Elektor Electronics

November 1987

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Acorn ISO Pascal Ref Manual	£10.00
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Intro to LOGO	£7.50
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Elektor Electronics

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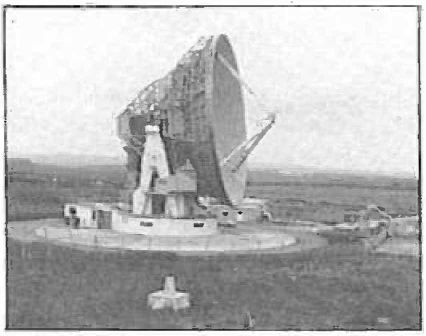
Volume 13
Number 150



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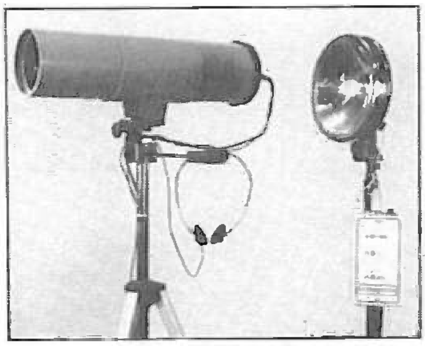

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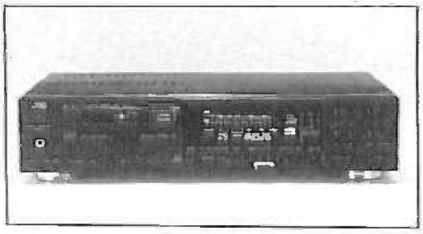

The digital audio taperecorder
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ELECTRONICS TECHNOLOGY

PROJECTS

INFORMATION

GUIDE LINES

In our December issue:

The main theme of the issue is measurement and test instruments with particular emphasis on oscilloscopes. Apart from a detailed review of a number of oscilloscopes, there will be news on many others.

Also included will be:

- Numbers and the machine
- Information theory and encryption
- British Aerospace: the first 10 years
- Logarithmic LCD VU meter
- 1987 cumulative index
- Readers' survey

Front cover

Although the Digital Audio Taperecording system, introduced in Japan earlier this year, has run into difficulties with the combined might of the western world's records producers and composers' and music writers' organizations, it appears that it is here to stay. But, in the absence of pre-recorded tapes, the impossibility of recording from CD players, and a relatively high price, it is probable that it will take a long time before it will make its presence felt on the market.

DECLINE IN SCIENCE

Now that the new academic year has started, it is worthwhile ro reflect on the reported multitude of unfilled university and polytechnic vacancies in science, more particularly physics, mathematics, chemistry, and biology. As far as can be gathered, this situation does not exist in western Europe, in spite of the greater difficulties there in financing a university course.

The reasons that our ablest youngsters read classics or English at Oxbridge rather than mathematics or chemistry at Southampton are manifold. One of them, however, must be status. In our country it is still considered more prestigious to be an accountant than a mathematician, physicist, or, dare one say it, engineer.

Now, there is nothing wrong, of course, in being an accountant or bank employee. But, as every sensible and intelligent person knows, the world's economy is science-led and likely to remain so for a long time to come. Most countries are, therefore, formulating their educational policies accordingly. In this, Britain is, and has been for some time, slowly but surely falling behind.

This is caused in the main by a lamentable apathy on the part of our society in general, on short-sighted government policies, and on an industrial management that to a large extent seems to be geared to short-term gain without investing in the future.

That the public at large generally does not care much about science is clear, for instance, from our complacency at the shortage of secondary-school science teachers over the past few decades.

Government policies aimed at cutting university grants, and thereby forcing universities to become more efficient in running their colleges, have, in the main, been successful. But the government has been woefully deficient in differentiating between research geared to industrial needs and research that is, or is likely to be, important to the country in the long term. The former should be funded primarily by industry and the latter by the government, at least in the initial stages. The government's attitude to, for instance, Britain's space research is, in this context, not encouraging.

The trouble goes deeper, however, and starts well before youngsters go to university. There has been an increasing tendency for secondary-school pupils not to continue science courses beyond their third year. The reasons for this are hard to find, but part of the blame for it must be laid with educational authorities and teachers for not engendering a strong enough interest in science subjects in the early years. The replacement of O-levels by the less academic GCSE standards has also not helped.

There also seems to be a strong case for a rapid review of science teachers' pay, which should be increased (in relation to other teachers' pay) to remedy the shortage of science teachers in both primary and secondary schools.

However, pay and conditions, important as they are to every individual, should not be the be all and end all for our teaching profession. The nation can rightfully demand that its first task is to shape and formulate the country's educational needs for now and the future.

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ELECTRONICS NEWS • ELECTRONICS NE

Second AEBLE 150 for ES2

Less than a year after taking delivery of a Perkin Elmer AEBLE 150 direct-write E-beam machine at its San Jose, California, premises, ES2 is installing a second of these machines in its ultra-modern Rousset factory in the south of France.

The AEBLE 150, which is the very first of its type to be installed outside the USA, will enable ES2 to introduce the first direct-write manufacturing line for ASICs in Europe. The high throughput of the machine will enable ES2 to write all layers of an IC without the use of masks, thus allowing unprecedented flexibility in the production of prototypes and small quantities of parts.

Power semiconductors in Europe

A report just completed by Frost & Sullivan, *Power & Smart Power Semiconductors in Europe* (≠E954), predicts that European sales of power semiconductors will climb from £785 million in 1986 to nearly $1.2 billion a year by 1992 (in constant dollars).

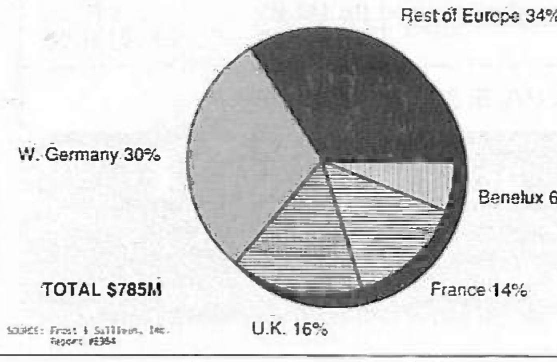
The 316-page analysis says that the devices, which control power in a number of ways, have their greatest growth potential in the automotive field. It is expected that many European car makers will switch over from relays and other electromechanical devices to multiplexing systems and SMART power devices before very long. (SMART semiconductors contain not only a power switching device, but also the control logic for it on a single integrated chip).

Electronic equipment now accounts for 2% of the average European car's value, and by 1990 this could reach 8%, according to the report, noting that one leading audo firm expects to see around 50 power modules and six microprocessors in every car then.

The four top suppliers in this market are Motorola, Philips, Siemens, and Thomson.

The report is available from **Frost & Sullivan • Sullivan House • 4 Grosvenor Gardens • LONDON SW1W 0DH.**

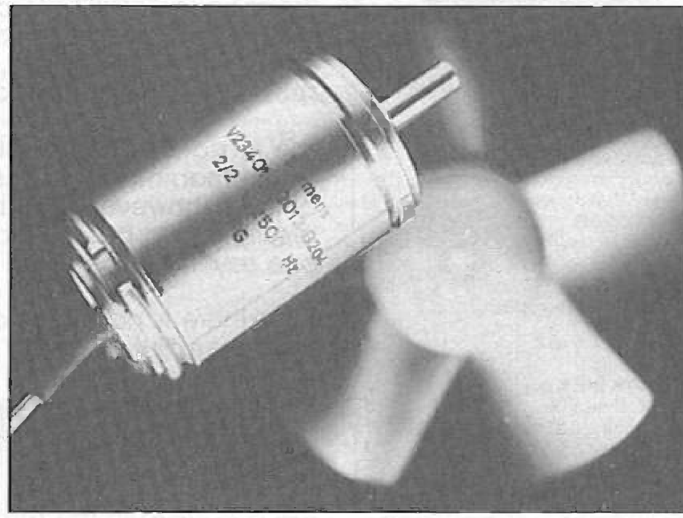
THE EUROPEAN POWER SEMICONDUCTOR MARKET BY COUNTRY - 1986



Cossor radar for Zurich Airport

Zurich Airport has become the latest airport to obtain Cossor's monopulse secondary surveillance radar (MSSR). Radio Suisse Ltd has ordered two systems to the value of £800,000. This is the second Swiss airport to install Cossor's MSSR. Earlier this year, Cossor installed a system at Geneva, an airport where, because of the surrounding mountains, SSR operation had been virtually impossible until the monopulse system became available.

