6.50
MC6847 6.50
SFF96364 8.00
TMS9928 10.00

INTERFACE ICs
AU7581 15.00
ADC0808 11.90
AD561J 20.00
AM25S10 3.50
AM25LS2521 3.50
AM25LS2538 3.50
AM26LS31 1.20
AM26LS32 1.20
AM7910DC 25.00
DAC80CB1-V 28.00
DM8131 6.00
DP8304 3.50
DS3691 3.50
DS8830 1.40
DS8831 1.50
DS8832 1.50
DS8833 2.25
DS8836 1.50
DS8838 2.25
D7002 8.00
MC1488 0.60
MC1489 0.60
MC3446 2.50
MC3459 4.50
MCS3470 4.75
MC3480 8.50
MC3486 2.25
MC3487 2.25
MC4024 5.50
MC4044 5.50
MC6883 16.00
MC14411 7.50
MC14412 7.50
75107 0.90
75108 0.90
75109 1.20
75110 0.90
75112 1.60
75113 1.20
75114 1.40
75115 1.40
75121 1.40
75122 1.40
75150P 1.20
75154 1.20
75159 2.20
75160 5.00
75161 6.50
75162 7.50
75172 4.00
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BUS98	5 70
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IRF840	7 59
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100µF50V	0 17
330µF16V	0 12
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1000µF10V	0.15
2200µF16V	0.30
4700µF25V	1 58

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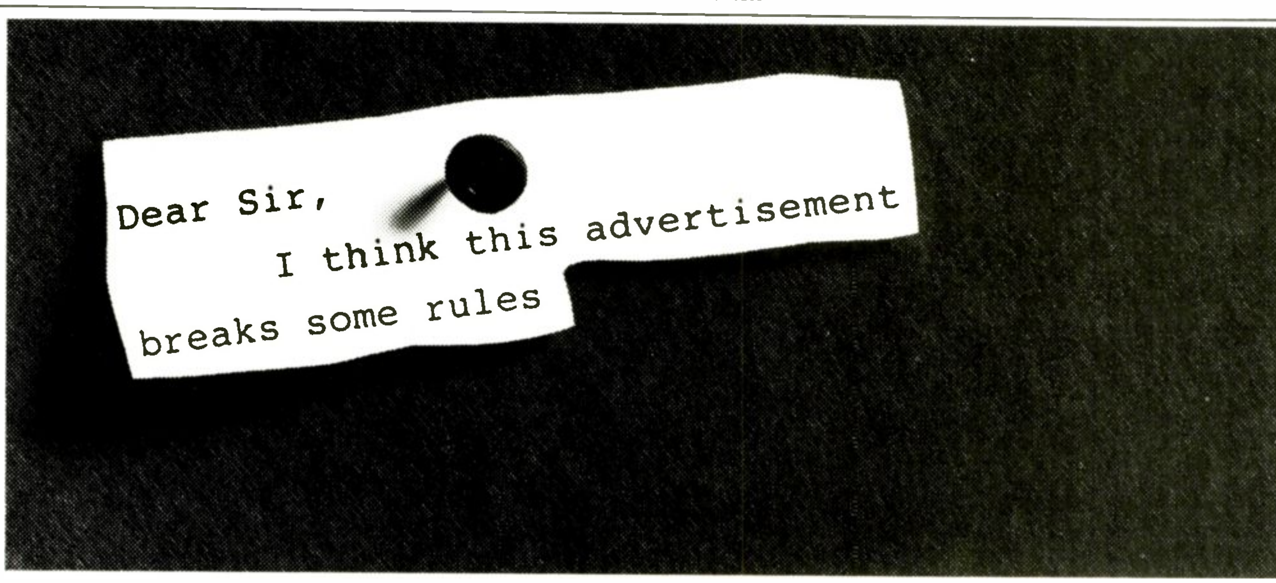

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Leetronex 87

The 24th Leeds Electronics Exhibition (Leetronex) takes place at the Department of Electrical and Electronic Engineering, University of Leeds, between 30th June and 2nd of July. With over 100 exhibitors and a programme of lectures, the organizers are aiming to re-establish it as the best electronics show outside London.

