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ALL IN ONE

The age of 'two-in-one' and 'three-in-one', a combination of radio and cassette player, is being replaced by the 'four-in-one.' A wristwatch is not a mere wristwatch anymore. A Japanese firm has introduced a watch with which you can talk! The gadget can decipher your voice and understand your queries. Of course, the gadget should be made familiar with your voice so that it can synthesise the characteristic notes and use the data as a dictionary for decoding the speech.

Dr. Raj Reddy of Carnegie Mellon University, whose talk on robotics is covered elsewhere in this magazine, has gone one step further. He informs us that the Japanese technology now has the limitation that the watch cannot understand the language if someone other than the owner spoke to it, unless it is re-tuned. Carnegie Mellon has developed a technology which is 'speech-independent', meaning the gadget can understand anybody’s talk.

The profound changes in the technology of computer, communication and Artificial Intelligence is bringing about a metamorphosis. Thus, the concept of a four-in-one is a distinct reality. There will be a portable electronic office. A small gadget will have audio and video facility, in addition to functioning as a computer, enabling data, video and voice transmission.

The idea of a phone in every home will be replaced by the slogan, a phone in every pocket. This micro-gadget can store a 100 pages of a daily newspaper.

Should you think these are exotic gadgets meant only for Japan and the US, you are mistaken. As Dr Reddy predicts, low-power, battery-operated, cheap computer will dominate the future and the computer will have both speech and visual facilities enabling even an illiterate villager to use the gadget. Less sophisticated the person is, more sophisticated the machine will be.

If transistors, two-in-ones, colour TVs and electronic telephone could make inroads into our villages, the days of four-in-one computers, functioning at the village panchayat office cannot be far behind.
LAUNCH OF IRS

With the launching of the indigenously-built remote sensing satellite IRS-1A, India has joined the select group of nations, the USA, the USSR, France and Japan, in having such a sophisticated facility. India is the first developing country to have a remote sensing satellite. IRS-1A, weighing 980 kg, is the heaviest satellite to be built by India and it is her tenth one to be put in orbit.

Placed in polar sun-synchronous orbit, the satellite will cover the entire Indian sub-continent once in 22 days and help in the study of natural resources during various seasons under identical conditions. The satellite is orbiting the earth over the poles at a height of about 900 km, taking 103 minutes for each orbit.

The IRS-1A carries three linear imaging and self-scanning cameras which take pictures of 148 km-wide scenes in four different colours. The data will be received at the ground station near Hyderabad. The satellite will pass over India seven to eight times a day with each pass having a duration of five to ten minutes. The data sent down will be equivalent to some 4000 volumes of 300 pages each, roughly a good sized library of about 10,000 books each day. The National Remote Sensing Agency, Hyderabad, will receive, process and distribute the satellite data to several user-agencies within India and abroad. The IRS-1A is designed to operate for a minimum of two years. IRS data will be vital in areas like agriculture, forestry, geology and hydrology and its data would be the key element in the National Natural Resources Management System.

The satellite IRS-1A was the seventh to be launched with foreign launchers and the fourth to go up from the Soviet Union. The other three satellites which were launched from the Soviet Union were Aryabhata (1975), Bhaskara-I (1979) and Bhaskara II (1981). The Indian National Satellites (INSAT-1A and IB) were launched from the United States. India's first experimental communication satellite, APPLE, was launched by the European Space Agency.

LOW-COST EARTH STATIONS

The International Maritime Satellite Organisation, Inmarsat, has approved the trial use of limited capability earth stations (LCES) for the provision of telex services to ships and possibly other mobile units. The new stations could provide easy access to the Inmarsat satellites particularly for the developing countries and from areas where the existing telecommunications infrastructure is inadequate or traffic requirement is fairly low.

Currently operating earth stations with Inmarsat satellites are substantial and expensive installations. With large, steerable, parabolic antennas, averaging 13 metres in diameter, and the capacity to handle a large number of simultaneous voice, data and telex calls, they cost several million dollars to build. There are now 20 such stations in the Inmarsat system, owned and operated by telecommunications authorities or companies in the countries in which they are located.

The new earth station will have an antenna of less than one metre in diameter and it will handle only a single telex communication channel at a time. It will operate in effect as a ship-to-ship link, through a main coast earth station. The Inmarsat council has agreed for a lower segment charge because of the restricted requirement of LCES.

SATCOM IN BALLOON

The National Aeronautics and Space Administration of the US will use satcoms in a space project. The Inmarsat council has approved the installation of a modified ship earth station on a high-altitude balloon.

The SES will be carried on a ‘Supernova long duration space balloon flight’. The balloon, which will carry equipment for observation of a large supernova visible from the southern hemisphere, will use the satcom terminal for transmission of observational and navigational data through its flight. The balloon will travel from Australia to Brazil in a journey lasting seven to ten days at heights up to 40 km, an altitude at which satcoms had not been used before.

The satcom terminal is being supplied by the US firm, Radar Devices, under a contract worth 27,000 dollars. It will be a modified form of the firm's satcoms ship earth station, normally sold to ships and yachts for communications through the Inmarsat system.

The satcom unit will transmit 20 minute data stream every four to six hours via Inmarsat satellites to computers at the University of California's Centre for Astrophysics and Space Sciences. Scientists will use the positioning data to make directional changes in balloon course, which will maximise the observational opportunities.

EUROPORT '87

Europoort '87, held in Amsterdam, showed the latest developments in electronics for shipping and it was evident that movement towards electronics at sea is gathering force.

In Satellite communication, the main attraction was Standard-C which made a debut. Standard-C offers all satcoms facilities except voice over a tiny omnidirectional antenna. Thrané and Thrané of Denmark is a forerunner in this field. The firm, STC, showed a mock up of a Standard-C. Marconi was displaying its new ship earth station, Oceanray 2, which has lighter, more rigid antenna (60 kg). Its target is the yacht market.

The newly unveiled transportable version, Satpax, which is packed in two cases weighing 20 kg and 40 kg respectively also made its entry. A third case to carry the plug-ins such as computer, facsimile, and UHF/VHF patch is also provided. Airdrop cases are offered and the whole system is designed to a military specification.

On display for the first time were two public phones which Comsat is promoting for use with the Inmarsat system. A credit card phone began extended trials in 1987. Interest has already been shown by cruise ships and offshore installations. Alongside was the system without credit card slot, dial or keypad. Here the caller is automatically connected to the operator at one of Comsat's earth stations and gives a card number or home phone number debit the charges before being connected manually. A number of other value-added services were being presented by Comsat, including an electronic mailbox facility called Seabox, a packet-switching service, and a chequeing facility, Cashcall, which uses a device to check a caller's account and print out a cheque for cashing on board.

NO MORE NIGAMS

The Department of Telecommunications does not favour the idea of creating more corporations like the Mahanagar
TELECOMMUNICATION NEWS • TELECO

Telephone Nigam Ltd. Instead, it proposes to accord greater financial autonomy and decision-making powers to telephone exchanges in major cities and towns.

The main reason for dropping the creation of nigams for big cities is that these are major revenue earning centres. Without these centres, network of smaller cities and towns would be starved of funds. Also, the government would be saddled with loss making centres, while the revenue earning centres would be taken away in the form of autonomous corporations.

The department is considering a proposal to set up a separate financing agency for the telecommunication sector with a view to borrowing funds from the market for the entire telecommunication sector.

DELAY IN RAX

The scheme of introducing a rural automatic exchange (RAX) a day from April 1 is likely to be delayed by at least three months. The delay is mainly due to the non-availability of required number of units.

The unpreparedness of the seven RAX producers who have been given licence to produce them, DOT's delay in granting environmental clearance for testing the units developed by the C-DOT and the delay in identifying suppliers of back up components were among the other causes resulting in the postponement of the scheme.

ELECTRONICS NEWS • ELECTRONICS N

NIC OUT OF DOE

The National Informatics Centre (NIC) of the Department of Electronics has been shifted and attached to the Planning Commission. Dr. N. Seshagiri, director-general of NIC, who was reporting to the minister of science and technology now reports to the planning minister. Subsequent to this major policy change, the DOE has been reorganised. A financing agency for electronics has been cleared by the government in principle.

The shifting of NIC from DOE was inevitable because of its growing size. About 2000 experts work in NIC which is responsible for 57 departments, in addition to advising all the state governments. The centre would bring 439 districts in the country under its satellite communication network.

The union cabinet and the Electronics Commission felt that either a separate department should be created for NIC or it should be attached to a suitable ministry. Hence, it is attached to the Planning Commission. The Planning Commission has to formulate the eighth five-year plan in a more relaistic manner with data from the districts, NIC, with its vast network, will provide the input to the commission.

Following the reorganisation, DOE will have 14 divisions. The materials and components division will have three subgroups namely microelectronics group, components group and special projects in components. The second division will be consumer electronics division. Control and instrumentation division will look after power electronics, instrumentation and capital goods. The fourth will be the computers and communication division. This division will look after software development, computer aided designs and rural information system.

Other divisions are strategic electronics, information, planning and analysis, library and publication, manpower development, industry promotion, technology development, appropriate automation promotion and microprocessor application.

BOOST TO HI-TECH

The Department of Electronics will launch a special drive to increase investment in the high-tech electronic components sector. Despite liberalised investment conditions, the private sector failed to set up hi-tech components units, which have an export potential. Now, investments are likely to be made in the public sector.

The seventh plan envisaged a turnover of Rs. 40,000 crores in the electronics sector and components accounted for one-fifth of this. To achieve this target, an investment of Rs. 850 crores was expected in the components sector. But, private units concentrated only on consumer items like colour picture tubes and glass shell.

The DOE is now making efforts to ensure that the investments are made in areas such as manufacture of bi-polar ICs, multi-layer PCBs and surface mounted devices. State electronic corporations would be encouraged to take these areas. Banks have been advised to provide finances to manufacturing these devices rather than supporting the import of electronic goods.

The DOE has also plans to upgrade the Semiconductor Complex Ltd., Chandigarh, for which an allocation of Rs. 11 crores has been made. Emphasis will be given to products which have ready marketability and export potential. Initially, requirements of calculators and telecommunication industry will be met. The department has approved the setting up of two calculator units for manufacturing two million calculators.

C-DACT AFTER C-DOT

The proposed Centre for Advanced Computing Technology (C-DACT) will have the development of a supercomputer within five years as its major objective. The goal is to make a machine with a peak computing power of 1000 megaflops within three years. Based on this parallel processing computer, a fifth generation calculator system will be developed with a rating of one to ten million logical inferences per second (LIPS) in five years. The initial funding of the project, to be made by the Department of Electronics, is about Rs. 37.50 crores, including foreign exchange worth Rs. 12.50 crores.

C-DACT, besides the computer project, will take up commercial products such as VLSIs and chips for personal computers, advanced board level products, parallel
processing workstations and software products.

Under the Administrative control of the DOE, C-DACT will be a permanent scientific society and it will be modelled after the Centre for the Development of Telematics. Dr. Vijay K. Bhaktawar, a director in DOE, will be its first executive director. Mr. K.R. Narayanan, minister of state for science and technology, and Mr. Sam Pitroda, adviser to the Prime Minister on technology missions, will be chairman and vice-chairman respectively of the governing council of the C-DACT.

Other members of the council include Mr. K.P.P. Nambari, secretary, DOE; Dr. Vasant Gowerkar, secretary, DST; Dr. R. Narasimha, director, National Aeronautical Laboratory; Prof. B. Nag, director, IIT, Bombay; Prof. V. Rajaraman, Indian Institute of Science, Bangalore; and Dr. A. Paulraj, Defence Research and Development Organisation.

The existing supercomputer project and the fifth generation computer project at various centres like IIT, Madras, NAL, Bangalore, TIFR, Bombay and C-DOT will be co-ordinated by C-DACT.

In another development, the Electronics Research and Development Centre of the Kerala government at Trivandrum will be taken over by the DOE. The ERDC will be developed as a regional centre. The DOE is taking over the centre as the state government is unable to find sufficient funds for the centre.

MICROELECTRONICS

An empowered committee of the government of India on the microelectronics policy has suggested that indigenous designs should be protected from international competition through fiscal measures.

The committee set up by the DOE has recommended that design centres be set up with prototyping facilities near electronics industries clusters. The committee has also favoured commercial interaction between the chip manufacturing and assembly units and the industry.

The expert group has laid emphasis on improving the competitive strength of the microelectronics manufacturers by giving them fiscal support. Investors are shy of entering microelectronics, fearing international competition.

The special group was set up by the government to evolve a separate microelectronics policy as this sector was not growing in the country. While microelectronic devices are used in the developed world to the extent of 12 per cent, in India it is hardly one per cent.

NUCLEARIC WEIGHER

The Indian Institute of Technology, Bombay, has successfully tested and commissioned a microprocessor-based nuclearic weigher for use on conveyor belts to measure weight of materials like coal, coke, fertiliser, lime stone, iron ore and so on.

Conventional weighing machines using load cells encounter errors of the order of plus or minus 10 per cent. Nuweigher technique, being a non-contact method, sustains the precision on measurement over very long periods with the error not exceeding plus or minus half a per cent. This is a radioisotope device for industrial application.

The application of microprocessor has made the unit intelligent in that a single unit by suitable software can use different isotopes like cobalt-60 Csium-137 or Barium-132, corrected for decay and print out the total weight at regular intervals on command. A single central processing unit can monitor five or more belt conveyor systems every second and log the weight.

The technology, developed by Prof. B.S. Magal and Prof. V.P. Sundersingh of IIT, Bombay, is available for commercial exploitation from the dean (R & D), IIT, Bombay.

MANAGING TECHNOLOGY

A telephone and a television in a wristwatch, a cheap and simple computer that can be used by a villager, a machine replacing the mother's womb to grow a foetus, a dietary pill as substitute for food, a non-vegetarian tomato, produced by cloning the gene of a calf with that of a tomato-these are products of emerging technologies in the next two decades. How will a professional manager cope with this change and exploit it? The Indian Institute of Management, Ahmedabad, to mark its silver jubilee year organised a seminar entitled "Managerial Response To Emerging Technologies" in Bombay.

An expert in each field namely, Robotics and Artificial Intelligence, Electronics and Information Technology, Plastics and Petrochemicals and Biotechnology delivered a talk.

Mr. V. Krishnamurthy, chairman, Steel Authority of India Ltd., and Technology Information Forecasting and Assessment Cell, in his keynote address pointed out that success depended not so much on the capital or hardware equipment but on the technology we possessed. Technological strength characterised the emergence of new economic powers like Korea, Japan and Taiwan. Pleading for a phased technological change with a phased upgradation of the human resources, Mr. Krishnamurthy said: "We cannot move from primitive data entry machines to sophisticated, satellite-based computer networks overnight."

The chairman of Electronics Commission opined that government should not run the industries and leave them to the private sector as the government was inherently not suitable to manage the industry. The private sector would perish if it was inefficient.