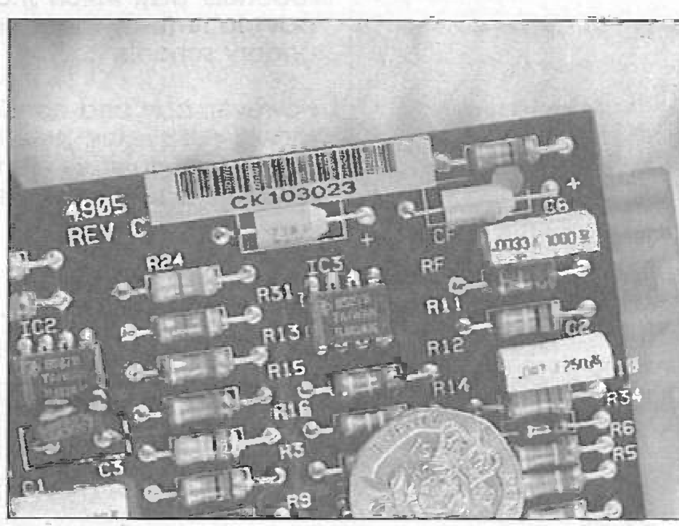
Cossor's MSSR systems have now been ordered by nine countries. Forty-one systems have been ordered for Canada, the first two of which are undergoing integration trials in Norwood, Mass, at the plant of primary radar manufacturer, Raytheon. Systems are being fitted throughout the UK for the Civil Aviation Authority, the RAF and the Royal Navy. Earlier this year, Cossor announced an order for the first three sites in Sweden's national refit programme, and the company has also sold the system to Australia, Dubai, Greece, Bahrain, the People's Republic of China, and Saudi Arabia.



The size 11 brushless resolver developed by Siemens operates in the frequency range of 400 Hz to 5,000 Hz and at a maximum speed of 10,000 rev/min. The resolver is designed specifically for connection to resolver analogue/digital—RAD—converters, which convert the resolver signal (angle information) to an absolue digital 10- to 16-bit signal. Further information from Siemens AG • Zentralstelle für Information • Postfach 103 • D-8000 München • Telephone +49 89 2340.

BEAMA working party on electricity privatization

The Federation of British Electrotechnical and Allied Manufacturers' Associations has set up a working party on privatization of the Electricity Supply Industry—ESI—to advise the BEAMA Council.



A new hostile environment bar code lable, specifically for use on PCBs is now available from *Computype • Oslo Road • Sutton Fields • HULL HU8 0YN • Telephone (0482) 835366.*

ELECTRONICS NEWS • ELECTRONICS NE

Ford/IEE Faraday Lecture Tour

The Ford Motor Company is the first motor manufacturer to participate in the IEE Faraday Lectures since the series was founded in 1924.

The major aims of the IEE's annual lectures are to stimulate the maximum possible interest in the field of electrical engineering and to pay tribute to the father of electromagnetism, Michael Faraday (1791-1867). As *the* pioneer in the field of electronics, he gave us the transformer, the electric motor, the generator, and the solenoid, and thus unknowingly laid the foundation for many of today's prime automotive developments.

These developments have gelled into such a revolution that, very soon, some 50% of the major components of all new cars will either be completely electronically controlled or employ electronics in some form. Ford's lecture fully explores these exciting cars of the future. Aptly entitled "The Intelligent Car", it will be presented by Mike Westbrook, the manager of Ford's Research and Engineering Centre at Dunton, and members of his technical research group.

Anyone remotely interested in the exciting world of automative electronics will discover something new in this unique lecture, of which there will be a number of presentations throughout the country. The list of venues and dates is as follows.

November 4	Odeon	Birmingham
November 12	Conference Centre	Harrogate
November 18	Empire Theatre	Sunderland
December 1	De Montfort Hall	Leicester
December 8	Scottish Exhibition Centre	Glasgow
December 14/15	Festival Hall	Basildon
January 13/14	Octagon Centre	Sheffield
January 19	St David's Hall	Cardiff
February 4	Great Hall	Exeter
February 11	Ulster Hall	Belfast
February 23	Mayflower Theatre	Southampton
March 1/2/3	Royalty Theatre	London

Admission is free, and by ticket only. These tickets must be acquired in advance from the IEE; they are NOT available at the individual venues. Phone or write the **Faraday Officer • IEE • Station House • Nightingale Road • HITCHIN SG5 1RJ • Telephone (0462) 53331.**

Protel schematic

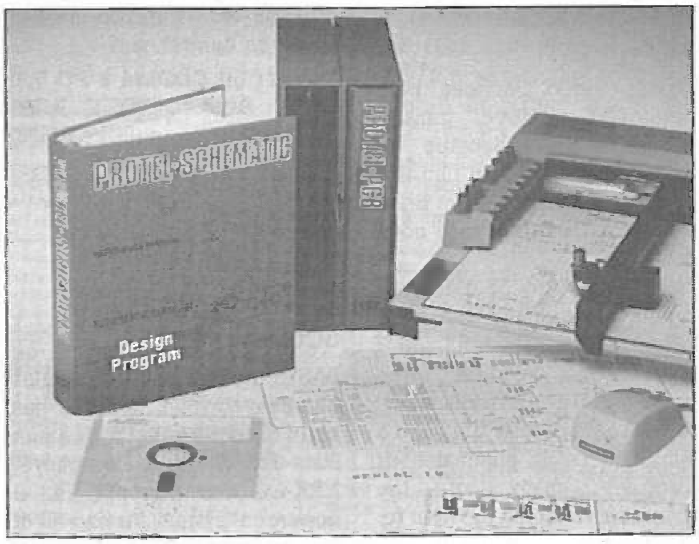
Engineering Solutions Ltd, sole UK distributor of the popular PROTEL-PCB Design Program, now announces the availability of the complementary schematic drawing package PROTEL-SCHEMATIC.

PROTEL-SCHEMATIC allows anyone with an IBM PC (or compatible) to produce professional quality circuit diagrams and to output them to a dot matrix printer or pen plotter.

PROTEL-SCHEMATIC is supplied with a library of more than 3,000 component outlines and has facilities for allowing the user to create additional library components as required.

A special feature of the program is its comprehensive text creation ability: with the aid of the built-in word processing function, text can be placed anywhere on the drawing.

PROTEL-SCHEMATIC costs £499. Together with the PROTEL-PCB package, which costs only £799, Engineering Solutions now provides a comprehensive but low-cost solution to the designer's problems of precise control over the electronic circuit design process.



Further details from **Engineering Solutions Ltd • King's House • 18 King Street • MAIDENHEAD SL6 1EF • Telephone (0628) 36052.**

Total capability in thick/thin film hybrids

Marconi Electronic Devices Ltd now has a total capability in both thick-fil and thin-film circuitry, including hybrid devices combining the best of the two technologies. The company also has a rapid technology transfer facility and has been involved in the establishment of advanced microelectronics facilities in many.

Besides the usual applications of fine-line conductor definition and resistor integration, microwave circuit designs from the company can now include integrated capacitors, airbridge interconnections, solder barrier layers, and overlay couplers.

Another new development making an impact on microwave integrated circuit design is MiMAC—Microwave Monolithic Alumina Circuit. Currently available up to 20 GHz and under extension to 40 GHz, MiMAC allows complete integration of all passive components with subsequent addition of selected active devices.

This new technology complements the emerging gallium-arsenide MMIC (Monolithic Microwave Integrated Circuit).

Besides thin film hybrids, a complementary RF thick film hybrid capability has also been introduced. In thick film circuitry, specially formulated pastes are applied and fired on to a ceramic substrate in a definite pattern and sequence to produce a set of individual components, such as resistors or capacitors, or a complete functional circuit.

British Electrostatic Control Association

Fifteen companies involved in the supply of equipment, materials, and services concerned with the control of static electricity in industry have together founded the British Electrostatic Control Association—BECA. The objectives of the association are to promote good electrostatic control practice supported by clear and appropriate information to assist proper selection and application.