The exhibition was created in 1963 through requests from a number of electronics instrument manufacturers who wanted to demonstrate their equipment to the expanding higher education market. The equipment was shown to a selected audience of university staff. The event was so successful that it was repeated the following year and Leetronix became established. It grew to a peak of several thousands of visitors from all over the UK in 1979.

The economic recession of the early 1980s reduced the number of exhibitors and visitors. Last year, the Department of Electrical and Electronic Engineering took over the running of the show and made a major effort to re-establish it as "the best electronics exhibition outside London." The 1986 exhibition increased its attendance by nearly 50% over the previous year. The presence of over 100 exhibitors this year suggests that their efforts have been rewarded.

The re-introduction of a programme of seminars, organized by the Yorkshire branch of the IEE, also helped to restablish the status of the show, already the longest running electronics exhibition in the UK.

The exhibition has several qualities that distinguish it from other shows; Any profit is used to improve the undergraduate teaching facilities; last year's profits were used to enhance the computer teaching laboratory. The show is supported by a number of leading national and international companies and offers a link between industry and higher education.

PROGRAMME OF LECTURES

Lectures, sponsored by the Department and the Yorkshire Centre of the IEE, will take place in the Lecture Theatre (room 192) on the first floor.

Tuesday 30th June

1100h
The changing technology of electronic components and assemblies.
H.W. Ellis, Mullard Ltd.

1400h
Customized design of integrated circuits.
P. Forshaw, Ferranti Microelectronics Centre.