Indian industry, having enjoyed the luxury of protected environment, fought shy of facing challenges. Managers should accept new challenges and be creative as the success or failure depended on the timely action taken by them, Mr. Deodhar said.

Dr. Raj Reddy, university professor of computer sciences and robotics and director of the robotics institute, Carnegie Mellon University, said the power of computers had increased 100-fold in the last few years. If the automobile industry had progressed at the same pace, a Rolls Royce would have become available for five dollars and it would have had a speed of 50,000 miles per hour, running 500,000 miles for a litre of petrol.

A supercomputer, now costing 10 million dollars may be available for a mere 10 dollars in the next 10 years. The technology is changing at such a fast pace, that the limits of physical laws would be reached in the next 20 years, leaving no scope for new development thereafter.

At Carnegie Mellon an automobile that drives itself is being developed. It has two stereo cameras to detect million pixels. For this computation, at least a trillion operations would be needed, coupled with 1000 computer instructions. To make the car take you to your home on its own, 10 billion operations would have to be carried out, Dr. Reddy cited as an example.
Self-operating, multipurpose micro factories will be the mainstay of industries in future. These factories, based on computers, would accept designs, get instructions through satellite and produce the goods locally. Problems could be solved by contacting the computer and experts need not fly to carry out repairs. High quality products can be made here using computer, communication and knowledge industries, employing local talent and labour. This will lead to minimal inventories, while capacity will be stockpiled.

This technology, however, may result in a social problem. Low-cost labour will become increasingly unimportant. Loss of manufacturing jobs will be likely. But, what kind of new jobs would emerge cannot be even imagined today.

Computer-aided simultaneous engineering will enhance production capability. Rapid redesigning and prototyping will reduce costs. Large automotive manufacturing companies spent 100 weeks to make a new car lamp in the US while the Japanese did it in 50 weeks. Preparation of a plastic lens for the lamp involved time consuming, tedious study. Instead of the normal six days, a computer does it in 10 hours now. Tooling for injection moulding dyes used to take six to 12 weeks in the past. Now, computer-aided design and manufacturing enables the dyes to be made in less than 24 hours.

The managerial problem now and in future will be to react to trends and customers' response quickly. The industry cannot survive if customers' need is not rapidly satisfied. This implies that customer response should be obtained almost every day. Short-cycle innovation to bring the products out quickly will become indispensable. Reverse engineering will be the strategic point in future R & D and the workforce must be suitably trained to become expert reverse engineers.

Thirty million TDA4600s

Seven years ago, Siemens found a way of integrating the control circuit for switch-mode power supplies used in TV sets on a single 7 mm² chip. Since then, sales figures have reached 30 million for the bipolar TDA4600 and 10 million for the TDA4601 version (with extended voltage range: 80-270 V). Its ability to produce the required voltages at varying input voltages and loads in an economical way has made the TDA4600/4601 the unrivalled top product on the market, favoured by more than 200 customers throughout the world. An enhanced version, the TDA4605, using "Sipmos" transistors has now reached the production stage. As early as 1972, engineers at the Applications Research Laboratories of Siemens had conceived the idea of using a flyback converter as a power supply for TV sets. Until then, the standard practice had been to provide a rigid, and cost-intensive, coupling with the line frequency circuit. The introduction of the flyback converter drastically reduced the circuitry and components. The integration of the entire control circuit on the TDA4600 further simplified the power supply section in the TV set. The improved reliability of power supplies equipped with the TDA4600 is reflected in the significant reduction in TV set failures over the past several years.

New VME board from National

National Semiconductor have introduced a high-performance 32-bit board-level system based on the company's new NS32532 32-bit microprocessor, and is compatible with the widely used VMEbus standard.

The new system, the VME532, can execute up to 10 million instructions per second (MIPS), the highest performance available in VMEbus CPU at present. The VME532 is an ideal solution for systems integrating building UNIX Systems V-based multi-user systems (64 to more than 200 users). It is also well-suited for high-performance board-level embedded control applications such as automated test equipment, factory automation (robotics and machine vision), imaging applications, and aircraft flight simulators.

Electronic fingerprint recognition

An electronic fingerprint recognition system developed by scientists at Edinburgh University's electrical engineering department has received £500,000 backing to build a full-scale demonstrator and carry out field trials. The system was invented by the department's Professor Pete Denyer and a prototype has already been built and tested. Potential applications for the device, which electronically matches a presented fingerprint against a memory store of "authorized" prints, include door and computer systems security and point of sale machines.

Initial development work was supported by the Quantum Fund, which is backed by the British Linen Bank, the Scottish American Investment Company, and Edinburgh University to provide venture capital for commercially exploitable work at the university. Quantum will provide further capital to enable the university team to build a full-scale demonstrator of the device. This will then undergo field trials with De La Rue Company, who will have exclusive rights to the technology.

Linear IC Data book

Now available from the House of Power is the Unitrode Linear Integrated Circuits Data Book for 1987-88, a comprehensive guide to the functions and applications of the Unitrode ranges of power, control and interface circuits.

Products covered in the book include power-supply circuits, motion-control circuits, power-driver, and interface circuits.

House of Power • Electron House • Cray Avenue • ORPINGTON BR5 3AN • Telephone (0689) 71531.

SEMI optimistic for 1988

Semiconductor Equipment and Materials International (SEMI), the trade association for the semiconductor equipment and materials industry, has predicted a much improved 1988 for its members.

SEMI’s data collection programme represents input from more than 200 members around the world. Figures show an escalating backlog, as orders steadily rise and drive a positive book-to-bill that reached 1.18 in the 3rd quarter of 1987, up from 0.91 in the 4th quarter of 1986.

This optimistic attitude was initiated by strong worldwide semiconductor device shipments, reported by the Semiconductor Industry Association (SIA), which topped $3 billion in September last year, up from $2.5 billion for the same month in 1986.

SEMI European Secretariat • CCL House • 59 Fleet Street • LONDON EC4Y 1JU • Telephone 01-353 8807.
A NEW MULTILAYER PROCESS FOR INTEGRATED PASSIVE DEVICES

by Dr. Gordon R. Love

This article describes a new process, derived from techniques used to produce multilayer ceramic capacitors, which is the key to a technique, known as Multilithics®, allowing complex integrated multi-functional passive circuits to be produced.

Introduction

There are two fundamentally different build-up processes for multilayer ceramic devices or assemblies. Each begins with a slip of finely divided ceramic particles dispersed and suspended in a complex organic system. In the more commonly used process, this slip is cast in thin sheets of controlled thickness and dried; patterns are then printed on it by thick-film silk-screen processing, and the array of finished devices is assembled by stacking and laminating these single sheets. This process is generally known as dry stack or 'tape' manufacturing. The alternative process involves casting the slip onto an inert carrier, drying it, printing the patterns by thick-film processing, and then casting the next controlled thickness layer in situ. This build-up process is then repeated as many times as is necessary. This technique is known as wet stack or 'paint' processing.

These two manufacturing processes cannot easily be compared, as each has its own strengths and weaknesses. For example, single sheets can be inspected and discarded if found defective in the tape process, whereas in paint processing this is virtually impossible. On the other hand, tape processing requires high precision at two distinct processing steps (printing and stacking), whereas paint processing requires high precision only at the printing stage.

Process differences

For both manufacturing processes, a minimum amount of organic binder is required both to encourage device formation and to facilitate the eventual binder removal. Binders free of metallic contaminants are preferred because they are less likely to contaminate the ceramic formulation, and they should be removable completely and easily because they must not distort the ceramic or

Fig. 1. Cross sectional schematic of a Multilithic device.
leave refractory residues which might interfere with the sintering process. These binders and the associated solvents should be cheap, non-toxic, and easy to dry without film formation or cracking; moreover, the binder for the ceramic powders must be compatible with the (usually different) binder selected for the metal powders.

For a tape-based system, the organics must have excellent strength because the tape is handled as a self-supporting sheet for at least part of the process. In addition, many variations on the tape process involve locating the tape for printing or laminating (or both) by mechanically contacting the tape itself. Hence, reference holes must be both well defined and dimensionally stable.

In what appears to be a relatively fundamental conflict with these requirements, the tape has to be sufficiently plastic to permit very high-quality laminate; otherwise, the sintered body can become vulnerable to internal laminar voids or 'delaminations'. The tape binder should be relatively insensitive to variations in ambient temperature and humidity, in order to maintain the dimensional stability required between the multiple precision steps in the process.

For a paint-based system, dimensional stability and reproducibility are determined largely by the carrier plate, and all strength requirements are essentially met by the carrier. In addition, since the mixture is assembled in situ with each layer being solvent bonded to its predecessors, plastic deformation is not required, and this source of 'delaminations' does not exist.

On the other hand, since visual inspection for pinholes and other casting/drying defects becomes impracticable, it becomes essential for high-quality layers to be obtained every time. High-speed drying is more important in this process because paint drying cannot easily be isolated from the rest of the build-up process, and so can limit production rates and overall productivity.

Quantum improvements

Wet build processing has been successfully employed in the capacitor industry for over 25 years, and a combination of organic chemistry expertise and mechanical engineering skills has recently introduced quantum improvements to the basic process. The latest generation of process developments has resulted in a technology that is specifically optimized for both printing and print location accuracy, as well as for uniform high productivity for both large and small manufacturing runs. The new technique is sufficiently different to warrant its own name: P-4 (for Precision Paint & Print Process) manufacturing.

Process benefits

The high dimensional stability and high yields produced by the P-4 process are absolutely essential to the Multihytics concept. Because a Multihytics device is an array of components rather than a discrete device, the whole array must be discarded if a single component in the array is defective. Hence, if array yields are to be acceptable, single component yields must be very high.

By way of illustration, if the component yields are 95%, an array of 100 components would have a yield of 0.59%; a 99% component yield would improve the array yield to 36.6% etc. The P-4 process has been found to lead to satisfactory yields.

Another benefit of P-4 assembly is modularity. Historically, a major limitation of wet-build processes has been their relative inflexibility. Where unit volumes allow the assembly process to be run at its optimum throughput, it can be extremely productive, and efficient in both labour and capital investment. However, small runs can be made only by 'iding' major components of the manufacturing line for significant lengths of processing time.

By re-configuring the assembly equipment into smaller process modules, the P-4 process allows manufacturing to take place at constant labour and capital productivity over at least a 4:1 ratio of batch sizes. This is a particularly important change in the context of the market for which Multihytics is intended, since a contributory factor to the relatively high costs of hybrid thick film manufacturing has been the difficulty in achieving meaningful automation for small manufacturing runs.

The P-4 assembly process has been tightly integrated with a computer-aided design facility so that customers can design their own devices and obtain a manufactured product in a relatively short time.

Dr. G.R. Love is Vice President of Technology, Sprague Electric.
COMPUTER MANAGEMENT SYSTEMS TAKE OVER

by James Lock

The second half of the 1980s is witnessing the full flowering of fourth generation interactive computer systems, the integration of batch with continuous control, and a trend towards the location of intelligence close to plant of equipment under control.

Several companies in the United Kingdom are investigating the application of expert systems to process control, and software systems such as Auditor from Energy Efficiency Systems(1) are emerging by which plant data can be transferred, via a company’s mainframe computer, into accounts and costing systems or into sales forecasting and business planning software.

An important new control system, introduced this year by Ferranti Computer Systems(2), is the PMS 100. Ferranti describes it as an integrated, fully distributed process control and information system for supervisory and direct control, for continuous, sequence and batch control, and for high availability configurations.

It is a far cry from the process plant computer control system installed by Ferranti in 1962 for control of a soda ash plant at ICI’s site in Fleetwood. Believed to be the first in the world, that had a program of only 1200 words.

Computing cards of various performance, all based on the Ferranti Argus 700 family of processors, are now used at various locations. Computing power varies from 700 000 inputs per second to more than two million inputs, depending on the configuration.

PMS 100 is a natural development of the first PMS - process management system - installed for the Bayer company at Leverkusen, Federal Germany, in 1975. Over the years, Ferranti technology has been applied in areas ranging from steelworks to radio astronomy.

Making modifications

The data highway, Systembus SB10, is an open system based on international communication standards able to connect to other manufacturers’ equipment. In a dual configuration, System SB10 data highways are treated identically. There is no master and no standby, messages are simply transmitted down a free data highway with the advantage of allowing twice the bandwidth in normal operation. A combination of System SB10 and Ferranti’s wide area network X.25/T-NET provides a communication capability for any size of PMS 100 network.

PMS 110 is a dedicated process controller that incorporates mixed sequence and continuous control facilities. Normally mounted close to the plant under control, it can be interfaced directly to it or through loop controllers and programmable controllers.

A process engineer can modify and develop new control schemes from either a terminal at the process management information system or on a portable Access 110 programmer located, say, in the engineer’s office.

The PMS 105 device gateway allows any make of process control or operator device to be integrated into PMS 110, permitting any make of programmable logic controller (PLC) or single loop controller to be specified.

Familiar engineering terms

Batch control in PMS 110 is provided by PMS unit operations, which provides a complete batch control environment for simple product, single stream and multiproduct multi-stream batch processes. Typical is use by the Pfizer company for batch processing a range of pharmaceutical processes. A number of batches can be in progress simultaneously through different process steps using the same train of equipment.

The production supervisor can redefine production routes and resources on-line, allowing multi-product manufacture with a minimum of downtime. Automatic batch scheduling permits a campaign to be set up in advance so that production is initiated immediately the plant becomes available and it is also possible to change the order of batches. Part of the PMS operations software package is Constructor (IPC) which enables the engineer quickly and simply to build up colour graphic process diagrams, graphs and logs. The PMS system’s on-line development facility uses a high level programming language which has terms familiar to the engineer and requires no specialist programming expertise.

The trend to put the intelligence of a computer control system in close proximity to the sensors and actuators of a plant rather than relying on a single, central computer is reflected in Newmark Technology’s(3) Omnibus range. This stems from the Janus Project, conceived by Professor John Brignell at Southampton University for the application of advanced microprocessor technology to measurement and control.

Omnibus measurement and control systems comprise one or more Omnibyte computers acting as master station/operator interface and a number of Multipoint measurement and control computers distributed over an Omnibus network. The Multipoint units have been developed jointly by Newmark and Jeball, a company formed by Professor Brignell, while the Omnibyte computers are IBM PC or compatible computers in standard or industrial packaging.

Collaborative project

At the heart of the Omnibus concept is a powerful dual processor that implements the synchronous data link communications (SDLC) protocol. To achieve this, Newmark took the Intel Bitbus and enhanced it to handle up to 250 stations over a range of 5 km, from systems that can start with control of a single loop. Although a personal computer (PC) is an integral part of the systems loop, the essential difference is that this computer is used simply as a central programmer and data manager rather than as a decision manager.