British Electrostatic Control Association • Heathcote House • 136 Hagley Road Edgbaston • BIRMINGHAM B16 9PN • Telephone 021 454 4141.

TELECOMMUNICATIONS NEWS • TELEC

Video transfer to moton film

Colour Video Services have developed a direct transfer system from videotape to 35 mm motion picture film that compares favourably in price with its only (American) competitor.

Pictures on the "Superscan" system are digitally enhanced in both colour and definition.

The process requires three basic units: a television signal processor, a display unit, and a film camera. It eliminates or disguises many of the blemishes common to video recording.

Possible applications are varied and include, for instance, the transfer of TV advertisements for distribution through cinemas.

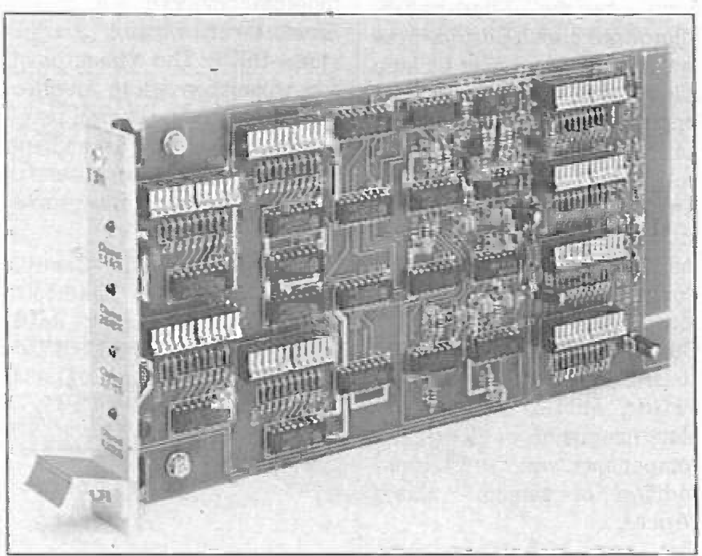
Details from **Colour Video Services Ltd • 22-25 Portman Close • Baker Street • LONDON W1A 4BE • Telephone 01-486 2881.**

CTCSS decoder panel

Communication Development Specialists now manufacture a clone of the TAIT 311 Panel. The board is compatible with the original TAIT equipment and can be used as a direct replacement.

The panel provides the facility to decode any of the 38 CTCSS subtones when used in conjunction with the T311 Master Interface control card.

Details from **CDS Ltd • PO Box 83 • BASINGSTOKE RG25 2PX • Telephone (0256) 83528.**



BASYS success in Scandinavia

BASYS, the newsroom computer company owned by ITN, has been chosen by the Norwegian State Broadcasting Company—NRK—as the supplier for a newsroom system serving all of Norway's radio and TV news operations. The system will have 80 terminals and another 40 peripheral devices (printers, telex interfaces, and so on) and will operate in Norwegian.

Another BASYS customer in Scandinavia, the Finnish National Broadcasting Organization—YLE—which has been working with BASYS since 1986 and has almost 100 terminals in operation, is carrying out a system expansion. YLE is to add another 72 terminals to the system in Helsinki. This is part of a much larger expansion programme which will extend the system to all parts of Finland, and which will make YLE's computer system on of the biggest of its kind in any broadcasting organization.

Now, the Swedish State Radio Broadcasting Company, Sveriges Riksradio AB, has followed the Norwegian and Finnish broadcasting companies in selecting BASYS. Under a recently signed contract, BASYS will install a computer system in the newsrooms of the Swedish Broadcasting Company.

As in Norway and Finland, the Swedish system will be based on DEC MicroVAX II computers linked to BASYS communication concentrator units. In the first stage of the contract, a total of 72 devices will be installed on the system, including 45 terminals and printers, wire agency interfaces, telex, and modems. The system will later be expanded to link all of Swedish Radio's regional stations.

In recent months, BASYS has signed a number of other contracts, and Swedish Radio joins a long list of users that includes BBC TV and Radio; Channel Four News; TV-am; ITN; Granada; Anglia; Channel TV; Business Television and Air TV; the Swiss Broadcasting Corporation; the Italian Broadcasting Corporation; France's La Cinq; the Broadcasting Corporation of New Zealand; NBC; ABC; and the Cable News Network.

Cableship for 21st century

A £28 million cableship ordered by Cable & Wireless has been designed to meet the future needs of high-capacity submarine optic cable systems around the world. The ship, which will carry a remotely controlled submarine, is due to be delivered in early 1989. It will be built by Swan Hunter Shipbuilders of Wallsend.

Cable & Wireless owns and operates the world's largest fleet of commercial cableships. It operates seven of them, as well as two submersibles.

The new ship will be similar to the company's *Pacific Guardian*, which was completed by Swan Hunter in 1984 and has proved to be a highly successful design. It will be ice-strengthened and fully air-conditioned to enable it to maintain cables in any part of the world, irrespective of climate. Its precise deployment has not yet been decided, but it is expected to take over from one of the older vessels in the company's fleet.

Through-the-glass keypads for New Zealand

The revolutionary through-the-glass keypad from TTG Communications Ltd has been ordered by EMU International, the New Zealand communications specialist. The keypad will be a vital part of an easy-to-use public information system, which will be installed throughout New Zealand.

Tourist information, including bus, train, and ferry timetables for the whole country, will be available 24 hours a day from EMU's Electronic Marketing Unit, which will incorporate the keypad. All it takes to operate the system are a few touches on the glass surface behind which the keypad is installed. In response to such external finger pressure, the information is flashed up onto a video screen behind the glass.

In the photograph, Mike Johnson and Paul Turner of EMU congratulate themselves on tying up the deal with the New Zealand authorities.

Further information from **Balthazor Press & Public Relations • Balthazor House • Church Street • SEAFORD BN25 1HD • Telephone (0323) 897469.**

TELECOMMUNICATIONS NEWS • TELEC

3Com Corporation in Scandinavia

One of Scandinavia's major distributors of computer products and services, Datateam, has signed an agreement to become authorized distributor of 3Coms full line of networking products for workgroup computing applications.

At about the same time, it was announced that Ericsson Information Systems AB has renewed its Original Equipment Manufacturer—OEM—agreement to carry 3Com workgroup computing products worldwide for the fifth consecutive year. The one-year, renewable agreement is estimated to be worth $2 million.

Single-mode fibre optic multiplier

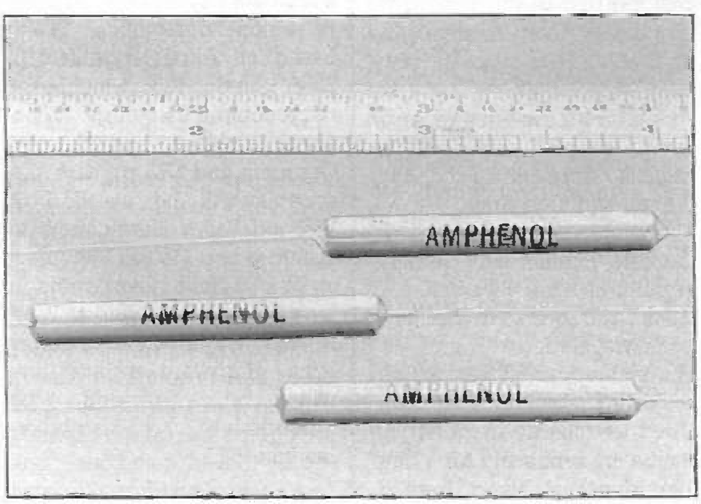
Amphenol has announced the 945 Series single-mode Wavelength Division Multiplexing—WDM—fibre optic couplers.

These couplers combine or divide signals of differing wavelengths onto, or from, a single optical fibre. They have low insertion loss and high wavelength isolation. Isolation is maintained over the temperature range of 0-90 °V, and for random input polarization states. The small and rugged packages have two operating-wavelength options.

In communications, the WDM couplers are ideal for bi-directional data links, and for increasing the capacity of existing fibre optic networks. Further applications are in test and measurement, talksets, and multi-channel light sources.

Operating wavelengths are 1300/1530 nm or 1300/1550 nm. Wavelength isolation is less than 20 dB. Centre wavelength tolerance is ±5 nm. Port configurations are 2×2.