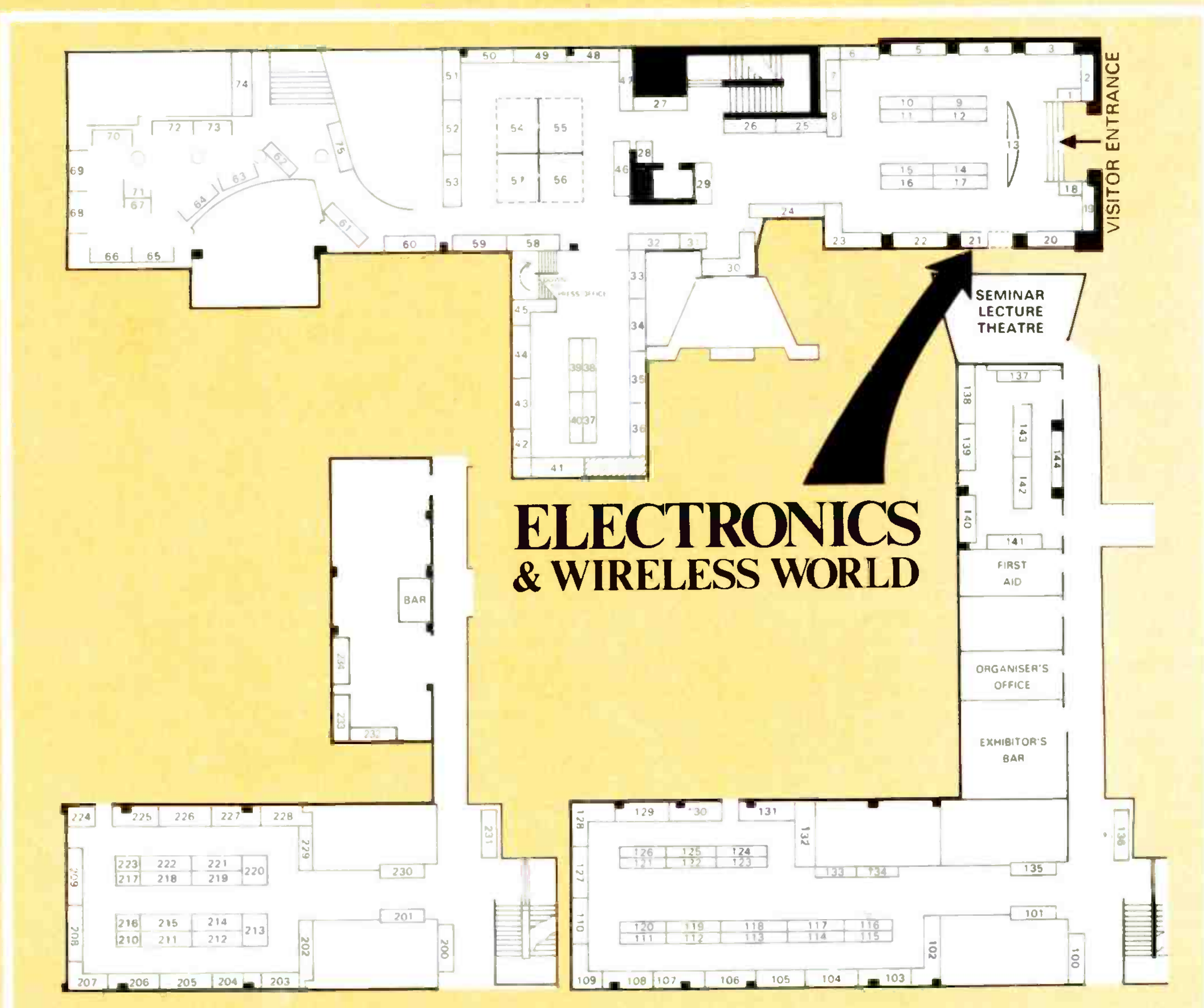
Wednesday 1st July

1100h
DBS receiver architecture and technology.
D.W. Walton, Thorn-EMI Ferguson Ltd.

1400h
Satellite tv – the present and the future.
J. Hazell, British Telecom.

Thursday 2nd July

1100h
Modern tools for microprocessor software development.
L.M. O'Carroll, Computer engineering group, DE&EE, University of Leeds.



4Mbit chip uses 'trench cell'

The first laboratory samples have been produced for a dynamic ram chip that can store four million bits of data. Produced by Siemens in collaboration with Philips, the 4Mbit d-ram uses a 'trench cell' in which a trench only one micron wide is etched four microns deep into the silicon. Each trench cell, with a capacitance of 40fF, stores one binary digit and occupies an area of only $5\mu m^2$.

To obtain the more than 4 million memory cells on a silicon chip, 450 process steps in c-mos technology are necessary. Compared with the 1Mbit d-ram ($54mm^2$), the storage capacity of the 4Mbit device is quadrupled without doubling the chip area ($91mm^2$). Typically the 4Mbit chip can store the equivalent content of about 250 pages of typewritten text.

The Siemens part of the project has been supported by the German government to the tune of DM240 million. Production is expected in 1989.

Engineers register broadened

The Engineering Council has set up a register for people who have gained either a degree, a Higher National Certificate or a National Certificate in engineering as the first step towards becoming a qualified engineer.

Up to now the Council, which has 300,000 Chartered Engineers, Technician Engineers and Engineering Technicians on its official register, has registered engineers in those three categories only after they have completed three stages: achieved the exemplified academic standard (known as Stage 1), completed an approved training period (Stage 2), and gained acceptable experience and professional responsibility (Stage 3). Now the Council's board for engineers' registration has approved the first list of candidates for registration at the Stage 1 academic level.

Professor Jack Levy, the Council's director for the engineering profession, said: "We have the largest professional register of members in the United Kingdom, but the country needs many more to help us improve the competitiveness of British industry. We have already persuaded the Government to provide more engineering student places in universities and polytechnics but we are pressing for even more."

He stresses the importance of registering as soon as possible after gaining a recognised degree, Higher National Certificate or National Certificate qualification so that they quickly proceed to becoming qualified engineers in one of the three categories. The Council and the professional engineering institutions advise and encourage young entrants.