The majority of decisions made by the system take place at the outstations, removing the problems associated with a failure of the main computer or its communication systems. The use of a plug-in card allows control of the Omnibus network without loading the PC. The
Multi-point units form the remote outstations, each one designed for use in a particular application or environment — the MP100, MP200, MP300, MP400 and now the MP500.

Omnibus communications ensure the compatibility of all Omnointpoint and Multi-point units to communicate via a fast multi-drop serial data highway, as well as Omnibus products from other suppliers. Since Omnibus is Intel Bitbus compatible it is a widely supported fieldbus. Moreover, gateway into the manufacturing automation protocol (MAP), direct from the host PC or via a standard interface on the instrumentation computer board, enable the Omnibus range to communicate through standard protocols in both process and manufacturing industry.

The need to combine the skills of software and process experts has formed the basis of an on-going collaboration between Biotechnology Computer Systems (BCS) and the Department of Chemical and Biochemical Engineering at University College London (UCL) in the development of a comprehensive fermentation management system. BCS is a member of the Porton International group of biotechnology companies that operate worldwide. UCL is one of the British Government’s Science and Engineering Research Council (SERC) designated centres for biotechnology. Some 50 staff and researchers are involved and there is collaborative work with some 14 other organizations besides academic institutions and other departments in UCL on various aspects of control.

Digital controllers

The first two products are the software packages BIO-i and BIO-pc. BIO-i is a powerful fermentation process management system. BIO-pc is a single user bioprocess management system for up to four reactors with associated on-line equipment.

The design objectives for BIO-i were to produce a single fermentation management system that would satisfy the differing needs of the fermentation plant process engineer and worker, and the research scientist. So BIO-i has been configured as a supervisory system in which distributed digital controllers associated with each fermenter are linked to the process computer. Designed for use with the Digital Systems Equipment range of computers, the package employs well proven programming languages and real time process plant databases. Mass spectrometer data is used in the monitoring of off-gases. The distributed nature of the system and the ease with which it can be configured means that new fermenters, sensors and analytical equipment are simply incorporated when they become available.

Fresh results of the collaborative programme, such as the current work on adaptive control, can be added to the package. This has been thoroughly tested on the sophisticated range of fermenters and reactors in the UCL pilot plant.

BIO-pc is configured on an IBM-AT or compatible computer, with monitors and other peripherals, and uses the standard MS-DOS 3.1 software package operating system. Its software elements include a complete professional Smart applications package, a feature of which is a spreadsheet with graphics that can be used while the computer is data monitoring and logging the plant.

Short payback time

Kent Process Control Systems has developed integrated configurations of its originally centralised K90 computer process control system, the P4000-ICS. This interesting development, instead of the single or hierarchical configuration of the K90, permits a number of units to be linked via the peripheral highway into one integrated system.

Each peripheral highway, of which there may be more than one per system, has a maximum of eight units, up to four of which may be operator control panels and the rest control processors. The arrangement allows a system to handle different sized process control applications, besides offering a low cost entry to ICS systems. The first two ICS systems have already been supplied to a pharmaceutical company and a major steel producer.

Kent has also introduced an expert system, based on LISP and using a Picom shell, as an option with the P4000 distributed control system. The expert system is designed to simplify interpretation of the volume of data from the process variables being monitored on a medium-to-large system. The volume of incoming data is particularly high during plant changes such as start-up and shut-down procedures.

Several companies are examining the application of expert systems to process control. The first publicised success in the United Kingdom has been LINKman. The Blue Circle cement company, in conjunction with SIRA, formerly the Scientific Instrument Research Association, set it up on a KPCS P4000 distributed control system. LINKman succeeded where attempts at more conventional computer process control failed. SIRA has made an agreement with Blue Circle to market the system to other cement producers. Blue Circle has also ordered five complete systems and is anticipating a payback time of six to nine months. This quick return is largely due to energy savings.

Higher level information

In 1984, the Alvey Commission set up a number of expert system demonstration clubs in various industrial sectors. The first of these was in control instrumentation — the Real Time Expert Systems Club of Users (RESTCU). The study of an expert system as an adviser on quality control at an ICI company ethoxylates plant for batch production of detergents.
The direct interface system on a microcontroller is, in principle, very similar to that on a microprocessor. In fact, there are slight differences between the individual processor manufacturers, but the applications, i.e. connection of dynamic RAMs, demultiplexing of processor buses or mailbox functions, appear to be very similar. That is why all semiconductor manufacturers offer a range of standard chips which can be connected directly to their own processors. However, there remain many more applications, where these interface modules, or even logics, i.e. latches or other TTL logics, must be added. For this, discrete logics in the 74xxx series are often relied upon. PLAs and EPLDs (erasable programmable logic devices) are also frequently used.

It is now possible to integrate a circuit interface and the interface to the controller or processor in a single EPLD. The density of this module of up to 1800 gate equivalents is therefore quite sufficient. However, thanks to the very simple and regular structure of the bus interface, many of these gates remain unused on the chip. This essentially has two disadvantages. Firstly, the chip could be even cheaper if the superfluous gates were totally dispensed with. Secondly, EPLDs and PLAs with large numbers of gates are slower, since the internal capacities are greater and the signal propagation speeds are slower. In some circumstances therefore it is necessary to rely on several small modules.

The new member of the EPLD family from Intel, the 5CBIC (bus interface controller), fills this gap perfectly. As the name implies, this chip offers a highly integrated solution for all designs which contain bus transfer lines or generate control signals. Even the driver, which in some cases still has to be provided in a bus interface, can more often than not be dispensed with when the 5CBIC is implemented. The maximum current on the bus side can be 32 mA. The 5CBIC thus offers all the advantages of high integration such as low space requirement, low current requirement, low system and manufacturing costs, and so on.

Figure 1 shows the basic 5CBIC design. The 8-bit wide A port on the bus management unit, BMU, lies directly on the processor or controller bus. On the "user side" there are two further 8-bit ports, B and C. As will be seen later, these three buses are bidirectional and can be combined randomly, even dynamically, with each other. The second largest block is the programmable logic unit, PLU, which contains an 8 macrocell EPLD unit. The PLU has 8 dedicated inputs and 8 bidirectional pins. Both blocks can be supported via the control unit.

**Bus Management Unit**

The bus management unit links ports A, B and C together and controls and monitors the data flow over their lines. At the same time, the user can choose whether the data flowing into these ports is to be latched or not. For this a latch enable signal can be generated in the PLU or supplied directly via a pin. Various EPROM cells, or dynamically modifiable signals generated by the PLU, control the data flow. Each port can also be connected with any other. Depending on the requirements or the subsequent hardware, the signal can be given out on one of the outputs inverted or directly. Three signals generated in the

telecom.india may 15 5.25
PLU can be sent by the output buffer to the ports in the high resistance state, in order that data may then be received there. A multiplexer can make the signals from a port, latched or not, available to the PLU AND/OR array. The connections between the three ports on the BMU itself, are programmed via EPROM cells (Figure 2).

and C. The driver current of 32 mA per pin should be sufficient for most applications. The working frequency of the external logic can be up to 12.5 MHz. Internally, the 5CBIC can work with up to 20 MHz. The PLU can now "observe" the data or address flow and chipelects, generate other control signals or simulate an additional parallel port.

Programmable Logic Unit

The second large block on the 5CBIC chip is the programmable logic unit, PLU. This essentially has a 5C060 EPLD superset. Eight macrocells can, with the help of EPROM cells, be adapted to the application (Figure 3). Eight dedicated input pins and 8 bidirectional pins can be connected to the macrocells. Considering that data from ports A, B or C can also be obtained via the internal feedback bus, the user has up to 24 inputs, and up to 8 outputs available per product term.

As has already been seen with the EPLDs and PLAs logic operations, sequences are firstly converted into an AND/OR structure, which is usually generated and optimized by the development system, IPLDSII (Intel Programmable Logic Development System, version 2). This structure can then be very easily implemented in the AND/OR array on the input of a macrocell as a so-
IPLDSII: expansion of the development system supports the 5CBIC

On many points the development systems of the EPLDs have been improved with the IPLDSII (Intel Programmable Logic Development System, Version II — Figure 4). The new hardware is now based on the Intel Programmer IUP-PC. Apart from EPLDs, all other EPROM-based modules, EPROM microcontrollers, etc. can also be programmed.

More important though for daily working with EPLDs are the changes in the software. So a new algorithm for optimization (Espresso Minimizer) was implemented. For large EPLDs in particular, important improvements were made in the design density. The fitter, and thus the program part, which assigns a design for optimization of the macrocells in the selected EPLD, has also been improved.

Working with the IPLDSII has also been simplified considerably and made more comfortable. Although previously it was possible to use modular design methods and link together several source files, now it is possible to go even further back to the design macros. The macro-library comprises three blocks:

- TTL macro-library
- Intel Gate Array Library
- User-defined library

The TTL library comprises a collection of the most-used modules in the 74 series. The user enters the modules with the corresponding connections to the remainder of the logic. The macro-expander then converts this information into EPLD primitives which are reunited.

called sum of products. Each macrocell always has available the 8 dedicated input signals, the 8 macrocell feedback loops, the 8 signals on the bidirectional pins, and the signals on one of the BMU ports. Since all signals are dealt with directly and inverted on the AND/OR array, any combination can be programmed by setting the corresponding EPROM cells. As opposed to the 5C060, each input signal can be individually latched. The only exception are the 8 bits which come from the BMU. These may only be latched together, or not at all. The latch enable signal for each input latch can either be generated individually with the help of a product term or by a common control signal.

Behind the OR gate, which can comprise eight product terms, there is an inverter whose optimum algorithm (Espresso Minimizer) makes life a little easier, since it allows DeMorgan's theorem to be reproduced in the hardware. The consequent I/O section of the macrocell is therefore very like that of the 5C060 (Figure 3). Combinatorial or register logics can be created here. With register logics there is a choice of four registers. Depending on what is most suitable for the application, either a D-, toggle, JK- or RS-flipflop is used. Whereas when using a D- or toggle-flipflop all eight product terms are connected to one input, with the RS- and JK-flipflops the product terms are shared arbitrarily between both inputs. Each register in the I/O part of a macrocell has a set and a clear input which are controlled via one of its own macrocells. The clock signal, the latch-enable and the output-enable signals can be individually selected for control between either the control bus (synchronous) or a product term (asynchronous). This also gives greater flexibility in comparison with the macrocells of, for example, the 5C060.

The output of a macrocell can be fed back into the AND/OR array via either the control- or feedback bus. This signal is picked off before the tristate buffer in the cell's output. Behind the buffer, and thus physically linked with the I/O pin, there is a second pick-off. If, therefore, the variable generated by the macrocell is only needed internally, it can be further used as input if the buffer has to be switched to high resistance. Using this dual feedback option, it is very simple to generate the so-called buried registers. The development system keeps these functions transparent for the user.

Fig. 5. With the aid of the IPLDSII, the 5CBIC bus management unit can be configured very easily.
in the minimizer. The expander also recognizes if a chip is not being fully utilized and erases the remaining gates. So, for example, if with the 7400 only 2 of the 4 gates are used, only 2 will be implemented in the EPLD.

Sometimes it is possible to use EPLDs as prototypes or backups for a gate array design. In order to make this as simple as possible, Intel has grouped the gate-array macros in a further library, which can be implemented in an EPLD.

Of great interest, of course, is the possibility, with the help of a few utilities, for the user to create a library himself, the elements of which can also be made up of those of the other two, i.e., the TTL library.

As with the old version of the IPLDS, the schematic diagram can now be input and advantage taken of the SCHEMA software, i.e., by plotting on simple EPSON printers or HP LASERJET, and even on plotters working with larger than A4 format. The circuit, which may, of course, contain TTL symbols, is converted into an advanced design file, which then serves as input to the IPLDS compiler. The design is minimized and then fitted into the EPLD selected. In addition to the plot files, the same output files are generated for documentation as when the logic builder is used. In addition SCHEMA II offers a range of other aids. Thus, it is possible for the user to automatically create parts lists, carry out a design rule check, check routing, and print out various data formats, pinlists, netlists, and so on.

Fig. 6. Two 5CBICs in a 16-bit, twin-processor system carry out the control of the dual-ported RAM.

Fig. 7. Photograph of the experimental set-up of Fig. 1.
16 Bit dual port memory

A popular way of making computers faster is to have several processors working in parallel on a single task. Here, the processors must time to time exchange data for synchronization and management from shared memories. This exchange takes place more often than not via a dual-ported RAM. The logic, which is necessary for managing such a RAM, can now very easily be created with the help of two EPLDs of the 5CBIC type (Figure 6). Here, two 16-bit processors are accepted which can access a joint memory bank. Each 5CBIC can work with an 8-bit width. Two are therefore required. The first module manages the upper 8 bits of the databus. It also takes care of arbitration. The second manages the lower 8 bits. In the PLU, a 8-bit counter is implemented which is required in other parts of the application. Further information is available from Intel in the form of applications leaflets.

Eckart Baum is with Intel, Munich.

TEST & MEASURING EQUIPMENT

Part 1: dual-trace oscilloscopes (E)

The final article in Julian Nolan's review of dual trace oscilloscopes deals with the Hung Chang OS-635.

The Korean company of Hung Chang is, perhaps, better known for its range of DMMs, frequency sources, and counters, some of which are sold under a variety of retail trade names. The Hung Chang OS-635 is a 35 MHz delayed sweep oscilloscope with a 6 kV CRT retailing at £399 (excl. VAT), which is only about £80 more than one would expect to pay for a 'basic' 20 MHz model.

The delayed sweep is of the 'coarse' variety; the instrument is also fitted with trigger hold-off and single sweep modes. The OS-635 is fitted with a standard IEC mains socket. The line voltage is externally adjustable to 100, 120, 220, or 240 VAC.

The instrument is not fitted with a swivel stand, but the single position stand provided instead allows easy stacking of the unit.

The OS-635 is of average depth and width: 352 mm and 294 mm respectively, but its height of 162 mm is perhaps rather more than might be expected. Two high-quality probes (1.4 ns rise time when in 10:1 attenuation mode) are supplied as are accessories for use with them, including a BNC adaptor and spring-loaded clip.

Front panel. The front panel is probably one of the OS-635's most distinguishing features, with colour-coded sections such as triggering and Y-amplifier functions. Although the colour coding adds to the ease of operation, the panel is not, as common, anodised, but the markings have been printed on. This, together with the exposed potentiometer bushes of some controls, gives the instrument a rather rough and ready appearance. However, this certainly does not mean that it is of low quality.

Y-amplifiers. The attenuation coefficient of both Y-amplifiers is variable over a range of 10 V/div to 5 mV/div. In addition to this, a ×5 magnification facility is also available, enabling maximum sensitivities of 1 mV/div to be achieved.

Undoubtedly, one of the main features of the OS-635 is its 35 MHz bandwidth. This is maintained down to 5 mV (-3 dB). The 1 mV/div sensitivity brings with it the restriction of a 10 MHz bandwidth (rise time 35 ns).