Further details from **Amphenol Ltd • Thanet Way • WHITSTABLE CT5 3JF • Telephone (0227) 264411.**



Worldwide electronic picture editing

Newspaper picture editors from many countries will be choosing photographs for their news pages from desktop video screens within two months.

Reuters News Picture Terminals—RNPT—is complementing its existing wired hard copy picture service with a daily selection of pictures sent by satellite and land lines. The screens are being distributed throughout the world.

More than 100 pictures can be stored and the receiving editor can flash 16 of them on screen in mini format size before making a selection. The chosen picture can then be adjusted for contrast and scaled for newsprint reproduction before being printed at the press of a button. Printing can take place up to 100 metres from the desktop terminal. Subscribers will soon be able to interface the RNPT with computerized page make-up systems.

Details from **Reuters News Pictures • 85 Fleet Street • LONDON EC4P 4AJ.**

Leading telex into the 1990s

Designed to lead telex into the 1990s, the Opal modular telex system from Trend Telecommunications has a printer and controller that can be located up to 20 cm away from the operator's desk. British Telecom has decided to market the Opal system under the Leopard name as a replacement for the long- established Puma, which is also made by Trend.

Details from **Trend Telecommunications Ltd • Knaves Beech Estate • Loudwater • HIGH WYCOMBE HP10 9QZ.**

Racal to provide UK Pan-European digital cellular radio service

Following the recent announcement by John Butcher, Parliamentary Under Secretary of State for Industry that Racal-Vodafone is to be one of the two companies to provide the UK part of the Pan-European digital cellular radio service due to come into operation in 1991, Sir Ernest Harrison, Chairman and Chief Executive of Racal Electronics said that this decision was a further vote of confidence in Racal-Vodafone, which has now well over 100,000 subscribers. He said that the Vodafone analogue (TACS) network will increase its capacity to 600,000 subscribers and that this will cope with all anticipated growth until at least 1992.

In May this year, Racal was a co-signatory to the Pan-European Quadripartite Agreement between the United Kingdom, France, Germany, and Italy. Racal has made a significant contribution to a Memorandum of Understanding with other European operators. This commits the signatories to a detailed timetable for the procurement and establishment of the new digital network services.

The government decision emphasizes the importance of the formation of Orbitel Mobile Communications Ltd, a company owned equally by Racal Electronics PLC and the Plessey Company PLC. This was formed mainly to design, develop, manufacture, and market infra-structure and subscriber equipment to meet the requirements for the pan-European digital cellular radio system in the UK, on the Continent of Europe, and for worldwide sales.

Worldwide Skyphone set for take-off

The final countdown has started for British Telecom's Skyphone with the award of a £2.6 million contract for the quipment which will automatically connect airline passengers' telephone calls to customers on the ground.

The contract, with E.B. Communications (GB) Ltd, means that British Telecom International—BTI—has now completed the purchasing of all the major equipment and software required for Skyphone.

Trials of the service, with calls connected by the operator, will begin next April on three British Airways 747 airliners, allowing passengers to make international calls during flight.

The new contract represents a first for BTI, because the equipment will be the first designed to meet the full INMARSAT aeronautical standards for ground earth stations. It will be installed at BTI's satellite earth station at Goonhilly Downs in Cornwall.

Skyphone is BTI's satellite aeronautical communications system currently being developed and tested under a collaborative agreement between BTI, Racal, and British Airways.

COMPUTER NEWS • COMPUTER NEWS •

LSI Logic in licensing agreement with ASIX

LSI Logic has concluded an agreement to license its proprietary ASIC design verification software and applicable libraries to ASIX Systems Corporation.

Design engineers who have used LSI Logic's modular design environment software tools to design ASIC products can now recreate simulation input files, and use the resulting files to automatically produce a test program. Using the ASIX test system, the design engineer can verify a design in an integrated software environment.

Computer security

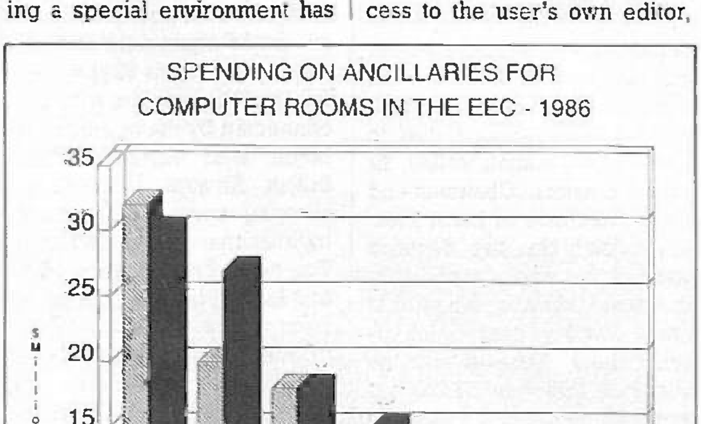
Computer security in the institutions of Europe—from government to universities to industry—is a growing concern in what will be a $363 million market in the EEC by 1991: equipment to protect the computer room.

Computer Room Environment Equipment in the EEC (#E931), a 273-page report from Frost & Sullivan, says that the need to cool processors and the presence of intensively used peripheral equipment requiring a special environment has been, and remains, the main reason for building computer rooms. But, it adds, while heat is the most common culprit to be controlled, the need to keep facilities secure is an increasingly important factor.

Thus, while the market for ancillary computer room equipment is predicted to increase by about 90% in volume between the base year 1985 and 1991, access control gear will increase by 106%.

With reference to the bar chart, it is interesting to note that in spite of the de-industrialization in the UK, the country remains the EEC's second largest consumer of computer-room gear.

The report is available from **Frost & Sullivan • Sullivan House • 4 grosvenor Gardens • LONDON SW1W 0DH • Telephone 01-730 3438.**



TED provides help for developers

New software to ease and speed program development with the aid of microprocessor emulators has been announced by Pentica Systems. The TED Terminal Emulation Development) system provides a complete menu-driven development environment, giving access to the user's own editor, compiler, and other programs. As well as MS-DOS-compatible TYPE and PRINT commands, TED includes a UNIX-style MAKE utility which, once set up, initiatates compilation, assembly, and linking of a complete program with one command. The system has the intelligence to recompile only the source files that have been updated since the previous link.

Further information from **Pentica Systems Limited • Station Industrial Estate • Oxford Road • Wokingham RG11 2YQ • Telephone (0734) 792101.**

Translating speech by computer

People who can not speak a word of each other's language will soon be able to talk over the phone with the aid of a system developed by British Telecom.

The world's first instantaneous translation of speech by computer was unveiled by BT's Research Laboratories recently when simple sentences in English were translated into French and vice versa.

The prototype equipment can translate English into German, French, Spanish, Swedish, and Italian. The reverse capability is being developed.

The system recognizes spoken proper names and makes no attempt to translate them, for instance, by rendering Mr White into Monsieur Blanc. Instead, the names are repeated in the original speaker's voice in the translation.

Kinburn completes AES acquisition

Kinburn Technology Corporation of Ottawa has announced that it has completed the acquisition for $16.5 million of all the outstanding shares of AES Data Inc. of Montreal. The AES headquarters will remain in Montreal.

Altos for EMAP

Printing and publishing systems specialists Microdrive Systems has won a contract worth over £200,000 from EMAP Newspapers Ltd to install integrated advertisement sales and accounting systems at three of its regional companies.

Based on Altos Models 3086, 2086, and 1086 multi-user microcomputers, thirty Wyse visual displays, and thirteen Genicom and OKI printers, the systems will be installed at Welland Valley Newspapers in Stamford and Melton Mowbray; at West Suffolk Newspapers in Bury St. Edmunds; and at West Norfolk Newspapers in Kings Lynn. Hardware maintenance will be provided by Microdrive's distributor, Logitek PLC.

COMPUTER NEWS • COMPUTER NEWS •

Psion Organizer II

The Psion Organizer II is a powerful hand-held computer with up to 304 K of on-board memory that is intended for a multitude of applications. It comes with built-in menu-driven programs, but can be programmed to the user's individual needs with the aid of the built-in OPL programming language, and run off-the-shelf software by plugging in optional program packs.