"Our titles and designatory letters of Chartered Engineer (CEng), Technician Engineer (TEng) and Engineering Technician (Eng Tech) are recognised guides to employers and others of the competence and standards achieved by registered engineers," says Prof. Levy. "We now urge the larger numbers who are completing their education in engineering and technology to register with us." Engineering Council, 10 Maltravers Street, London WC2R 3ER. Tel: 01-240 7891.

Domesday extensions

Development has been designed to extend the applications of the interactive video system and Domesday discs developed by the BBC, Philips and Acorn Computers.

A new videodisc provides the users with a practical guide to ecology, taking as its basis the simulation of a Devon nature reserve. The 'Ecodisc' enables users to draft a plan for management of the reserve and its activities by discovering, learning and applying ecological knowledge and concepts.

Floppy-disc software offers enhanced facilities for the use of the Domesday discs. One enables the extraction of relevant pictures and information which can then be displayed independently. In autumn a further software package will enable users to integrate their own information with the maps included on the discs.

Next year, an additional disc for the Domesday system will contain detailed maps down to street level with updated and new data sets for specific sectors of industry and commerce.

Spray-on superconductors

Scientists at IBM have found a way to spray-paint large and complex surfaces with high-temperature superconductor material. This raises the prospect of inexpensive, easy-to-apply magnetic shielding, computer wiring and other applications that might benefit from its properties and workability.

IBM has coated items of various sizes using an industrial technique called plasma spraying. Plasma spraying quickly heats a material to thousands of degrees and instantly deposits the substance on a surface where it resolidifies. After coating, objects are reheated to anneal the surface. At this stage the coating becomes superconductive. The material's superconducting properties were discovered last year, and the researchers believe they are the first to quickly and easily coat complex shapes such as pre-formed wires, contoured and flat surfaces and even tubes made from ceramic, quartz and metals.

The materials, combinations of yttrium, barium and copper oxides, resemble flat black paint. After annealing, they become superconducting in the temperature range of liquid nitrogen – 'warm' enough to be practical for many scientific and industrial uses. (Liquid nitrogen boils at 77K.) Most materials and wires that IBM researchers have coated become completely superconducting at temperatures as high as between 60 and 82K. In addition to their ability to pass current without resistance, superconductors are impervious to magnetic fields, and might serve as an easy-to-apply and economical magnetic shielding. Superconducting wires for computer chip packages might also be made by plasma spraying. Coated thin lines have been added to ceramic substrates used for integrated circuits and microscopic holes have been successfully coated.