Both Y-amplifiers have a continuously variable attenuation control, which increases the maximum attenuation coefficient to 30 V/div. Only one channel can be inverted.

The performance of the Y-amplifiers is reasonable in terms of frequency response and bandwidth, given their relatively high frequency range. But, despite these mediocre characteristics, they are still undoubtedly better than the average 20 MHz Y-amplifier at this price level.
Table 17.

**ELECTRICAL CHARACTERISTICS**
- Line voltage: 100, 120, 220, 240 VAC ± 10%, externally adjustable.
- Power consumption: 30 Watts
- Line frequency: 50-60 Hz

**MECHANICAL CONSTRUCTION**
- Dimensions: W 284 mm, H 162 mm, D 352 mm
- Housing steel sheet
- Weight: approx. 7.5 kg

**Y AMPLIFIER ETC.**
- Operating modes:
  - CH1 alone, CH2 alone.
  - Inversion capability on CH2 only.
  - Any combination of CH1, CH2 (alternate or chopped 250 kHz)
- CH1 + CH2
  - Frequency response: 0.35 MHz (3 dB)
  - Rise time < 10 nscc, (35 nscc × 5 Mag.)
  - Deflection factor: 10 steps: 5 V/div - 9.5 V/div ± 3%
  - 5 magnifier extends range to 1 mV/div, MHz bandwidth.
  - Input coupling: AC, DC or Gnd.
  - Input impedance: 1 MΩ/26 pF; max input voltage 300 (DC + peak AC)

**X-Y MODE**
- CH1 X-axis and CH2 Y-axis. Less than 3° phase shift at 60 kHz
- Bandwidth DC to 1 MHz (1-3 dB).

**SWEEP**
- Operating modes: normal, timebase A displayed (no delay), intensified, timebase A intensified by trigger delay over magnification area, delayed: A sweep starts after delay time.
- A sweep time 100 ns/div to 0.6 s/div ± 3% in 21 ranges, 1-2-5 sequence.
- Verron control slows sweep down by up to 2.5:1.
- Delay time: 10 ms to 1 μs in 5 steps, 1:10 sequence; variable control for fine adjustment.
- Sweep magnification: ×5 ± 10% total error.
- Hold off: variable up to 10:1.
- Delay modes: continuous delay.
- Delay jitter: 1/5000.
- Single sweep facility.

**TRIGGERING**
- Trigger modes: auto and normal.
- Trigger coupling: AC; DC; HF reject; LF reject; TV frame and line (auto).
- Trigger sources: CH1, CH2; alternate; line; ext.; ext/10.
- Triggering sensitivity: internal: 1 div at 35 MHz; external: 0.2 Vp at 35 MHz.

**MISCELLANEOUS**
- CRT: measuring area 80 x 100 mm; accelerating voltage 6 kV; metal backed, PDA.
- Compensation signal for divider probe: amplitude approx. 0.5 Vpp ± 3%; frequency 1 kHz.
- Z modulation sensitivity: 3 V (complete blanking).
- Warranty: 1 year.

Despite being specified at 3%, overshoot is particularly evident on some ranges, although it remains within the quoted limit.

The dynamic range is somewhat limited at about 4½ divisions at 35 MHz, but should, none the less, be acceptable for most purposes.

A minor point is that the ×5 magnifier has the effect of magnifying the trace offset, which is set by the Y position control, with the result that some repositioning of the trace is required when the ×5 magnifier is actuated.

Since the ×5 switches are incorporated in the Y position controls, it happens that when these controls are accidentally turned when they are pulled out to actuate the ×5 magnifier, the trace shifts. If this has already been centred, an unnecessary adjustment is required to re-centre it.

Chopped (200 kHz) or alternate sweep is selected automatically by the time base speed setting.

**Triggering**
- Triggering on the OS-635 is comprehensive, including LF and HF filtering, alternate channel sourcing and TV synchronization. In addition to this, unusually for a scope in this price range, an external ±10 facility is also provided.
- The auto/normal and triggering threshold controls are combined into one in a similar manner to the ×5 attenuation coefficient magnifier. Here, the problems brought about by this are not so acute, but still noticeable; the auto position is selected with the level control fully on. All other triggering controls (of the slider type) are, however, relatively easy to operate.
- TV triggering is particularly notable, being selectable from positive or negative synchronization and, with the inclusion of automatic line and frame switching, incorporated into the timebase coefficient selector. Triggering sensitivity is also good: typically 0.2 div to 10 MHz, increasing to 1 div at 35 MHz and 3 div at 60 MHz, which is the maximum reliable trigger frequency. External triggering sensitivity is also good at 100 mV to 10 MHz and 0.2 V to 35 MHz. This can, however, be increased by means of the ±10 control to eliminate false triggering, caused, for example, by noise. An alternate channel, or composite mode, is also incorporated for observation of two unrelated (in terms of frequency) signal sources. Triggering symmetry (rising or falling slope) proved to be out by approximately 1 division over a total vertical deflection of 8 divisions. The HF and LF facilities provided were effective in obtaining a stable trace even in cases of waveforms with a very high modulation content, and are a further useful addition to the OS-625's trigger functions. Both trigger and 'ready' LEDs are also incorporated, lighting when the scope is stably triggered or reset respectively. Trigger holdoff is also a feature of the OS-635, which makes the triggering facilities provided by this scope amongst the best in its class.

**Timebase**
- The OS-635 is equipped with a single timebase and an uncalibrated vernier delay time control. This has the consequence that in the vast majority of situations only uncalibrated delayed sweep measurements can be made of waveforms which exceed the maximum horizontal deflection limit of 10 divisions. In most cases this limitation does not affect the measurement of waveform rise times.

The main timebase itself ranges from a 0.5 s/div to 100 ns/div, although, obviously, to limit the cost of the deflection circuitry, only a ×5 horizontal magnification system has been incorporated, increasing the maximum deflection speed to 20 ns/div. The trigger delay time coefficient can be selected from one of 5 (the front panel is marked for 6) covering the range from 1 sec to 100 msec in a 1:1 sequence. This departure from the standard 1-2-5 sequence is false economy since, although it reduces the number of switch positions to 5 instead of 15, highly accurate adjustment of the vernier control is required at higher magnification levels. It also has the effect of reducing the ease of use of the delayed sweep facility significantly in my opinion, largely due to the accurate vernier adjustments which have to be made. Rise time measurements would have been greatly helped by the provision of a triggered delay facility in addition to the normal continuous mode, as well as a delay line. Looking at the situation in perspective, however; these facilities can hardly be expected for £399, but effective operation of the delayed sweep facility without them may in many applications prove extremely difficult. The delayed sweep display modes of normal, intensified or delayed should be adequate for most purposes.

Timebase accuracy is inside the specified ±3% (and the rather high ±10% when using the ×5 magnifier). Linearity is also within the quoted ±3% over most of the range. Although it is noticeable at the start of the trace over the first 1½ small divisions on the maximum timebase speed that the deflection characteristics were, to say the least, non-linear.

**CRT**
- The 6 kV CRT enables both good intensity and brightness to be maintained over the whole range of sweep speeds. The CRT itself is of the metal backed PDA variety and gives a good performance, especially in terms of focusing, which is certainly of a high standard. The tube is slightly curved across its face, however, and while this is
not to a great degree, and should not affect measurements, it is still worth noting. Tube geometry is reasonable, with some barrelling and pincushioning present. The tube's good performance is hindered by the lack of an automatic focusing circuit, with the consequence that any major alterations in tube brightness can cause considerable defocusing of the trace, making some form of focus adjustment essential for accurate measurements.

Construction. Construction of the OS-635 is poor. While mostly not of low quality, the OS-635 is in places poorly finished, with a number of sharp edges evident on the enclosure both internally and externally. Internally, masking tape and small pieces of dowelling are used to separate some of the wire interconnections, which, while perhaps not impairing the reliability of the instrument, are really unacceptable in a modern instrument.

External construction is based on a steel chassis, with two sheet steel panels enclosing the top, sides and underneath of the scope. These appear to have had little done to them in terms of machining since being originally pressed and folded since they still contain one or two sharp edges. The front panel surround is constructed from four separate pieces of aluminium with the consequence that they are joined at each corner.

Internal construction is of a higher standard, with the high voltage and EHT supplies enclosed, and the Y-amplifiers partially screened. The scope is based around four PCBs, connections from which are all made by connectors for easier servicing and while this leads to a large number of interconnections, it should not affect reliability. As well as being used to separate some of the interconnections, masking tape is also used around the CRT.

Overall construction both internally and externally appeared to be average in its class, and whether this will affect the reliability remains to be seen. The quality of components used is generally good and this may be worth taking into account.

Manual. The 30 page manual includes a full circuit and PCB layout diagrams. A full circuit description and initial set up information is also given, along with calibration and preventative maintenance sections.

Conclusion. Looking at the specification alone, the OS-635 appears to represent an extremely good price/performance ratio, with a 35 MHz (-3 dB) bandwidth, 6 kV PDA tube and delayed sweep facility. In reality, some of these facilities are limited in their performance, which is especially true of the delayed sweep facility, which in some situations offers little more than can be achieved with a scope that possesses a good trigger performance. Having said this, both the triggering performance and facilities offered by the OS-635 are good for a scope in its class and should not be ignored. An automatic focusing circuit is not fitted, which is unfortunate since the 6 kV PDA is capable of producing a trace of both excellent intensity and sharpness, but to maintain this without the provision of an automatic focusing circuit requires an adjustment in the focusing potential for a significant change in trace intensity. Both the internal and external construction have the appearance of a preproduction prototype rather than a production model, but despite this there is not apparent reason why the OS-635 should not be reasonably rugged in a variety of environments. To sum up, for its specification the Hung Chang represents a very good price/performance ratio, its particular strengths lying in its 6 kV CRT and 35 MHz bandwidth.

The OS-635 may well be worth considering for a large number of applications where a bandwidth of 35 MHz and high brightness tube are required on a limited budget, or as a cost effective alternative to a 20 MHz scope.

Other oscilloscopes available in the Hung Chong range.

OS-618S — dual trace 15 MHz portable; rechargeable battery operated; weight 4.5 kg; sensitivity 2 mV; maximum deflection speed 100 ns/div; 1.5 kV CRT; up to 2 hours operation from fully charged batteries; £399 excl. VAT.

OS-620 — dual trace 20 MHz; sensitivity 5 mV; maximum deflection speed 40 ns/div; 2 kV CRT; component tester; power consumption 19 W; £295 excl. VAT.

OS-650 — dual trace 50 MHz; sensitivity 1 mV; maximum deflection speed 40 ns/div; 17 kV CRT; delayed sweep 100 ms to 1 µs; £579 excl. VAT.

Table 18.

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<th>Satisfactory</th>
<th>Good</th>
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A high-quality stereo sound effects board for the Universal I/O bus, based on Valvo's Type SAA1099 advanced single-chip complex waveform generator. Applications include enriching computer games and operation as a programmable test generator for simulation of composite AF waveforms.

Six amplitude controllers can be programmed separately for each tone generator by writing a 3-bit number in registers 10h, 11h and 12h. The frequency range covered within each octave is given in Table 2. The frequency produced, \( f_n \), is determined by the contents of registers 08h to 0Dh incl., and can be calculated from

\[
f_n = \frac{8 \times 10^6}{2^{17} \times \{0 + (F_n - 255)\}} \quad [\text{Hz}]
\]

(consult Table 2 for \( O_n \) and \( F_n \)). The contents of registers 14h and 15h determine which signals are passed by the six on-chip mixers. There are four possibilities: (1) all signals are blocked; (2) only the tone is passed; (3) only noise is passed; (4) both the tone and noise are passed. The noise generator clock rate—hence the noise colour—is individually programmable on the left and right channel by writing the appropriate data to register 16h.

Digital sound

The block diagram of the Type SAA1099 programmable sound generator chip from Valvo (Philips/Mullard) is shown in Fig. 1. The interfacing logic is shown to the left and at the top of the drawing. To the computer, the chip appears as a WOM (write only memory). Reading of the chip status is, however, possible if the processor writes copies of the commands and data into a RAM table for retrieval at a later stage. Input line A0 of the sound generator chip is made high for loading register address bytes, and logic low for databytes. The interface logic on board the SAA1099 latches the register address, obviating the need to repeat this when writing new data to the last selected register. The process of sound generation in the SAA1099 is completely digital, and based on pulse-width modulation.

Table 1 gives an overview of the function assigned to each bit in a particular register. The required octave is pro-
The letters in brackets to the right of the envelope waveforms in Fig. 2 refer to the bit combinations in Table 2 (E0-E1; bit 1, 2, 3).

When the envelope mode is selected for a channel, the amplitude of the associated amplitude-controller is rounded down to the nearest even value (the LS bit is considered low). If, for example, the volume was set to value 1, it is rounded down to 0. An envelope generator can also function as a tone generator. If the controlled frequency channel is inactive (tone & noise generator turned off), the programmed envelope waveform will appear at the output. In this way, the sound generator board can function as a programmable waveform generator with a maximum output frequency of about 1 kHz. Faster envelope waveforms can be achieved by reducing the resolution of the envelope from 4 to 3 bits (bit 5 of byte E0 or E1). The speed of the envelope is determined by frequency generator 1 (or 4), or by the computer repeatedly writing to the address latch, clocking the envelope generator with the WRITE signal (WS). The period of the envelope, \( t_e \), is calculated from

\[
t_e = \frac{8}{f_{\text{clock}}}
\]

in the 4-bit mode, or

\[
t_e = \frac{4}{f_{\text{clock}}}
\]

in the 3-bit mode.

Bit SE (sound enable) can be used for turning the sound generator on and off. The programming of sounds is largely a matter of trial and error establishing of the required bit patterns, writing data to the chip, listening to the resultant sound, debugging the data and register selections, and making the required modifications.

**Circuit description and construction**

The sound generator board is composed of relatively few parts—see the circuit diagram of Fig. 3. The WR signal for the SAA1099 is made by combining R/W and \( \Phi_2 \) in gates N₁ and N₂. The crystal-controlled oscillator built around T₁ and T₂ provides the 8 MHz clock signal for the sound generator chip. The pulse-width modulated output signals of the SAA1099 are converted to analogue in R-C filters composed of \( R_1 \ldots R_4 \) and \( C_1 \ldots C_5 \) incl. Integrated stereo output power amplifier IC₁ can provide about 2x200 mW to the loudspeakers.

Construction of the board is straightforward, and requires no further detailing. Supply power for the sound generator board may be obtained from the computer. Due attention should be paid to adequate decoupling, however: in some cases, interference on the supply lines from the computer will necessitate feeding the board from a separate, regulated, 5 V supply (cut off pins 1 and 2 at the board side of edge connector K₁).