The Psion Organizer II can be used as a clock, a calendar, filing cabinet, diary, calculator, accountant, reference library, mathematician, bar code reader, magnetic card reader, formatter, eraser, and much more.

Available from **Psion Limited • Psion House • Harcourt Street • LONDON W1H 1DT • Telephone 01-723 9408.**

New computer publication

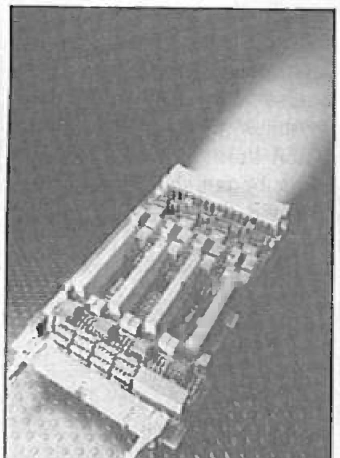
To help users get and stay ahead in information technology and office practice through events and training, a new international quarterly guide has been launched. Entitled *What's on in Computing... Communications and Management* and published by Tomorrow's Office Today Publications, the guide should prove useful not only to users, but also to firms who market computers and computer-related products, and communications and management equipment and services at home and overseas. The new publication is printed on A4 paper and the first issue runs to 36 pages. A sample copy costs £5 (UK) and £8 (overseas). Annual subscription rates are £19.50 (UK) and £28.50 (Overseas) including postage.

Further information from **TOT Publications • Hatfield LOdge • 30 Granville Road • CLACTON-ON-SEA C)15 6BX • Telephone (0255) 420553.**

Analogue isolation board

Arcom's SCB12 signal conditioning board offers control systems designers four channels of 1,000 V isolation for heavy-duty real-world interfacing. The board includes a standard signal-conditioning interface, which allows direct interface to STEbus modules.

The SCB12 is based on the Analog Devices' AD204 chopper-driven isolation amplifier, and offers adjustable gain in addition to 1,000 peak isolation. Users can select unit, x10, or x 100 amplification.



Also included on-board is active filtering for noise rejection. In its standard form, the SCB12 works from either a voltage input or a jumper-selectable 4-20 mA current loop input.

Further details from **Arcom Control Systems • Unit 8 • Clifton Road • CAMBRIDGE CB1 4WH • Telephone (0223) 411200.**

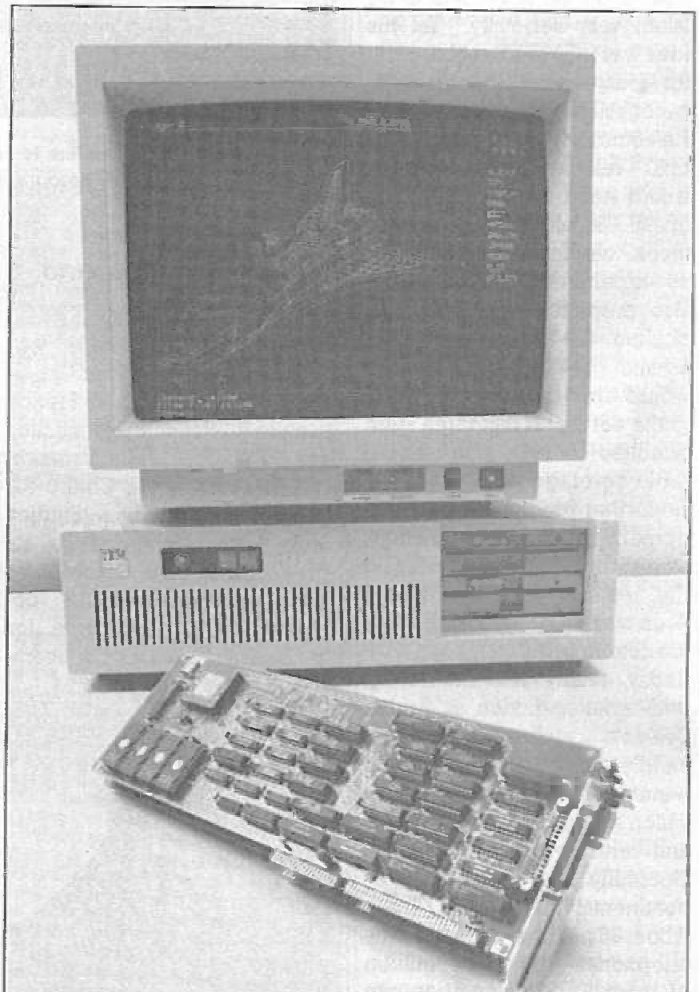
New ROM programming technology

National Semiconductor has developed a new technology that employs a high-energy ion implantation process to program a microcontroller's on-chip ROM after the wafer has been metallized. National's popular COP400 family of four-bit microcontrollers are the first chips to benefit from this quick-turn ROM programming process.

Called Post Metal Programming, the new process has been fully qualified and is now being used to program National's COP413L—a very p
opular four-bit microcontroller
sells at a very competitive p
rice compared to other micro
trollers.

Teradyne wins Hitachi order

Teradyne has broken into the Japanese memory market with the sale of a J937 Memory Test System to Hitachi for $1.3 million. In addition to testing 1- and 4-bit dynamic and static RAMs, the system will be used to test high-speed video RAMs. Hitachi also purchased Teradyne's Factory Integration and Resource Management System—FIRMS—which will be used to integrate the test system with the factory's Management Information System.



The Kone AT1290 Graphics Processor has a resolution of 1280 x 1024 pixels and is completely compatible with the IBM professional graphics controller, but is 20 times faster. Further information from *Kone Oy Instrument Group • Industrial Division • Jouko Ala-Tuori • Ruukintie 18 • SF89 02320 ESPOO • Finland • Telphone +358 0 801 70 11 • Telex 122441*

THE BIRTH OF SATELLITE COMMUNICATIONS

Twenty-five years ago worldwide communications entered a new era. Telstar, the world's first commercial communications satellite, was launched on July 10, 1962, and the first live television signals via satellite were received by British Telecom's Goonhilly earth station in the early hours of the following morning.

In October 1945, the magazine *Wireless World* published an article by Artur C. Clarke, today probably better known as the autor of *2001—A space Odyssey*, entitled *Extra-terrestrial relays—can rocket stations give worldwide radio coverage?*
Arthur C. Clarke commented in his article: "Many may consider the solution proposed in this discussion too farfetched to be taken very seriously." Yet his idea was to prove the blue-print for today's satellite communications network.
He accurately predicted the orbital velocity that a rocket would need to become an artificial satellite, or second moon, circling the world with no expenditure of power. He also predicted that a satellite circling the earth above the equator at a certain height would appear to be stationary to the earth and that three such satellites could give global radio coverage.
He further predicted that development of rocket technology, started by the Germans during the second world war, would soon make it possible to place a satellite in orbit.
Today, reality has caught up with science fiction as British Telecom International-BTI-handles more than three million minutes of telephone calls, television pictures, data, facsimile, and telex, every day through Goonhilly and its other intercontinental links.
About 90 per cent of the world's telephones—some 600 million of them—in 173 countries can be dialled direct from the UK. Telephone services are provided to more than 200 countries and each day more than 500,000 calls are connected from the UK to the other countries.