EXHIBITIONS & CONFERENCES

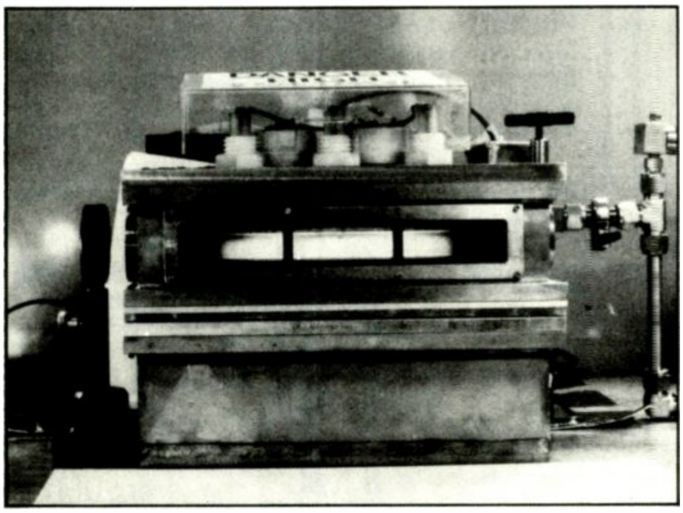
22–26 June 1987
Laser 87 Opto-electronics, microwaves.
8th International congress and exhibition. Munich Trade Fair Centre, F.R. Germany, MMA, Messegelande, Postfach 12 10 09, D-8000 Munchen, FRG.
23–25 June 1987
KBS 87 & Software Tools 87, Knowledge-based systems and software. Wembley Exhibition Centre, London. Online International, Tel: 01-868 4466.
24–26 June 1987
APRS Show, (professional sound recording) Olympia, London.
24–27 June 1987
SMT 87 Berlin: Surface mount technologies, International Congress Centre, Berlin. Details from AMK Berline, Postfach 19 17 40, Messedamm 22, D-1000, Berlin 19, FRG.
26–30 June 1987
BKSTS 87, 10th international film and tv technology conference and Exhibition, Metropole Hotel, Brighton, BKSTS. Tel: 01 242 8400.
30 June–2 July
Leetronex '87 the 'premier exhibition of the North' Leeds University. Tel: 0532 431751 ex 328.
30 June–3 July
Exhibition of electronic musical instruments and systems at the London College of Furniture, Commercial Road, London E1.
4–16 July
Electronic Design Automation Show, Wembley Exhibition Centre.
7 July 1987
World final of the Micromouse competition, Maze-solving, self propelled computers will be running round the IEE, Savoy Place, London E1 at 1730h. Further details, and rules and entry forms, from Andrew Wilson at the Institution. Tel: 01 240 1871 Ext. 260.
28 August–6 September
Funkausstellung: International audio and video fair Berlin (incorporating MediaForum), International Congress Centre, Berlin. Details from AMK Berlin, Postfach 19 17 40, Messedamm 22, D-1000, Berlin 19, FRG.
15–18 September 1987
Design Engineering Show, NEC, Birmingham, Cahners Exhibitions. Tel: 01 891 5051.
EED 87, electronics in engineering design, NEC, Birmingham, Cahners as above.
Test and transducer: international conference and exhibition. Wembley Conference Centre, London. Trident International, Tel: 0822 4671

X-rays can pre-ionize lasers

The use of X-rays to pre-ionize the carbon dioxide gas of high-powered pulsed lasers is being investigated at the British Aerospace Sowerby Research Centre.

Conventionally, gas preionization is achieved by subjecting the gas to ultra-violet radiation produced by spark discharges triggered off within the cavity of the laser. The research centre has produced the same effect by subjecting the gas to X-rays instead of ultra-violet radiation. Among the advantages of this is that greater volumes of gas can be ionized, enabling lasers of much higher intensity to be developed.

The area where the pre-ionization occurs can be determined with greater precision, leading to more efficient energizing of the laser. Laser tubes can be simplified, as only two electrodes are needed, and the laser gas remains purer as u-v radiation can cause the gases to dissociate.



Experimental CO_2 laser with x-ray pre-ionization is claimed by British Aerospace's Sowerby research laboratories to demonstrate greater laser efficiency and less gas dissociation.

EXHIBITIONS & CONFERENCES

23–27 September 1987
PCW 87; 10th Personal Computer World Show, Olympia, London.

29 September–1 October 1987
NAV 87. Navigation data, dissemination and display conference and exhibition, Heathrow Penta Hotel, Organized by the Royal Institute of Navigation. Tel: 01-589 5021.
Semiconductor International; design, assembly, test, materials and chemicals, NEC Birmingham, Cahners Exhibition, Tel: 01-891 5051.

5–8 October 1987
HDTV 87; International colloquium, Ottawa, Canada. Details from HDTV colloquium, Journal Tower North, 300 Slater Street, Ottawa, Ontario K1A 0CB, Canada.

Technological achievement

A high proportion of this year's Queen's Awards for Technology have gone to electronics companies.

Integrated switching. AB Automotive Products for their processor-controlled switching system for use in cars. The system for the Jaguar XJ40 has over 200 auxiliary items that require switching.