**Control software**

Control programs for the sound generator board should be written with ease of register operations in mind. A simple, yet effective, way of achieving access to the registers and their contents is to...
This array is set up to enable the computer to keep track of the data written to the registers in the interface. Next, all registers in the SAA1099, and array "register", are reset to nought in a FOR-NEXT loop. The program then enters an infinite loop for fetching register selection codes and data from the keyboard, and transferring these to the SAA1099 via the Universal I/O bus. First, the register contents are displayed on screen, so that the status of all registers is known at any time. Consecutive INPUT statements then prompt the user to enter the register address, and associated data. The program then updates the contents of array "register", and, of course, that of the addressed register. It then returns to the loop entry point.

Finally, here are two examples of sounds that can be generated by the sound effects board:

Steam locomotive: set AR2 and AL2 to an arbitrary value greater than 1. Set NE1=1; N0=8; E0=4. Bits and bytes not mentioned are set to nought, except, of course, the sound enable bit.

Bell: set the volume as required (AR2 and AL2). Set F2=FFH, O2=7; FE1=1; FF2=1; E0=4 and SE=1. Bits and bytes not mentioned are set to nought. St

Reference:

<table>
<thead>
<tr>
<th><strong>REGISTR DESCRIPTION</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>ARx, ALx</td>
<td>4 bits for amplitude control of generator x, left and right channel.</td>
</tr>
<tr>
<td>Fx</td>
<td>8 bits for frequency control of generator x in designated octave.</td>
</tr>
<tr>
<td>Ox</td>
<td>3 bits for octave control of generator x.</td>
</tr>
<tr>
<td>000 lowest octave</td>
<td>30...60 Hz</td>
</tr>
<tr>
<td>001</td>
<td>60...122 Hz</td>
</tr>
<tr>
<td>010</td>
<td>122...244 Hz</td>
</tr>
<tr>
<td>011</td>
<td>244...488 Hz</td>
</tr>
<tr>
<td>100</td>
<td>489...977 Hz</td>
</tr>
<tr>
<td>101</td>
<td>978...1950 Hz</td>
</tr>
<tr>
<td>110</td>
<td>1.95...3.90 kHz</td>
</tr>
<tr>
<td>111 highest octave</td>
<td>3.91...7.81 kHz</td>
</tr>
<tr>
<td>FEx</td>
<td>1 bit FEx = 0 indicates that generator x is off.</td>
</tr>
<tr>
<td></td>
<td>FEx = 1 indicates that generator x is on.</td>
</tr>
<tr>
<td>NEx</td>
<td>1 bit NEx = 0 indicates that mixer x does not add noise.</td>
</tr>
<tr>
<td></td>
<td>NEx = 1 indicates that mixer x adds noise.</td>
</tr>
<tr>
<td>N1, N2</td>
<td>2 bits for noise generator control. These bits select the clock rate of the noise generator.</td>
</tr>
<tr>
<td>00</td>
<td>31.3 kHz</td>
</tr>
<tr>
<td>01</td>
<td>15.6 kHz</td>
</tr>
<tr>
<td>10</td>
<td>7.6 kHz</td>
</tr>
<tr>
<td>11</td>
<td>51 Hz to 15.6 kHz (frequency generator 0/3)</td>
</tr>
<tr>
<td>E0, E1</td>
<td>7 bits for envelope control.</td>
</tr>
<tr>
<td>bit 0</td>
<td>0 = left and right component have the same envelope.</td>
</tr>
<tr>
<td>bit 1</td>
<td>1 = right component has inverse envelope of that applied to left component.</td>
</tr>
<tr>
<td>bit 2</td>
<td>0 = zero amplitude (e)</td>
</tr>
<tr>
<td>bit 3</td>
<td>001 maximum amplitude (b)</td>
</tr>
<tr>
<td>bit 4</td>
<td>010 single decay (c)</td>
</tr>
<tr>
<td>bit 5</td>
<td>011 repetitive decay (d)</td>
</tr>
<tr>
<td>bit 6</td>
<td>100 single triangular (e)</td>
</tr>
<tr>
<td>bit 7</td>
<td>101 repetitive decay (f)</td>
</tr>
<tr>
<td></td>
<td>110 single attack (g)</td>
</tr>
<tr>
<td></td>
<td>111 repetitive attack (h)</td>
</tr>
<tr>
<td></td>
<td>waveforms are illustrated in Fig. 2.</td>
</tr>
<tr>
<td>SE</td>
<td>0 = all channels disabled.</td>
</tr>
<tr>
<td></td>
<td>1 = all channels enabled.</td>
</tr>
</tbody>
</table>

**Parts list**

**Resistors (± 5%):**
- R1 = 10K
- R2 = Rs incl., Rs = 1K
- Re, R7, R10 = 4.7K
- Ra = 10K

**Capacitors:**
- C1, C4, C7, C8 = 100n
- C6 = 10n
- C2, C6, C11 = 100µ; 6 V
- C5, C13 = 1µ
- C12, C14 = 470µ; 6 V
- C13 = 150µ
- C17 = 470µ
- C19 = 33p

**Semiconductors:**
- T1: T2 = 8P454 (Cricklewood Electronics)
- IC1 = SAA1099 (CSI Electronics)
- IC2 = U24328 (AEK Telefunken; Cirkit)
- IC3 = 74HC00

**Miscellaneous:**
- X1 = quartz crystal 5 MHz
- K = 21-way right-angled plug to DIN41617, list no. 471-418. Electromall 0536
- L204566
- LS1, LS2 = miniature loudspeakers 8 Ω
- 250 mW
- PCB Type 67142

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Fig. 4. Printed circuit board for building the stereo sound generator.
Before proceeding with a discussion of the parametric equaliser it is perhaps a good idea to discuss why it is superior to the more common 'graphic' equaliser. A 'graphic' equaliser such as the Elektor Equaliser consists of a number of band selective filters with fixed centre frequencies spaced at equal intervals on a logarithmic frequency scale, usually at octave intervals, though more expensive units may boast third-octave filters. Each of these filters is equipped with a gain control so that it can apply boost or cut to the band of frequencies over which it is active. The term 'graphic' arose from the common use of slider potentiometers in such equalisers whose slider position is erroneously supposed by some to represent the frequency response of the system. However, the term 'graphic' will be used to distinguish between this type of equaliser and the parametric equaliser.

The only variables in a graphic equaliser are the gains of the individual filter sections, since the centre frequency and Q (which determines the bandwidth) of each filter are fixed. A parametric equaliser has fewer filter sections than a graphic equaliser, but all the parameters of the filter are adjustable, e.g. gain, bandwidth and centre frequency. A block diagram of the Elektor parametric equaliser is shown in figure 1. This consists basically of just three parametric filter sections — band selective filters whose gains, centre frequency and Q are all adjustable. Deficiencies at the ends of the audio spectrum are catered for by a parametric Baxandall-type tone control to provide bass and treble adjustment. These controls operate in a similar manner to the parametric filter sections, but employ lowpass and highpass filters rather than band selective filters.

Figure 2 shows how the characteristics of a parametric filter section may be varied. Figure 2a shows variation of the gain, figure 2b shows adjustment of the bandwidth, while figure 2c shows adjustment of the centre frequency. Figure 3 illustrates the adjustments possible with the parametric tone controls. Figure 3a shows how variable boost and cut may be applied to the extremes of the audio spectrum, as with normal tone controls, while figure 3b illustrates the unique feature of the parametric tone controls, namely the adjustable turnover frequencies of the bass and treble controls.

Having briefly discussed the differences between parametric and graphic equalisers, the advantages of a parametric equaliser can now be illustrated. In a nutshell, the purpose of an equaliser is to make the frequency response of an audio reproduction chain flat by providing gain where there are dips in the response and attenuation where there are peaks. Figure 4a shows the response of a typical reproduction chain, as might be measured using an audio analyser. This has a number of obvious deficiencies. The 'grass' on the trace is due to a large number of sharp (high Q) resonances, which can be as much as 20 dB deep. Fortunately these peaks and troughs are inaudible due to their very sharpness, since they each occupy a bandwidth of only a few Hz. This is perhaps just as well, since it would be impossible to cancel out each of these resonances.

If this 'grass' is ignored then the response becomes something like that shown in figure 4b, in which the major deviations from a flat response are more readily apparent. It is evident that the response falls off sharply below 50 Hz and above 10 kHz, that a large peak exists at about 750 Hz and a trough at about 6 kHz.

In addition there is a slight 'ripple' in the response due to a number of peaks and troughs a few dB deep. If one accepts the fact that deviations of a few dB can be ignored (and that in any case they will be very difficult to eliminate) then the response curve can be simplified to that of figure 4c, which shows only the principal deviations from a flat response. These are the deficiencies that must be removed by an equaliser.

**Parametric or Graphic?**

It is fairly obvious that to remove a peak or trough from the frequency response the correction applied must be the exact inverse of the deficiency, i.e. the boost or cut applied must be the same as the depth of the trough.
Figure 1. Block diagram of a parametric equaliser, which comprises three filter sections with variable gain, bandwidth and centre frequency, and tone controls with variable gain and turnover frequency.

Figure 2.(a). Illustrating the effect of varying the gain of a filter section.

(b). Showing the effect of varying the Q of a filter section.

(c). The effect of varying the centre frequency of a filter section.
or height of the peak, it must be applied at exactly the right frequency, and the Q of the correction network must be the same as that of the peak or trough. It is apparent that these criteria can hardly ever be fulfilled by a graphic equaliser. Firstly, it is unlikely that the centre frequency of a peak or trough would coincide with the centre frequency of one of the equaliser filters. Secondly, since a graphic equaliser has filters with a fixed Q the shape of the filter response cannot be tailored to fit the curve of the peak or trough. In fact the only parameter that can be varied in a graphic equaliser is the degree of boost or cut. With a parametric equaliser on the other hand, the gain, centre frequency and Q of a filter section may be varied so that it is almost an exact fit for the peak or trough which it is to eliminate. At the extremes of the spectrum Baxandall tone controls with variable gain and turnover frequency can be used to compensate for the 'droop' which occurs.

Like the graphic equaliser, a parametric equaliser may have any number of filter sections. The filter sections are necessarily rather more complex than those of a graphic equaliser; however, since each filter section is considerably more versatile it is possible to achieve satisfactory results with fewer filter sections, so that the cost is comparable with that of a graphic equaliser. For normal domestic use an equaliser consisting of three parametric filter sections plus Baxandall tone controls should be quite adequate.

**Complete filter circuit**

Figure 7 shows the complete circuit of a parametric filter section. The state-variable filter around A1 to A4 is immediately recognisable, as is the variable gain amplifier, IC1. The Q determining resistors and potentiometers RQ become R6, R7 and P2, whilst the centre frequency is set by P3. This arrangement differs somewhat from that shown in figure 6.

However, if \( R_{\text{int}} \) were a potentiometer connected as shown in figure 6 then it would have to have an inconveniently large value if the desired tuning range were to be covered. The arrangement of figure 7 is electrically equivalent and allows the effective value of \( R_{\text{int}} \) to be...
Figure 4. The frequency response of a typical reproduction chain, as it might be measured using an audio analyser. The ‘grass’ on the trace can be ignored, so that the response can be simplified as shown here. The few dB of ripple can also be ignored, reducing the trace to its simplest form. The remaining peaks and troughs in this simplified frequency response graph can be removed by using an equaliser.
varied from 10 k with P3 at maximum to about 2.65 M with P3 at minimum. This allows the centre frequency of the filter to be varied between about 40 Hz and 10 kHz. The Q of the filter may be varied between about 0.45 and 5 using P2, while the gain can be adjusted by P1 between ±15 dB, which should be more than adequate for room equalisation purposes.

If desired the tuning range of the filter may be varied by changing the value of Rint, using the equation of figure 6 to calculate the required maximum and minimum values. Different components may then be substituted for P3, R12, R13, R15 and R16. The minimum value of Rint (P3 at maximum) is equal to R13 (R16), whilst the maximum value of Rint (P3 at minimum) is equal to

$$\frac{P3a + R12}{R12} \times R13,$$

similarly for P3b, R15 and R16.

The Q adjustment range may also be varied by altering the values of R8, R9, R10, R11 (R) and R6/P2a, R7/P2b (= RQ), using the second equation given in figure 6. However this information is included only for the benefit of experimenters, and the average constructor is advised to stick to the component values given.

**Tone controls**

The circuit of the parametric Baxandall bass and treble controls is shown in figure 8. This employs the same principles used in the parametric filter section. However, instead of using a band selective filter network the bass control uses a lowpass network connected between two buffers A1 and A2, whilst the treble control uses a highpass
Figure 8. Circuit of the parametric tone controls. These are essentially similar to the parametric filters but use highpass and lowpass sections instead of selective filters.

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Parts list to figures 7 and 9

Resistors:
- R1 = 100 k
- R2, R4 = 18 k
- R3, R5 = 39 k
- R6, R7, R8, R13, R16 = 10 k
- R8, R9, R10, R11 = 22 k
- R12, R15 = 36 k
- R14, R17 = 12 k
- P1 = 22 k lin stereo
- P2 = 100 k log stereo
- P3 = 10 k log stereo

Capacitors:
- C1 = 1 μ MKM, MKH (poly-carbonate, polyester)
- C2, C3 = 1n5 MKM, MKH
- C4, C5, C6, C7, C8, C9 = 100 n MKM, MKH

Semiconductors:
- IC1 = LF356A or LF357A
- IC2 = 4136 (Exar, Raytheon)

1 omitted on certain boards; see text
2 replaced by a wire link on certain boards; see text.

Figure 9. Printed circuit board and component layout for a parametric filter section.
Parts list to figures 8 and 10

Resistors:
- R1 = 100 k
- R2, R4, R6, R8 = 18 k
- R3, R5, R7, R9 = 3k9
- R10, R11 = 8k2
- P1, P2 = 22 k in stereo
- P3, P4 = 47 k log

Capacitors:
- C1 = 1 μ
- C2, C3, C4, C5, C6, C7, C10, C11 = 100 n
- C8 = 56 n
- C9 = 1n5

Semiconductors:
- IC1, IC2 = LF 356A or LF 357A
- MINI DIP (National)
- IC3 = 4136 (Exar, Raytheon)

1 omitted in certain cases; see text
2 in some cases may be replaced by a wire link; see text.

Figure 10. Printed circuit board and component layout for the parametric tone controls.

Figure 11. Interconnection of three filter sections and tone controls to form a complete parametric equalizer.
network connected between A3 and A4. The breakpoints of these filters can be varied between 60 Hz and 350 Hz for the bass control using P3, and between 2 kHz and 13 kHz for the treble control using P4. The maximum gain of both controls can be varied between ±15 dB using P1 and P2.

Construction
To make the equaliser more versatile it was decided to use a modular form of construction so that as many filter sections as required could be included. This also means that the sophisticated tone control section can be used as a unit in its own right by those readers who do not want an equaliser but would like a versatile tone control system.