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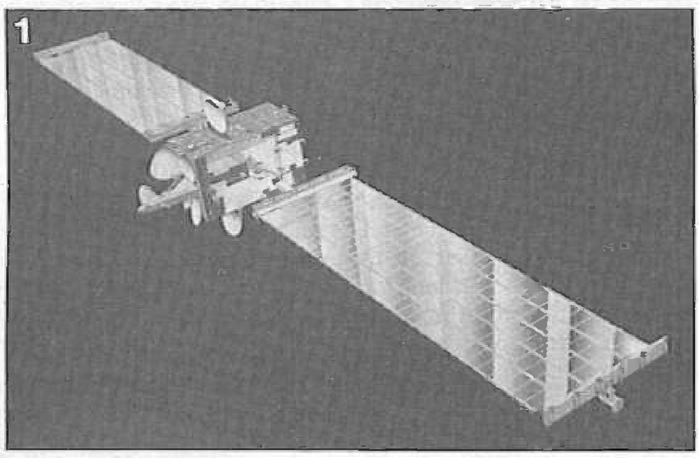

Fig. 1. The Olympus satellite is one of the largest and most powerful in the world. *Photograph courtesey of British Aerospace.*

The early Telstar demonstrations and tests

In the Spring of 1961 it was jointly announced in the United Kingdom, the USA and France that the US National Aeronautics and Space Administration (NASA), the French Centre for Telecommunications Studies and British Telecom, as its predecessor Post Office Telecommunications, would cooperate in a programme for transatlantic testing of communications satellites.
At the same time it was announced that satellite earth stations would be built in England and France "for the reception and transmission of telephone, telegraph and television signals across the Atlantic using satellites to be launched by NASA during 1962 and 1963."
Work began shortly afterwards to build the UK's first satellite station at Goonhilly Downs in Cornwall. The site was chosen because it was as far west as possible to obtain the maximum period of visibility to the United States via the satellite, to be remote from sources of electrical interference, and to provide an onobscured view to the horizon for the longest possible contact with the satellite.
In less than a year from gaining access to the site the station was ready. A massive, steerable dish antenna, weighing 870 tonnes with a 25.9m dish had been built. All of the equipment on the station was of British design and manufacture, with the exception of one American transmitting klystron valve.
The British design was the odd-man-out among the three earth stations to be used for the tests. Both the American station at Andover, Maine, and the French station at Pleumeur Bodou in Britanny were equipped with horn antennas housed in radomes. The British station had cost around £800,000 to complete, about a quarter of the cost of the American and the French stations.
In early July 1962 it was announced that Telstar would be launched from Cape Canaveral on either July 10 or 11.
The successful launch took place at 8.35 GMT on Tuesday, July 10, and the desired orbit was achieved. With Telstar circling the earth at heights varying between 590 and 3500 miles, it was possible to achieve three or four periods during each 24 hours when mutual visibility between Goonhilly and Andover lasted for 30 to 40 minutes.
During these periods the antenna at Goonhilly had to be accurately manoeuvred to follow the satellite from the moment it rose above the horizon until it again disappeared from view. The signal transmitted from the antenna to the satellite was con-

2


Fig. 2. A small section of Goonhilly Downs Earth Station: in the foreground Aerial No. 7. *Photograph courtesy of British Telecom.*

centrated into a narrow beam, one-fifth of a degree in width, so absolute precision was necessary. To maintain this accuracy in high wind meant that the antenna had to be massive and sturdy. In order to move the antenna so accurately it was equipped with electric motors of some 100 horse power. However, the engineering design resulted in such good balance and smooth movement of the antenna that normaly less than two horse power was required under reasonable weather conditions.

The primary purpose of the Telstar satellite tests was to acquire data on which to base the future design of satellite systems for commercial operation. However, during the period from July 10 to July 27 a number of demonstrations were carried out which illustrated the potentialities of satellite systems for world-wide telecommunications.

In the early hours of July 11 the first usable orbits were the sixth and seventh and the first attempt at television reception was made. Reception was decidedly poor. Some experts were quick to blame Goonhilly's unique antenna design, and *The Times* described the experiment as "an almost total failure". Some experts said the antenna was too heavy and cumbersome to accurately track the satellite, others blamed the driving mechanism. The problem proved to be that one component had been fitted the wrong way round and it was a twenty-minute job to correct it. The effect of the incorrect fitting had been to reverse the direction of the wave polarization of the antenna, relative to that of the satellite, introducing a serious weakening of the strength of signals received. The problem arose because of an ambiguity in the accepted definition of the sense of rotation of radio waves; a difficulty which had been encountered both in the USA and the UK in the period just before the tests. With the correction made, excellent pictures were received on orbit 15 during the evening of July 11, and during orbit 16 the first live television transmission between Europe and the USA was made from Goonhilly to Andover. The pictures and sound received at Andover were reported to be of excellent quality and were broadcast as received throughout the USA.

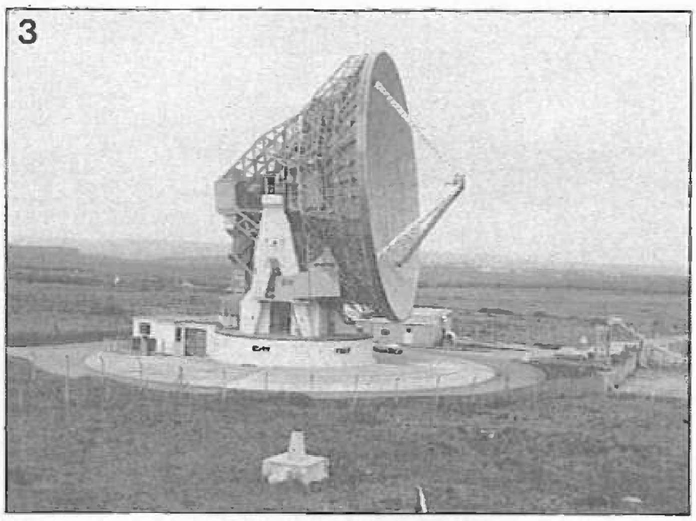

Fig. 3. The first of the dish antennas to be installed at Goonhilly Downs. *Photograph courtesy of British Telecom.*

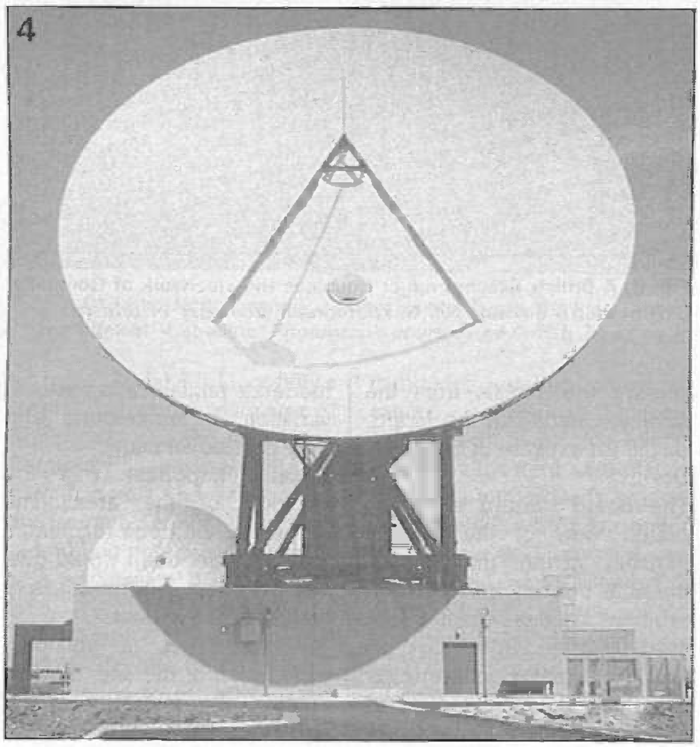

Fig. 4. Aerial 6 is Goonhily's largest dish with a diamter of 32 m. It was also the first "dual frequency" antenna, able to transmit and receive on two different frequencies simultaneously. *Photograph courtesy of British Telecom.*

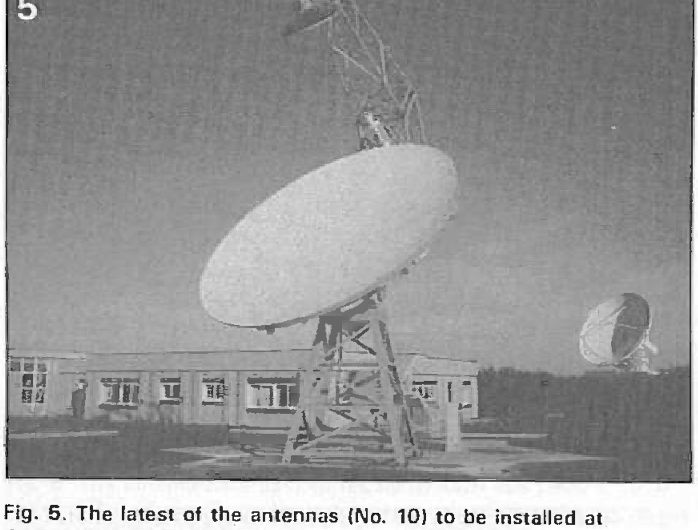

Fig. 5. The latest of the antennas (No. 10) to be installed at Goonhilly Downs. *Photograph courtesey of British Telecom.*

On July 12 the first two-way transatlantic telephony tests were made, showing that good-quality, stable telephone circuits with low noise levels had been achieved. These tests were to be followed two days later by the first transatlantic telephone call and photo-telegraphy (facsimile) transmission via satellite.