ISO network system. BICC Data Networks for the development of the Isolan system of hardware and software links for a local-area network that conforms to the ISO standards. The system allows the mixing of coaxial and optical fibre cables within one network.

Computer-controlled looms. Bonas Machine Company for computer-aided patterning for Jacquard fabric weaving looms. Designs can be programmed in a few hours compared with four days for the old punched-card system.

Radio-controlled switching. The BBC in collaboration with the Electricity Council for remote switching of electricity time switches. Low-frequency signals are added to the BBC's long and medium-wave broadcasts without affecting the audible signals.

Heat-detection system. Royal Signals and Radar Establishment in collaboration with EEV tubes for the development of heat detecting video cameras. The pyroelectric vidicon tube is capable of detecting temperature differences as little as 10^{-3}°C.

Night vision (twice). RSRE/EEV are also responsible for the award-winning night-vision system for aircraft, using new image intensifier tubes. Also The Royal Aircraft Establishment for their night vision system uses infra-red sensors, night-vision goggles and head-up visual displays.

SMC autoplacement. Dynapert Precima for automatic placement of surface-mounted components. Machines can place up to 6000 components in an hour and can be programmed to handle up to 120 different components types.

Oil reserve simulation. Exploration Consultants of Henley on Thames for Eclipse computer simulations of gas and oil reserves.

Surface-mounted p.c.bs. Ferranti Computer Systems for metal-core multilayer p.c.bs that avoid the problems of thermal expansion and heat dissipation.

Computer-controlled cam lathe. The Litton UK camshaft system automatically compensates for grinding-wheel wear and achieves much higher accuracies than previously possible.

CD mastering. Nimbus Records for developing their own system of mastering compact discs, involving coating the masters with photoresist 0.12μm thick, encoding of digital signals to control the laser writing beam, construction and control of the mastering lathe and control of the plating process. It cost about a tenth of the alternative system, exceeds the capabilities of that system and meets the expected requirements of the next generation of CDs.

Colour radar. Racal Marine Data for a digital scan converter in colour radar displays. It processes derived from a conventional radar scanner to be displayed in a high-resolution colour tv format. The system combines high-speed computing, video processing and memory management into a single small unit.

Self-calibrating data recorder. Racal Recorders for its Storehouse tape recorder for data acquisition. Its automatic calibration system allows the record and replay circuits to be set up in less than ten minutes instead of the hours previously needed.

Optical-fibre lasers. STC Defence Systems for 1300m lasers for optical fibre communication. The devices allow repeaters to be 30km apart at a data rate of 565Mbit/s, i.e. twice the range and four times the speed of former devices. They are claimed to be the first suitable for submerged use.

Aircraft simulators. Singer Link-Miles Ltd for functionally distributed simulation system for aircraft training. Processors are linked to provide real-time computing power beyond the scope of super-mini computers. the system is used in the first simulator for the new Boeing 747-400.

Network manager. Tech-Nel Data Products Ltd, of Banbury, the NMX Network Management Engine which integrates hardware and software systems knowledge for fault detection, restoring, and diagnostics in a single processor-based fault-tolerant data communications.

Magnets for spectrometers VG Analytical Ltd, for the development of laminated magnets for fast-scanning mass spectrometers. Existing magnets offered limitations in meeting the demands of capillary column gas chromatography. The company developed lamination and machining techniques to produce magnets assembled from 100 or more 0.3mm thick laminations. They meet the new requirements of medical and environmental biochemical analysis equipment.