Each filter section is therefore built on an individual printed circuit board, the track pattern and component layout of which is given in figure 9, whilst a separate board is used for the tone controls, the layout of which is given in figure 10. The boards are so designed that, when they are stacked side by side, the output of one board aligns with the input of the next. The connection points for the potentiometers are all labelled with letters, which correspond to those printed in the circuit diagrams of figures 7 and 8.

The interconnection of three filter sections and a tone control section to form one channel of a complete equaliser is shown in figure 11. If a stereo version is required then this arrangement must, of course, be duplicated. To avoid cluttering the diagram the potentiometer connections are shown to only one filter section and the tone control section. However, connections to the other three filter sections are identical. Since the inputs and outputs of each section have the same DC potential (zero volts) the input coupling capacitor C1 and resistor R1 are required only on the board connected to the input. On every other board R1 can be omitted and C1 be replaced by a wire link. Since the zero volt rails of each board are interconnected via signal earth the '0' connection of every board except the tone control should be left unconnected, otherwise earth loops may occur. Only the '0' connection on the tone control board should be connected to the 0 V terminal of the power supply.

For the power supply the use of a pair of the commonly available IC voltage regulators is suggested. Alternatively, if the equaliser is to be incorporated into an existing system with a ±15 V supply then it may be possible to derive the supply to the equaliser from this. The choice of a suitable housing for the equaliser is left to the taste of the individual reader. One point, however, is worth noting. Adjustment of the equaliser is fairly time-consuming, but once the controls are set they should not require readjustment unless there are any changes in the reproduction chain or listening environment. It is thus a good idea to make the controls tamper-proof, for example by fitting a lockable cover plate in front of them, or by fitting spindle locks to the individual potentiometers. Alternatively, the knobs could be dispensed with altogether, the ends of the spindles slotted to accept a screwdriver and the potentiometers recessed behind holes in the front panel.
TUNEABLE PREAMPLIFIERS FOR VHF AND UHF TV

The second, final, article on remote-tuned, masthead mounted, RF preamplifiers deals with high-performance aerial boosters for the VHF and UHF TV bands. These circuits give a considerable improvement in reception compared to run-of-the-mill wideband aerial boosters. Connected to a good directional aerial, they are ideal for picking up signals that are normally noisy, or impaired by cross-modulation from strong nearby transmitters. But TV DXers need not be told...

The preamplifiers described can be built by anyone with reasonable experience constructing electronic circuits. Special care has been taken in the designs to minimize the necessary work on inductors, while alignment is straightforward, because in most cases it only entails setting a direct current. The amplifiers are built on high-quality printed circuit boards available through our Readers' Services, and are tuned and powered from the master tuning/supply unit described last month.

VHF preamplifier: circuit description

What is commonly referred to as the VHF TV band is roughly the frequency range between 45 and 68 MHz (Band 1), but also that between 175 and 225 MHz (Band 3). Band 2 is the FM radio broadcast band. It is important to note here that the above band limits are given as guidance only, because they are set differently in many countries and regions in the world. This also goes for the TV system used (PAL, SECAM, NTSC, positive/negative video, horizontal/vertical polarization, number of lines, channel assignment, frequency of the sound subcarrier, etc.). In the United Kingdom, Band 1 is currently allocated to military communications; the former TV services in that band have been transferred to UHF in 1983.

The circuit diagram of the VHF preamplifier is given in Fig. 1. Unbalanced (50...75 Ω) or balanced (200...300 Ω) cables are connected to input inductor L1a. The aerial signal is coupled inductively to the base of low-noise RF transistor T1 via L1b and C1, which is connected on a tap for impedance matching. The input inductor, L1, is tuned to the relevant TV channel by the series capacitance formed by varactors D3-D4. The voltage at the junction of these variable capacitance diodes is the voltage on the download cable minus 8.2 V. The junction capacitance of a varactor decreases with the reverse voltage on it, so that the lowest value of the downlead voltage, 9 V, causes the input inductor, L1, to resonate at the lowest frequency, i.e., the preamplifier is tuned to the lowest TV channel.

The amplifier can be set up for operation in TV Band 1 or Band 3 simply by fitting the appropriate inductor in position L1 (this will be reverted to under Construction).

Choke L3 forms a high impedance for the amplified RF signal on the downlead coax cable, and feeds the tuning/supply voltage to series regulator T1 and zener-diode D1. The function of these components is similar to IC1 and D1 in the FM-band preamplifier described last month. The forward drop across LED D1 is fairly constant, and provides the reference voltage at the base of regulator T1. Preset P1 makes it possible to set the optimum collector current for the RF amplifier transistor, T1. RF signals at the base and collector of the BFG65 are blocked from the bias voltages by chokes L2 and L4, respectively. Gain of the preamplifier is fairly constant at about 18 dB, both in Band 1 and Band 3. The noise figure was not measured, but should be of the order of 1...2 dB, i.e., considerably lower than almost any conventional wideband aerial booster.

Fig. 1. Circuit diagram of the low-noise, remote-tuned, preamplifier for VHF TV Band 1 or 3.
VHF preamplifier: construction

Commence the construction with making L1 as required for the relevant frequency range (note that this may extend beyond the indicated band limits). Do not skip the constructional hints in the following paragraphs if you intend to build the Band 1 version of the preamplifier.

Band 3 (175—225 MHz):
1. Close-wind L1b as 4 turns Ø1 mm (SWG19) enameled copper wire around a Ø6 mm plastic former. Use a miniature screwdriver to spread the turns evenly at about 1 mm. Study the position of the inductor on the board, and bend the wire ends towards the holes provided. Use a scalpel or sharp hobby knife to remove the enamelled coating on the wire ends over a length of about 3 mm. Pretin the connections, scratch off residual solder resin, and pretin once more. Check for a smooth, tinned, surface.

Fig. 2. Close-up photographs showing inductor L1 in the VHF Band 3 preamplifier. Fig. 2a: seen from the side of L1a; Fig. 2b: seen from the side of L1b (note the tap made in twisted wire).

Fig. 3. The printed circuit board for the VHF Band 1 or 3 preamplifier.

Parts list

VHF PREAMPLIFIER. CIRCUIT DIAGRAM: FIG. 1.

Resistors (±5%):
- R1 = 100K
- R2 = 100R
- R3 = 680R
- R4 = 3K3
- R6 = 22R
- R6 = 10K

P1 = 100R preset H

Capacitors:
- C1, C2 = 1n0 miniature ceramic plate; pitch: 5 mm
- C3 = 47µ; 35 V; axial

Semi-conductors:
- D1 = red LED
- D2 = zener diode 8V2; 400 mW
- D3, D4 = 8V405
- T1 = BF686
- T2 = BC100

Inductors:

Winding data and materials are stated in the text.

Miscellaneous:
- PCB Type: 880045
2. Locate the position of the tap on L1b at 1 turn from the ground connection. Carefully scratch off the enamel locally, pretin the small copper area, and connect a short length of Ø0.5 mm (SWG25) enamelled copper wire. Place the plastic former plus inductor onto the PCB, and bend the tap wire towards the relevant hole. Do not solder any connection as yet. Make sure that the tap does not create a short-circuit between the turns of L1b.

3. The input coupling inductor, L1a, is wound as 2 turns Ø0.5 mm (SWG25) enamelled copper wire, with a tap at the centre. Wind this inductor in between the turns of L1b to assure the necessary inductive coupling. Insert the wire below the turn of L1a that has the tap on it. Wind the wire upwards into the free space between the turns of L1b, until it is opposite the connections of L1b. Draw out about 4 cm of the wire, fold it back again towards the former, and wind the last turn upwards into L1a.

4. Use precision pliers to twist the 2 cm long wire pair that forms the tap on L1a. Hold the ends of the wires in the pliers, and carefully roll these in your hand until the wires cross practically at the body of the plastic former.

5. Place the former with the inductors on it onto the PCB, and wind both L1a and L1b until all six wires can be inserted in the respective holes. Scratch off the enamel coating from the tap and the ends of L1a, pretin, clean again by scratching, and ensure a smooth soldering surface. Press L1a together to lock up the turns of L1a. The final appearance of the completed inductor is shown in the photographs of Fig. 2.

Drill and file the hole that receives the plastic former. Fit the wires of L1 into the respective holes, and verify correct continuity. Do not use a core in L1.

**Band 1 (45–68 MHz):**

For the lower frequency range, L1 is wound on a Type T50-12 ferrite core (Ø12 mm) from Micrometals.

1. Wind L1a as 8 turns Ø0.5 mm (SWG25) enamelled copper wire, with a twisted centre tap created as discussed above.

2. Wind L1b as 20 turns of Ø0.5 mm (SWG25) enamelled copper wire, with a twisted tap at 4 turns from the ground connection.

3. Fit the complete inductor onto the PCB, making sure that the windings remain secure on the ferrite ring.

Chokes L2, L3 and L4 are identical for both versions of the VHF preamplifier. They are wound as 4 turns Ø0.2 mm (SWG36) enamelled copper wire through small ferrite beads (length: approx. 3 mm).

The printed circuit board for the VHF preamplifier is shown in Fig. 3 (note that the component overlay is relevant to the version for Band 1). Completion of the preamplifier should not present problems. Grounded component wires and terminals are soldered at both sides of the board. Coupling capacitors C1 and C2 are miniature, plate or disc, ceramic types with a lead spacing of 5 mm. Mount these as close as possible to the PCB surface. Conversely, mount T1 in a manner that rules out any likelihood of a short-circuit between the TO5 case (which is at collector potential) and the PCB ground surface. Finally, fit a 15 mm high brass or tin metal sheet across T1 as indicated by the dashed line on the component overlay.

**The UHF preamplifier: circuit description.**

The circuit diagram of the low-noise, remote-tuned, UHF preamplifier for masthead mounting is shown in Fig. 4.

Like the VHF booster, this amplifier is based on the Type BFG65 RF transistor from Valvo (Philips/Mullard), but in this application has tuned input and output circuits. The tuning voltage for varactor pairs D1-D2 and D3-D4 is obtained as in the FM-band and VHF preamplifiers, namely by subtracting the fixed drop across a zener diode from the voltage carried on the downlead coax connected to the master tuning/supply control. The tuning range of the amplifier covers the entire UHF TV band (470—860 MHz). The shaded rectangular blocks in the circuit diagram are straight lengths of silver-plated wire that function as inductors (L1, L2).

Balanced aerials or feeder systems with a termination impedance of 200...300 Ω are connected to L1a. This coupling inductor is omitted when the input signal is unbalanced (50...75 Ω). In this case, the centre core of the coax cable is connected direct to a matching tap close to the ground connection (cold end) of L1a. Regulator IC 1 ensures that T1 is fed with a constant supply of 8 V, while P1 is used for setting the optimum collector current (this can be read on a microampmeter connected to test points TP1 and TP2).

The UHF amplifier has a typical gain of 12 dB and, like the VHF version, achieves a noise figure that beats the vast majority of wideband aerial boosters.

**The UHF preamplifier: construction.**

The UHF TV band preamplifier is constructed on the PC board shown in Fig. 4. Circuit diagram of the preamplifier for UHF TV reception.
Fig. 5. Study the component overlay, and bend L1a (if required), L3b, and L2 to size from 0.1 mm silver plated copper wire (CuAg). Do not solder these inductors in place, however, until they run straight over the full length, and are positioned so that the top of the wire is always exactly 3 mm above the PCB surface. Fit leadless disc or rectangular decoupling capacitor C5 in the slot provided in the PCB. This (brittle) capacitor is soldered once at the track side (connection to L2), and twice at the component side (ground and, again, L3). Now position the RF transistor, T1, between the wire inductors, and solder the 2 emitter terminals direct to the ground surface. Carefully bend the collector terminal upwards, cut it to length, and solder it to the tap on L2. One terminal of coupling capacitor C3 is also connected direct to this junction, while the other terminal is secured in a PCB hole—see the photograph of Fig. 6. Bend the base terminal of T1 upwards, and carefully cut this to a length of about 2 mm. Solder a 1 nF SMD capacitor, C4, in between the tap on L1a and the base terminal. R1 is also soldered direct to the base junction. Fit a 15 mm high screen across T1 as indicated on the component overlay.

Wind choke L3 as 6 turns Ø0.2 mm (SWG25) through a small (3 mm long) ferrite core. The fitting of the remainder of the components is straightforward.

Fig. 6. Top view of the line inductors in the preamplifier for UHF TV.

and should not present problems. Be sure, however, to observe the polarity of the 3 electrolytic capacitors and the 3 diodes.

Figure 7 shows completed prototypes of the VHF and the UHF aerial boosters.

Setting up

The setting up of the preamplifiers merely entails adjusting the collector current of the RF transistor, and finding out which value of the tuning voltage corresponds to a particular TV channel.

VHF preamplifier:

Insert an ammeter between the collector of T2 and L3. Connect the power supply/tuning unit described last month, and set the output voltage to 20 V. Adjust Pi for a reading of 5 mA, then verify the presence of about +11 V on the varactor junction. Vary the tuning voltage, and verify that the collector current of T1 remains constant. The LED will light dimly.

Connect the preamplifier to the aerial and the supply/tuning unit. Also connect the TV set, and set up a tuning scale by marking the channel numbers as a function of the tuning voltage. In the case of the Band 3 preamplifier, the tuning range can be corrected by carefully compressing or stretching the turns of L3.

The collector current of T1 is optimized by tuning to a weak transmission, and setting Pi for minimum noise. This setting is typically found at collector currents between 3 and 10 mA.

UHF preamplifier:

Connect a millivolt meter to TP1 and TP2 as shown in the circuit diagram. Set Pi for a reading of 500 mV. Make notes of the tuning voltage required for a number of TV channels in the UHF

 scren

PRECEDING PAGE:

Fig. 5. Track layout and component mounting plan of the PCB for the UHF preamplifier.

Parts list

**UHF PREAMPLIFIER CIRCUIT DIAGRAM: FIG. 3.**

<table>
<thead>
<tr>
<th>Resistors (±5%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>R1 = 220 kΩ</td>
</tr>
<tr>
<td>R2 = 100 kΩ</td>
</tr>
<tr>
<td>R3 = 10 kΩ</td>
</tr>
<tr>
<td>R4 = 100 kΩ</td>
</tr>
<tr>
<td>R5 = 10 kΩ</td>
</tr>
<tr>
<td>P1 = 1 kΩ preset H</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Capacitors:</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1 = 1 nF MDF</td>
</tr>
<tr>
<td>C2 = 1 nF mini plate ceramic</td>
</tr>
<tr>
<td>C3 = 1 nF leadless ceramic (disc or rectangular)</td>
</tr>
<tr>
<td>C4 = 1 nF 16 V, axial</td>
</tr>
<tr>
<td>C5 = 1 nF 40 V, axial</td>
</tr>
<tr>
<td>C6 = 47 nF 35 V, axial</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Semiconductors:</th>
</tr>
</thead>
<tbody>
<tr>
<td>D1, D2 incl. = 82054</td>
</tr>
<tr>
<td>D3 = zenerdiode 8V2</td>
</tr>
<tr>
<td>IC1 = 76508</td>
</tr>
<tr>
<td>T1 = 9F68</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Inductors:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Winding data and materials are given in the text.</td>
</tr>
</tbody>
</table>

Miscellaneous:

| PCB Type | 880044 |

---

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band, and provide a UHF tuning scale on the master supply/tuning unit.