On July 14 during orbit 34, the director general of the Post Office, Sir Ronald German, spoke from his home in London to the president of American Telephone and Telegraph Co (AT&T), Mr. Eugene McNeely, in New York. Simultaneously, one pair of channels was used to send facsimile pictures between London and New York.

On July 15 tests to assess the ability of a communications satellite to carry large numbers of telephone circuits were carried out during orbit 43. These demonstrated that at least 600 first-grade international circuits should be possible by satellite.

The first transmissions of colour television signals by satellite were made from Goonhilly during orbits 60 and 61 on July 16. With the co-operation of the BBC's research and designs department, who provided a colour slide scanner and monitor equipment, the signals, on 525-line NTSC standards, comprised captions, test cards and still pictures to assess colour quality. The transmissions were initially made from Goonhilly to the satellite and back to Goonhilly but were also received in Andover. Andover reported: "Colour—good; picture quality—excellent".

During orbit 87 on July 19 satellite communications were opened up to the press. Twenty-four calls were made by the British press from Fleet Building in London, to the American press in New York.

On July 23 during orbit 125 an 18-minute long programme from the European Broadcasting Union was transmitted from Goonhilly to Andover. The programme consisted of scenes from many European countries and was transmitted by the Eurovision link to Goonhilly, from Goonhilly to the satellite, and was received at Andover and broadcast throughout the USA.

During orbit 151 on July 26, the Telstar link between Goonhilly and Andover was used to provide telephone circuits for the US Information Agency involving conversations between "notable persons" in 20 pairs of cities in the USA and Europe for the Agency's "People-to-People" programme. The circuits were reported as excellent.

The Telstar tests confirmed that communications satellites could provide high-quality, stable circuits for television and multi-channel telephony. The performance of Goonhilly earth station was reported as excellent in every respect, and the equipment, almost all of which was of a unique new design, had worked well. In fact, Goonhilly's antenna design was to prove, as had Arthur C. Clarke's idea, to be the blue-print for the future.

A brief history of Goonhilly satellite earth station

The choice of Goonhilly Downs, on the Lizard Peninsula in Cornwall, as the site of the United Kingdom's first satellite earth station, was made for exactly the same reasons that Guglielmo Marconi chose the Lizard for his pioneering work in maritime and international "wireless" telegraphy. The Lizard offers an uninterrupted view across the Atlantic and little electrical interference.

The first transatlantic wireless message was sent from the Lizard on December 12, 1901. Three faint but discernible "dots" of the Morse letter "S" were sent from Marconi's transmitter at Poldhu and received by him in Newfoundland, Canada. A year later Poldhu sent a signal to the vessel *Philadelphia* more than 2000 miles away in the ocean. Long-distance telecommunications had been born.

Sixty years later the advance of technology had made satellite communications, first proposed by the author and scientist Arthur C. Clarke in 1945, a realistic possibility. The United Kingdom, the USA and France announced in 1961 that they would co-operate in a programme for the transatlantic testing of communications satellites.

The search for a suitable site in the UK for the station that would receive the signals from the satellites, ended in the Lizard, on the flat expanse of Goonhilly Downs.

The Lizard offered an unimpaired view of the Atlantic horizon, giving the longest possible contact with the low-orbiting satellites then being used. It suffered from little electrical and radio interference; was well placed to connect with inland communications, power supplies and transport links; and had a climate with moderate rainfall, little seasonal variation in temperature and only occasional snow.

Equally important was the geology of the area. The serpentine bedrock reaching a thousand feet deep would give vital support to the massive weight of the antennas.

Within a year of obtaining possession of the site, the first antenna, the control room and its associated equipment were installed and ready for the first tests which would use the Telstar satellite, to be launched by the US National Aeronautics and Space Administration (NASA) on July 10, 1962.

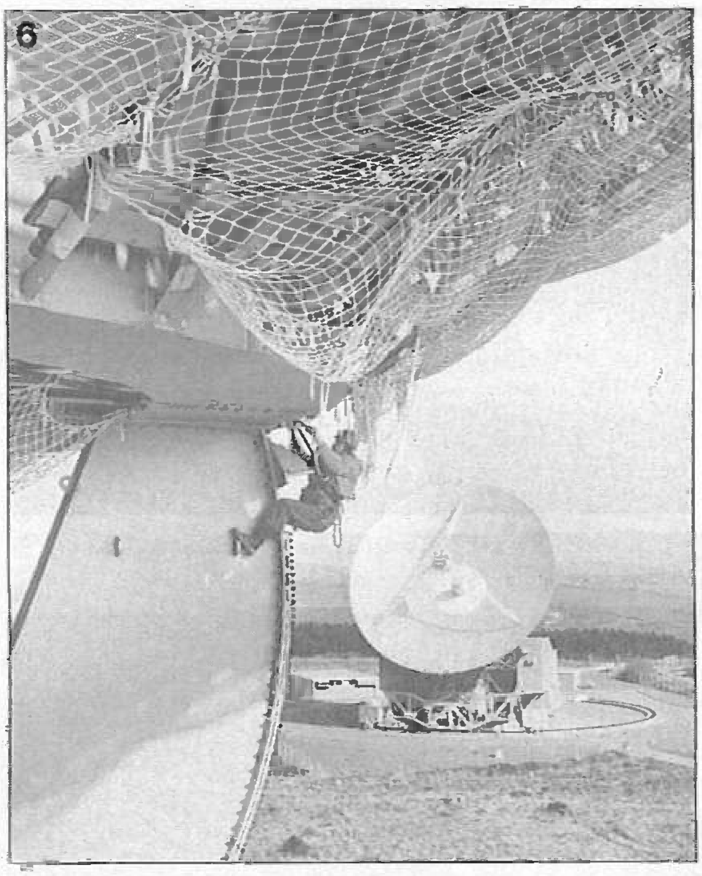

Fig. 6. A British Telecom rigger examines the steelwork of Goonhilly Eart Station's antenna No. 6. *Photograph courtesey of British Telecom.*

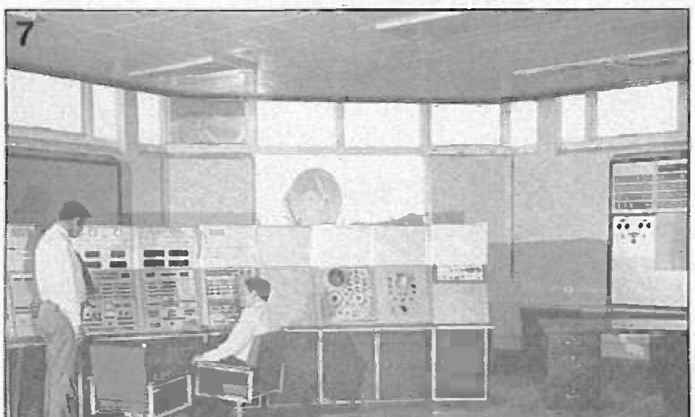

Fig. 7. A section of the control area at Goonhilly Downs. *Photograph courtesey of British Telecom.*

Those tests confirmed that satellites could have a commercial future in international communications. During a period of 16 days several world-firsts went into the record books—the first live television transmission between Europe and the USA, and the first telephone calls, facsimile transmission and transmission of colour television by satellite.

Because of the low orbit of Telstar—between 590 and 3500 miles above earth—the satellite was only usable for three or four 30-to-40 minute periods in each 24 hours. As the satellite raced across the sky from horizon to horizon, the antenna had to be nimble enough to follow the satellite to one-fifth of a degree's accuracy during each of these brief visits.

Aerial 1 at Goonhilly was a unique design - an 870 tonnes "dish" antenna, compared to the French and American horn antennas enclosed in radomes. Some initial problems during the first usable orbits of Telstar caused experts to blame the design of the British antenna, but a small problem with a component which had been fitted faultily proved to be a twenty-minute job to correct and the antenna then went on to establish its world-firsts.