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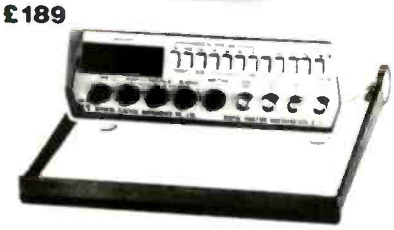

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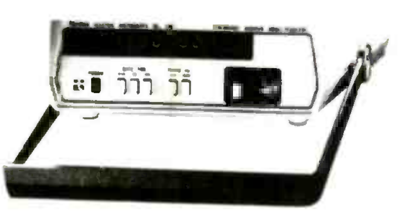

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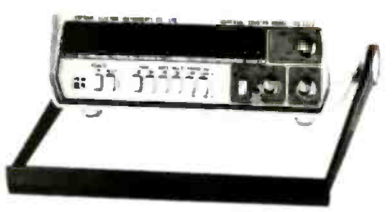

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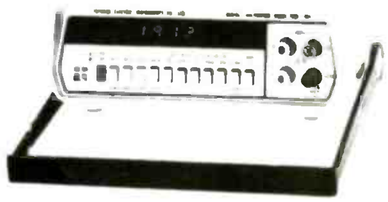

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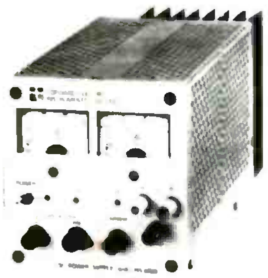

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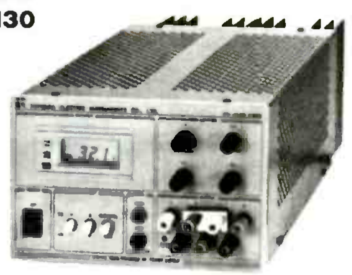

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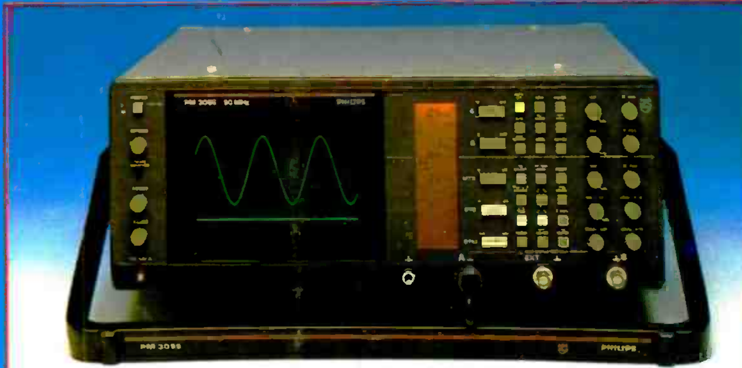

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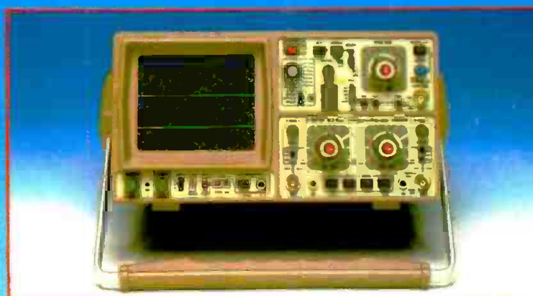

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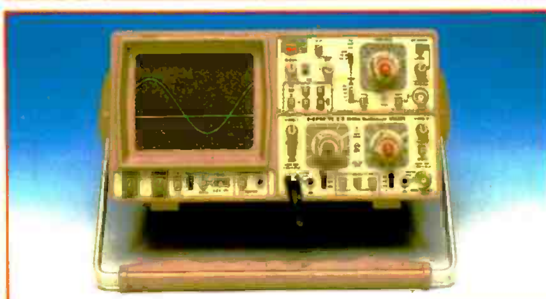

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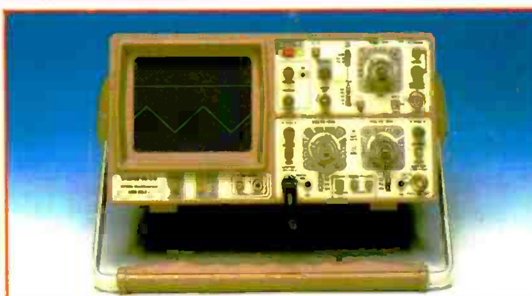

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