**General considerations**

The values stated for the operating current of T1 are given as a compromise between a low noise figure (low collector current), and high amplification in combination with good intermodulation characteristics (high collector current). The collector current may, therefore, be set to different values to suit the application in question.

As stated in last month's article, there is little point in installing the remote-tuned preamplifiers in any place other than as near as possible to the relevant aerial. This is the only way to prevent the attenuation introduced by the downlead coax cable degrading the system noise figure. The preamplifiers described have sufficient gain to bring the system noise figure down to practically the preamplifier noise figure, but only if they are properly aligned and installed.

Readers interested in TV-DXing are advised to contact the British Amateur Television Club - Mr Dave Lawton G0ANO - "Greenehurst" - Pinewood Road - High Wycombe - Bucks HP12 4DD.

**Fig. 7.** Prototypes of the VHF preamplifier (left; Band 3 version), and the UHF preamplifier (right).

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**RADIO COMMUNICATIONS FOR THE FUTURE**

by Dr. Chris Gibbins, Rutherford Appleton Laboratory

Overcrowding of the radio spectrum is severely restricting the reliability and information-carrying capacity of existing communications systems. But moving to higher frequencies, where there is more room, brings a different set of problems to do with the atmosphere and weather. Research at the UK Science and Engineering Research Council's Rutherford Appleton Laboratory is compiling valuable data for the design of systems for the future, exploiting frequency bands that are so far little used but for which the necessary technology is already available.

A massive expansion in radio communications over recent years has generated an ever-increasing demand for more channels, and those channels are having to carry more and more information, be it voice, television or other kinds of data. The net result is that the radio spectrum, a restricted resource, is fast becoming overcrowded. This creates problems of interference between adjacent channels (as anyone who listens to short-wave radio, especially at night, will know well) with reduced reliability. There is an additional side-effect of such overcrowding: the bandwidth available to each channel, which determines the amount of information that can be transmitted, is severely limited. That in itself restricts both the capacity and the reliability of communications systems.

**Millimetre waves**

A remedy for these problems is to be found in exploiting higher and higher frequencies, made possible through the development and availability of new technologies. Communications now extend well into the microwave region of the electromagnetic spectrum (frequencies up to 30 GHz) and even beyond...
with varying temperature, pressure and humidity. A great deal of research has been undertaken into this phenomenon and the effects of molecular absorption can now be predicted fairly accurately. So the designer of communications systems can take reasonably accurate account of attenuation by oxygen and water vapour when assessing the overall performance of microwave and millimetre-wave links.

**Fade margin**

Signal attenuation by rain and other forms of precipitation, however, presents a quite different problem. Precipitation is a highly variable phenomenon, changing both in time, space (that is, geographic location) and intensity. This makes it much more difficult to take account of rain attenuation in designing systems. The problem is generally treated statistically instead of by the sort of exact calculation that can be used for molecular attenuation. The systems designer specifies a level of reliability for a particular communications link, for example, the link might be required to provide acceptable voice communication for 99.9 per cent of the time, or acceptable television transmission for 95 per cent. That means the users can tolerate the service being unavailable for 0.1 per cent or 5 per cent of the time respectively. The designer then needs to know what level of signal attenuation will be exceeded on the link for these small percentages of time. This is known as the ‘fade margin’ which the link must be able to overcome when providing an acceptable signal-to-noise ratio, to achieve the specified level of reliability. This in turn, has an impact on the transmitter power, receiver sensitivity and the size of the antennas, which in the end affects the overall cost of the system. It is therefore of paramount importance that the systems designer should have available the most accurate information from which to derive the necessary fade margins, to achieve the most reliable and cost-effective design. Fade margins are not easily calculable and in general tend to be empirically derived from transmission measurements carried out over long periods. A great deal of work has already been done at frequencies up to about 40 GHz, and there are extensive data banks from which the necessary statistical information and service predictions can be derived. For example, the International Radio Consultative Committee (CCIR) at Geneva collates, distils and publishes information of this kind. At higher frequencies, however, there is a marked paucity of data.

**Foundation for systems**

To provide the necessary information on terrestrial radiowave propagation, the Rutherford Appleton Laboratory has set up an experimental transmission range at its Chilbolton Observatory near Andover, in southern England. This facility, represented schematically in the second diagram, works on a number of links transmitting over a distance of 0.5 km at frequencies of 37, 57, 97, 37 and 210 GHz in the millimetre-wavelength region of the electromagnetic spectrum and at wavelengths of 10.6 μm in the infra-red and 0.63 μm in the visible region. Frequencies of 37, 97, 137 and 210 GHz were chosen as representative of those parts of the spectrum where atmospheric attenuations due to oxygen and water vapour are low; such parts are known as atmospheric ‘windows’ and hold out the opportunity for cost-effective, widebandwidth communications. The 37 GHz channel can also provide the means for comparing the results from the 500 m range with exten-
The transmitter cabin at Chilbolton. Hoods keep rain off the windows through which the signals are transmitted. The transmitters are mounted on benches supported independently from ground, inside the four concrete pillars. This prevents vibrations in the cabin affecting the equipment. The anemometer and vane mounted on top of the cabin measure wind velocity.

Snow and fog

Of great interest is the effect that snow storms have on millimetre communications. There is shortage of such data and the few results available show wide variations. Snow is generally difficult to characterize quantitatively with regard to shape, size and wetness of the flakes. These characteristics vary widely, and when snow is carried by the wind it becomes difficult to measure effective deposit rates. However, we have developed a rapid response snow gauge which is producing very encouraging results. The effects of wind are kept as low as possible by surrounding the gauge with a fence, which reduces wind speeds close to the gauge and so improves the efficiency of capture. Using this technique, we find good correlations between attenuation and snowfall deposit rates. Results so far indicate that when snow is very dry the attenuations are low, compared with rain, for the same amount of liquid water deposited; but for wet snow, attenuations can be considerably higher. The attenuation clearly depends not only on the amount of liquid water falling, but also on the degree of wetness of the snow flakes. Considerable effort is being devoted to trying to characterize this in terms of other meteorological parameters such as air temperature, so that empirical relationships can be developed to help the prediction of attenuation.

Fogs, on the other hand, affect the millimetre links very little; the wavelengths are much greater than the size of the droplets and the scattering process, which causes the attenuation, is not significant. In general, the attenuations found at millimetre wavelengths are only a few per cent at the 500 m range. At infra-red and optical wavelengths, however, very severe attenuations, of more than 80 dB km⁻¹, often occur in the visible range in fog, representing a visibility of only about 200 m; only one million of one per cent of the signal remains at a distance of one kilometre from the transmitter.
Gas flares
The 500 m range can easily accommodate a variety of different measurements or experiments from other interested groups, especially as all the instrumentation and the data collection system are based on a universal interface standard. As an example of this, an interesting and novel investigation was carried out into millimetre-wave propagation through flames, in collaboration with one of the oil companies operating in the North Sea. The problem was what effect gas flares on the drilling platforms might have on the communications systems. A large flame was generated, about three metres wide, three metres high and half a metre deep, and the signals were transmitted through it. Little effect was observed at the lowest frequencies, though large attenuations occurred in the visible range. There was, however, a general increase in the level of scintillation of the signals, which might possibly be of concern at the very high frequencies but of little significance at the frequencies at present in use for communications systems.

The other type of analysis of results is aimed at obtaining the kind of statistical information needed for direct application to communications systems design, for example finding out what fade margins should be allowed for given levels of operational reliability. This is necessarily a long-term project, because it is important to find an average over extremes of the prevailing meteorology and it can be done reliably only over a number of years. Statistical data now being accumulated include such information as the percentages of time that various levels of attenuation are exceeded, from which fade margins can be directly derived; probability distributions of the duration of fades to yield information on the length of data ‘dropouts’; the times between fades, which tell us how often deep fades are likely to occur; and the rate of change of fading, which indicates how rapidly signals are likely to change, which is particularly important in digital radio communications systems. The propagation statistics are complemented by similar statistics of meteorological parameters, especially of rainfall rates. Direct comparison of these two sets of simultaneously obtained data then enables propagation conditions to be predicted simply from rainfall data, which is relatively easy and inexpensive to obtain and is measured routinely by weather bureaux in most countries of the world.

The 97 GHz receiver with its 15 cm diameter antenna and swan-neck waveguide feed. Its solid-state local oscillator is mounted on a heat sink on the right hand side. A battery-operated power supply biases the receiver’s Schottky-barrier mixer to its most sensitive operating region.

developing propagation models and prediction techniques for planning future communications systems. The data is being collected over a relatively short distance, chosen deliberately to ensure that the meteorological conditions would be nearly constant over the range. In general, however, practical communications links operating at millimetre wavelengths will have much greater path lengths, perhaps up to several tens of kilometres or more, depending on the frequencies.

It is generally found that precipitation, the dominant source of fading in the millimetre region, is characteristically not homogeneous or uniformly distributed horizontally. Widespread (stratiform) rain is found to contain imbedded convective cells with higher rainfall rates than the surrounding stratiform regions. Such cells tend, on average, to be about 12 km apart and from two the three kilometres in diameter. As a result, it is not practicable simply to scale the data obtained on the 500 m range to path lengths of more than about two kilometres.

To obtain data over the longer paths which would be used in operational millimetre-wavelength communications systems, an additional link is being developed to operate in conjunction with the 500 m range over a path of about seven kilometres. This will provide data on path-length scaling, in which the 500 m data are applied to longer, more

practical link lengths; at the same time it will produce a database for validating practical prediction techniques. The link will operate at frequencies of 55 GHz, near the peak of the oxygen absorption band, and 95 GHz, in an atmospheric ‘window’. These represent two regions of the radio spectrum in which there is considerable interest, for reasons already mentioned, to do with their application to specific types of future communications systems.

These two sets of multi-frequency transmission links, operated simultaneously, will enable us to build up one of the most comprehensive propagation data base for future millimetre-wave terrestial communications systems design. The detailed and extensive programme of data analysis now going on and being proposed will yield essential information for expanding terrestrial radio communications into the millimetre-wavelength regions of the radio spectrum for the foreseeable future.

Future work
The information obtained on the 500 m range will be of immense value in providing propagation statistics and in...
COMPUTER-CONTROLLED SLIDE FADER (1)

Revenge yourself on giggling friends and relatives joined to watch and criticize your clumsy slide presentation.

This project gives the creativity you put in your colour slides an extra dimension in the true sense of the word. A chance for all mindful photographers and slide makers to stun their audience with a dazzling show of fading and dissolving images, sudden or gradual colour changes, the repeating of "theme" slides, and many more special effects, achieved by intelligent control of four slide projectors.

The main difficulty in making a slide presentation is to capture the attention of the audience. Television, the motion picture, and modern advertisement techniques prove beyond doubt that the degree of attention depends strongly on the rate at which the human mind appears to perceive changing images. While appreciating the difference in character and objective between a well-prepared slide presentation and, say, a video clip, the former is often needlessly static. It is, of course, true that this is often useful for educational purposes, where it is required that an image be shown as long as necessary to allow for explanatory comments, but the show soon becomes dreary when pictures are abruptly changed with the operator occasionally forced to go through all the previous ones before he can pick out the slide that requires repeating for additional comment.

The computer controlled slide fader de-

Fig. 1. Functional blocks in the computer-controlled slide fader system.
Circuit description of the lamp dimmer

Slide images can be faded in and out, just like sound, if the intensity of the projector lamp can be controlled in small steps. Figure 2 shows the circuit diagram of 1 of 4 identical dimmers. At the heart of the circuit is the Type TCA280A dimmer chip, whose basic operation is discussed in reference [4]. The lamp intensity is varied by adjusting a voltage divider, which sets the lamp brightness. The lamp brightness is varied by adjusting the duty cycle of the output signal. The output signal is generated by a pulse-width modulator, which is controlled by the input signal.

Digital-to-analogue converter (DAC) ICs accept 8-bit digital information from the computer and translate this into a corresponding analogue output voltage between 0 and +2.5 V on the output, pin 4. The maximum value is derived from a reference voltage source set up around Rs and R5, and connected to pin 4. The forward drop on each of these is approximately 0.62 V. When the computer port sends a control voltage of 0.00V, 0.40V or 8.00V to the DAC, all 8 inputs DB1 to DB8 are pulled low, so that the converted analogue output voltage is 0 V. The maximum value of the output voltage, Uout (+2.5 V), is available when all DAC inputs are programmed logic high, i.e., when the computer sends 3Fh, 7Fh, or Fh (it makes no sense to activate bits 6 and 7 simultaneously).

Opamp ICs are set up as an inverting amplifier connected to the output of the DAC. Its function is to invert and then amplify the forward voltage span of 0 to +2.5 V into the corresponding dimmer input span. The amplification of the opamp is, therefore, therefore, -1. With a gain of 1, the output is obtained from an 8-bit output port (A, B, C, or D). With reference to the upper channel, A, 6 bits, A1...A5, are used for controlling the lamp intensity at a resolution of 64 (2^6) steps. The remaining bits, A6 and A7, control the relays for reverse and forward motion of the slide carrier on the projector.

Circuit description of the control interface

The circuit diagram of Fig. 3 shows 4 identical control channels: one for each projector used. The control information for each channel is obtained from an 8-bit output port (A, B, C, or D). With

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**MSX systems:**
- 6502, 68000 and Z80 based systems:
- IBM PC XT and compatibles: to be described in a forthcoming issue of Elektor Electronics. Controls 4 projectors.
- Centronics port: to be described in a forthcoming issue of Elektor Electronics. Controls up to 4 projectors.
Fig. 3. Circuit diagram of the 4-way computer interface.
Fig. 4. This PCB is used for building the interface and 4 dimmers.
Construction: 5 boards in 1

The ready-made printed circuit board of Fig. 4 is cut in 5 pieces to obtain 1 interface board, and 4 dimmer boards.

Commence the construction by populating the dimmer boards according to the component overlay and the parts list. Mount a 1kΩ and a 220nF capacitor in parallel if the 1.2μF type in position C3 is difficult to obtain. Electrolytic capacitor C1 and triac Tr1 are fitted as external components. This enables the triac to be cooled effectively, while avoiding tracks carrying lamp currents of several amperes. The dimmer board and the triac should be mounted in a suitable location inside the slide projector. A metal surface near the fan is, of course, ideal for mounting the triac because it forms a heat-sink (do not forget to insulate the triac with the aid of a mica washer). Figures 5 and 6 illustrate the mounting of the triac and the dimmer board in a slide projector Type Diamator 1500 AF.

In some cases, the existing DIN socket on the slide projector may have to be rewired in accordance with the pin-out on the socket fitted on the controller board. If this is impossible, or less desirable, it is a relatively simple matter to mount an additional DIN socket for ready connection to the interface. Whatever solution is adopted, be sure to know exactly how the slide carrier control system is actuated externally. In case of doubt, it is recommended to consult the user manual supplied with the projector. Universal 5-way DIN cords as used for audio equipment are perfectly adequate for connecting the slide controller to the projectors.

The completion of the 4-way controller board is straightforward. Note the use of PCB mounted DIN sockets, which make for a compact board, obviating the need for extensive wiring. The unit can be fitted in a suitable ABS enclosure, observing that the intensity span preset, P1...Pn incl., are easily accessible for adjustment purposes. Figure 7 shows a suggestion for the front panel layout.

Over to you: software

In principle, all effects in a slide presentation are based on 3 operations, namely visual mixing of slides, arranging the order of the slides, and lamp intensity control. As already stated, the number of possible effects depends solely on the creativity put into the computer program. It is, for example, possible to revert to an early slide in the show by reverse shifting of the slide carrier in projector number 3, whose lamp is turned off, while projectors numbers 1, 2 and 4 are used for the current images. This calls for a software slide counter on each channel to keep track of the slide numbers, and hence the forward/reverse mot-

Table 1. MSX BASIC test program for the slide fader.

<table>
<thead>
<tr>
<th>Line</th>
<th>Code</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>SCREEN : CLS</td>
<td>-----------------------</td>
</tr>
<tr>
<td>20</td>
<td>DEFINT A-Z</td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>DIM D(15),C(15),I(15)</td>
<td></td>
</tr>
<tr>
<td>40</td>
<td>FOR I=0 TO 3</td>
<td></td>
</tr>
<tr>
<td>50</td>
<td>A=I*16</td>
<td></td>
</tr>
<tr>
<td>60</td>
<td>D(I+4)(I+4)=4+A : D(1+I'+I)=S+A : D(2+I'+I)=B+A : D(3+I'+I)=9+A</td>
<td></td>
</tr>
<tr>
<td>70</td>
<td>C(I+4)(I+4)=6+A : C(1+I'+I)=C+A : C(2+I'+I)=B+10+A : C(3+I'+I)=11+A</td>
<td></td>
</tr>
<tr>
<td>80</td>
<td>NEXT</td>
<td></td>
</tr>
<tr>
<td>90</td>
<td>ON STOP GOSUB 590 : STOP ON</td>
<td></td>
</tr>
<tr>
<td>100</td>
<td>FOR X=0 TO 15</td>
<td></td>
</tr>
<tr>
<td>110</td>
<td>OUT C(X),255 : OUT C(X),0 : OUT C(X),7 : OUT C(X),3</td>
<td></td>
</tr>
<tr>
<td>120</td>
<td>OUT D(X),0</td>
<td></td>
</tr>
<tr>
<td>130</td>
<td>I(X)=0</td>
<td></td>
</tr>
<tr>
<td>140</td>
<td>NEXT</td>
<td></td>
</tr>
<tr>
<td>150</td>
<td>P=0 : X=1</td>
<td></td>
</tr>
<tr>
<td>160</td>
<td>ON KEY GOSUB 260,300,340,370,400,430,460,490,520,550</td>
<td></td>
</tr>
<tr>
<td>170</td>
<td>FOR I=1 TO 10</td>
<td></td>
</tr>
<tr>
<td>180</td>
<td>KEY (I) ON</td>
<td></td>
</tr>
<tr>
<td>190</td>
<td>NEXT</td>
<td></td>
</tr>
<tr>
<td>200</td>
<td>KEY1,&quot;OFF&quot; : KEY2,&quot;ON&quot; : KEY3,&quot;+&quot; : KEY4,&quot;-&quot; : KEY5,&quot;=&quot;</td>
<td></td>
</tr>
<tr>
<td>210</td>
<td>KEYS,&quot;PREVIOUS&quot;,KEY7,&quot;NEXT&quot;,KEY8,&quot;STEP-&quot;,KEY9,&quot;STEP+&quot;,KEY10,&quot;RESET&quot;</td>
<td></td>
</tr>
<tr>
<td>220</td>
<td>KEY ON</td>
<td></td>
</tr>
<tr>
<td>230</td>
<td>LOCATE 10,6 : PRINT&quot;PROJECTOR:&quot; ;P+1,&quot;&quot; : LOCATE 10,8</td>
<td></td>
</tr>
<tr>
<td>240</td>
<td>LOCATE 10,10 : PRINT&quot;STEP SIZE:&quot; ;X,&quot;&quot; : LOCATE 10,12</td>
<td></td>
</tr>
<tr>
<td>250</td>
<td>GOTO 220</td>
<td></td>
</tr>
<tr>
<td>260</td>
<td>' '</td>
<td></td>
</tr>
<tr>
<td>270</td>
<td>I(P)=I-P(X \times I(I)=0) THEN I(P)=0</td>
<td></td>
</tr>
<tr>
<td>280</td>
<td>OUT D(P),I(P) : X=S=&quot;-&quot;</td>
<td></td>
</tr>
<tr>
<td>290</td>
<td>RETURN</td>
<td></td>
</tr>
<tr>
<td>300</td>
<td>' '</td>
<td></td>
</tr>
<tr>
<td>310</td>
<td>I(P)=I-P(X \times I(I)=63) THEN I(P)=63</td>
<td></td>
</tr>
<tr>
<td>320</td>
<td>OUT D(P),I(P) : X=S=&quot;-&quot;</td>
<td></td>
</tr>
<tr>
<td>330</td>
<td>RETURN</td>
<td></td>
</tr>
<tr>
<td>340</td>
<td>' '</td>
<td></td>
</tr>
<tr>
<td>350</td>
<td>OUT D(P),64 : X=S=&quot;+&quot; : I(P)=0</td>
<td></td>
</tr>
<tr>
<td>360</td>
<td>RETURN</td>
<td></td>
</tr>
<tr>
<td>370</td>
<td>' '</td>
<td></td>
</tr>
<tr>
<td>380</td>
<td>OUT D(P),128 : X=S=&quot;+&quot; : I(P)=0</td>
<td></td>
</tr>
<tr>
<td>390</td>
<td>RETURN</td>
<td></td>
</tr>
<tr>
<td>400</td>
<td>' '</td>
<td></td>
</tr>
<tr>
<td>410</td>
<td>OUT D(P),0 : X=S=&quot;-&quot; : I(P)=0</td>
<td></td>
</tr>
<tr>
<td>420</td>
<td>RETURN</td>
<td></td>
</tr>
<tr>
<td>430</td>
<td>' '</td>
<td></td>
</tr>
<tr>
<td>440</td>
<td>P=P-1 : IF P=0 THEN P=5</td>
<td></td>
</tr>
<tr>
<td>450</td>
<td>RETURN</td>
<td></td>
</tr>
<tr>
<td>460</td>
<td>' '</td>
<td></td>
</tr>
<tr>
<td>470</td>
<td>P=P+1 : IF P&gt;15 THEN P=0</td>
<td></td>
</tr>
<tr>
<td>480</td>
<td>RETURN</td>
<td></td>
</tr>
<tr>
<td>490</td>
<td>' '</td>
<td></td>
</tr>
<tr>
<td>500</td>
<td>X=X-I : IF X=1 THEN X=1</td>
<td></td>
</tr>
<tr>
<td>510</td>
<td>RETURN</td>
<td></td>
</tr>
<tr>
<td>520</td>
<td>' '</td>
<td></td>
</tr>
<tr>
<td>530</td>
<td>X=X+1 : IF X=63 THEN X=63</td>
<td></td>
</tr>
<tr>
<td>540</td>
<td>RETURN</td>
<td></td>
</tr>
<tr>
<td>550</td>
<td>' '</td>
<td></td>
</tr>
<tr>
<td>560</td>
<td>P=0 : X=1 : X=S=&quot;-&quot;</td>
<td></td>
</tr>
<tr>
<td>570</td>
<td>FOR I=0 TO 15 : OUT D(I),0 : I(I)=0 : NEXT</td>
<td></td>
</tr>
<tr>
<td>580</td>
<td>RETURN</td>
<td></td>
</tr>
<tr>
<td>590</td>
<td>' '</td>
<td></td>
</tr>
<tr>
<td>600</td>
<td>FOR I=0 TO 15 : OUT D(I),0 : NEXT</td>
<td></td>
</tr>
<tr>
<td>610</td>
<td>DEFUSR=4434 : A=USR(0)</td>
<td></td>
</tr>
<tr>
<td>620</td>
<td>CLS : END</td>
<td></td>
</tr>
</tbody>
</table>
tion of the carrier. A library of routines can be written for fade-in and fade-out effects timed by the CTC (counter/timer controller) on the MSX I/O & timer board.

Programmers should have little difficulty spotting and adapting the slide controller routines in the test program of Table 1. This program runs on MSX computers fitted with at least one I/O & timer cartridge. Part 2 of this article will detail the use of 4 cartridges, so that the same program tests and controls a maximum of 16 projector channels.

Non-MSX users will find lines 260 up to and including 580 useful for analysing the ways in which the test program controls the interface. The instructions in lines 220, 230, 240 and 250 are executed in a loop. The ON KEY GOSUB statement does not form part of this because the function keys on an MSX computer can be programmed to call the relevant subroutine after generating an interrupt (see line 160).

Key the program into the computer, and familiarize yourself with the functions assigned to the function keys. Select a projector, and quench the lamp by holding down the INTENSITY key. Then adjust the relevant preset on the controller board such that the lamp just about lights. This setting guarantees fast response to software-controlled intensity variations while lengthening the useful life of the lamp.

Some projectors have single-key slide carrier control. This can be simulated by the interface board if the software ensures the correct duration of the forward and reverse pulses. Although it would be possible to omit 1 relay on the board, this is not recommended because it makes the controller less versatile. A better solution in this case is the connection of pins 2 and 3 on the socket internal to the projector in question.

The subject of software for the slide fader will be reverted to in part 2 of this article. We will then discuss an advanced effects program for no fewer than 16 projectors.

References:


(ii) Articles on MSX extensions in *Elektor India*:

I/O bus, digitizer and 8-bit I/O bus: January 1986, p. 66 ff.

Cartridge board. February 1986, p. 32 ff.;

Add-on bus board. March 1986, p. 55 ff.;


Please refer to *Past Articles* on the Readers Services page in this issue.

Fig. 5. The dimmer board fitted next to the fan motor in a slide projector. C1 is mounted at the track side of the PCB.

Fig. 6. An ideal location for the hot triac. Some filing is required to fit the heat-sink between the sides of the fan enclosure.

Fig. 7. Suggested front panel layout.
TORMENTOR

The pranks committed by the young devils are probably as old as the human race itself. In the course of time only the ways and means have changed. The electronics age must also have its effect on these pranks. If one puts a living spider or a frog in the bed of an unfavoured aunt, it will certainly achieve the desired result even in this electronics age. The placing of an electronic animal in the bedroom is not only modern, but it also contributes to the protection and conservation of the animal world.

An ingenious circuit provided here for this purpose, called the "TORMENTOR" is capable of causing enough harassment. It very closely imitates the noise of a fly or a cricket. Hiding in the bedroom, the tormentor starts making the noise as soon as the lights are switched off. Angry about the nuisance, the target would probably switch on the bedroom lights again, in order to search for the cause of this vile action. However, the tormentor immediately becomes silent. After a search in vain, as the lights are switched off again, the nuisance starts all over again. The electronic tormentor is really a genuine night animal.

CIRCUIT:
Figure 2 shows the circuit diagram of our tormentor. The "EYE" of the tormentor is an LDR (Light Dependent Resistor). The value of an LDR drops as the light increases and becomes very high in darkness. The LDR and the trimpot P1 form a voltage divider, with a ratio dependent on the light conditions. The voltage of this potential divider reaches over R1 to the input of the NAND gate N1. The combination of gates N1 and N2 functions as a schmitt-trigger, as the output signal of N2 is fed back to the input of N1 over the resistor R2.

If the voltage at the junction of the LDR and the trimpot falls below a certain value, then effectively N1 goes from logical 1 to logical 0 value at the input. Output of N1 goes to logical 1 and the output of N2 goes to logical 0, which is in turn connected to the input of N1 over R2.

A rise in the voltage at the junction of the LDR and trimpot switches the output of N2 from logical 0 to logical 1 in a similar fashion.

When the bedroom lights are on, the LDR resistance is low and this makes the transistor T1 conduct. When the lights are switched off, T1 is blocked. When T1 conducts, the capacitor C1 discharges through T1, when T1 is blocked C1 charges over resistor R5. The second schmitt-trigger consisting of N3, N4 and R7 controls the tone generator made of 555 IC. The tone generator is further connected to the loudspeaker.

The capacity of C1 decides the time, which passes from the switching off of the bedroom lights till the tormentor starts showing the signs of life. The nuisance

Figure 1:
The "TORMENTOR" and the target of harassment.
value depends on C2 and the ratio of resistance values of R9/R10. The volume is decided by R8.

**CONSTRUCTION:**
The "TORMENTOR" can easily fit onto a small SELEX PCB of size 1. The component layout is shown in figure 3 and the completed circuit in figure 4. The LDR can be directly mounted on the PCB as shown in the photograph. It can also be connected over a two core wire, which is not too long. This may make it a bit easier to hide the tormentor with the LDR still exposed to the bedroom light. The maximum length that can work should be decided by trial.

The trimpot can be adjusted to set the desired voltage level at the junction of LDR and the trimpot in such a way that the circuit starts functioning when the bedroom lights are switched off but stops functioning when they are switched on.

One final tip: The success of the tormentor depends on how nicely you are able to hide it. However, Elektor takes no responsibility of the consequences of the use of this tormentor! Use it at your own risk.

**Parts List:**
- R1, R6 = 4.7 MΩ
- R2, R7 = 10 MΩ
- R3, = 10 KΩ
- R4, = 100 KΩ
- R5, = 470 KΩ
- R8, = 220 KΩ
- R9, R10 = 27 KΩ
- R11 = LDR
- P1 = 47 KΩ Trimpot
- C1 = 100μF/10V
- C2 = 20μF
- C3 = 100 μF
- T1 = BC 547 C
- IC1 = 4011
- IC2 = 555
- LS = Loud Speaker 8Ω/250 mW
- 9 V Battery

**Figure 2:**
Circuit of the tormentor, Guaranteed anger at a low cost!

**Figure 3:**
Component layout and wiring diagram,

**Figure 4:**
The ready to use tormentor – the night ghost in the electronic robe!
Wattmeter

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