Goonhilly Station had cost around £800,000 to complete, about a quarter of the costs of the American and French stations, and it was the unique design of the British dish antenna which was to go on to become the norm for satellite communications throughout the world. The dish design is now used generally by nearly 700 satellite stations in more than 150 countries.

Following the successful tests with Telstar an international satellite organisation was set up in August 1964 - INTELSAT. Interim agreements were signed by 11 member nations - the USA, UK, Canada, Denmark, France, Italy, Japan, the Netherlands, Spain, the Vatican City State and Australia. Today INTELSAT is owned by more than 100 member countries.

INTELSAT launched its first satellite into orbit in April 1965. The satellite, INTELSAT I, known as *Early Bird*, was a high-orbiting satellite in "geostationary orbit".

Arthur C. Clarke had proposed in his 1945 paper that satellites, circling the earth above the equator at a certain height, would appear to be stationary to the earth's surface—their period of orbit would exactly match that of the earth's natural rotation. That distance was 22,300 miles above the equator. After INTELSAT I's successful launch to this height, commercial service opened in June 1965.

Arthur C. Clarke had also proposed that three satellites in geostationary orbit could give world-wide radio coverage.

A second satellite—INTELSAT II—was launched in December 1966, and at the same time, Aerial 1 at Goonhilly, which now no longer needed to track low-orbiting satellites across the sky, had an extra reflecting surface added, pushing its weight up to 1100 tonnes.

Satellite communications had now truly entered commercial operation. As the demand for transatlantic TV and telephone transmission grew, so did Goonhilly with the addition of Aerial 2 in 1968.

By 1969 three geostationary satellites were in orbit, fulfilling Arthur C. Clarke's prophesy of global communications. INTELSAT III was positioned above the Indian Ocean and demand for satellite communications with the Far East grew. To meet this need Aerial 3 was brought into service in 1972.

Aerial 4 was added in 1978, to meet an ever-increasing demand for communications across the Atlantic. This was also one of the first antennas in the world to use the 11/14 GHz frequency as soon as it became available for business satellite communications.

Demand for satellite communications grew by 20 per cent a year during the 1970s and early 1980s. Further satellites were put into orbit and in October 1978 a second earth station was brought into service by British Telecom at Madley in Herefordshire.

Demand for specialist sevices also grew during this period and in 1983 Aerial 5 at Goonhilly was completed to provide satellite services to ships at sea.

At the same time Aerial 6 was being built to provide further capacity on the busy transatlantic route. Aerial 6 is Goonhilly's largest dish with a diameter of 32m. It was also the first "dual-frequency" antenna, able to both transmit and receive on two frequencies simultaneously—doubling potential capacity. It entered service in September 1985.

While aerial 6 was being built, Aerial 7 was also being brought into service to provide leased TV services to North America.

With continuing growth in demand for satellite communications, British Telecom announced plans in August 1983 to built a third earth station in London's Docklands, primarily for satellite TV distribution and specialised business services. The London Teleport, in North Woolwich, opened for operation in February the next year—less than six months after site clearance began.

Aerial 7 at Goonhilly, initially used for TV circuits, is now being used for the trial of *Skyphone*—a telephone service to aircraft in flight—which is due to start by the end of this year.

Meanwhile Aerials 8, 9 and 10 have been built. These are small-dish antennas below 14m in diameter. They are used for research and development, and to provide monitoring and control facilities on the more than 130 satellites currently in use.

Today, development at Goonhilly continues. Aerial 6, the biggest antenna, has been equipped to operate to the latest development in satellite communications—Time Division Multiple Access/Digital Speech Interpolation (TDMA/DSI). TDMA/DSI means that signals from the station are grouped and sent by time rather than frequency, so that, on the principle that during the average telephone conversation either party is only speaking for one third of the time of the call, other groups of signals can be sent along the same channels during the lapses of conversation

While British Telecom's earth station at Goonhilly provides vital links for today and tomorrow, it has not forgotten its past—a past that goes back far beyond Marconi's early experiments.

The Lizard Peninsula is designated as an Area of Outstanding Natural Beauty and Goonhilly Downs was Cornwall's first National Nature Reserve. In developing the earth station, British Telecom spent £200,000 landscaping the scheme to form natural-looking mounds, or bunds, inside and outside the station's boundaries. Local heathers, gorse and willow were planted in the station, in keeping with the natural character of the Downs. With little intrusion from the public, amidst the silent giants of Goonhilly's antennas, the local flora and fauna have been able to flourish, making Goonhilly not only a pioneer in high-technology but also a botanist's paradise.

Fig. 8. Children from a nearby primary school being shown a model of the Intelsat V satellite. *Photograph courtesy of British Telecom.*

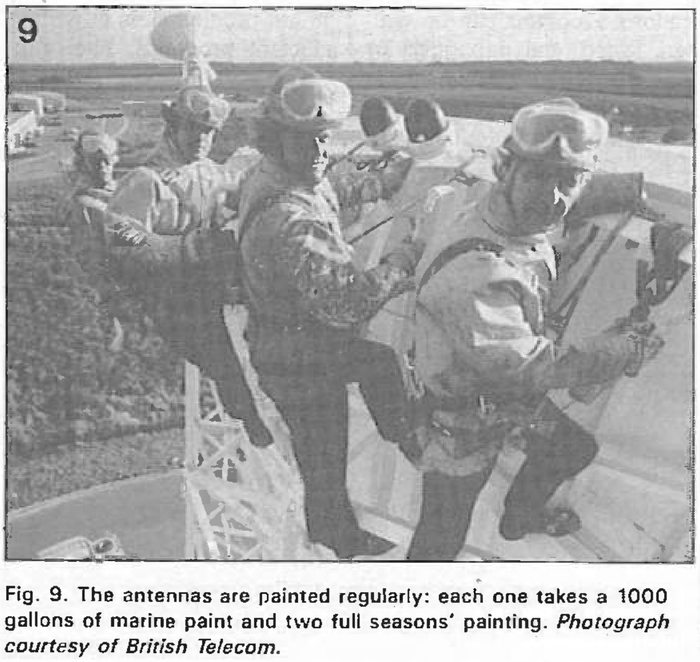

Fig. 9. The antennas are painted regularly: each one takes a 1000 gallons of marine paint and two full seasons' painting. *Photograph courtesy of British Telecom.*

BASIC COMPUTER

At the heart of this versatile and simple to build computer for process control and automation applications is Intel's Type 8052AH-BASIC microcontroller.

As already noted in reference [1], the Type 8052AH-BASIC V1.1 is a single-chip microcontroller tailored to data manipulation in intelligent instrumentation, measurement and control systems. Not surprisingly, therefore, the 8052AH-BASIC features an extensive and powerful set of input/output and timekeeping functions.

By virtue of its compactness and ease of programming, the BASIC computer described here is suitable for a wide range of domestic as well as industrial applications. Although not every programmer will applaud the use of BASIC, it can be argued that this is still the most widely known, and often first apprehended, programming language. Moreover, the BASIC interpreter of the 8052AH-BASIC is an advanced version offering instructions like DO-WHILE and DO-UNTIL which enable better structuring of programs than the GOTO statement. Also, variables can be stored and retrieved by means of instructions PUSH and POP. The BASIC interpreter is reasonably fast as compared with competetive 8 and 16 bit systems. In conclusion, the 8052AH-BASIC couples the power and versatility of the 8051 to the qualities of a well-written, reasonably fast, BASIC interpreter.

The computer described is suitable for experimental as well as stand-alone applications. Programs can be written, tested, and debugged by anyone with a reasonable command of BASIC. The microcontroller used is not cheap, probably because of its specialist nature, and the fact that it has hitherto found applications mainly in industrial control systems. None the less, the cost of the 8052AH-BASIC is justifiable considering its impressive potential.

To aid programmers in writing efficient programs, Intel supplies the indipensable *MCS BASIC-52 USERS MANUAL*, which carries reference number 270010-003.

It is important to note that ready-made programs for the BASIC computer are not available. The proposed system is intended primarily for applications where the BASIC programs are not an end in themselves, but where the hardware-software link is readily accessible to enable developing and testing computer controlled systems of a wide variety. Once a program is debugged and known to function satisfactorily, the computer can act as a reliable stand-alone controller.

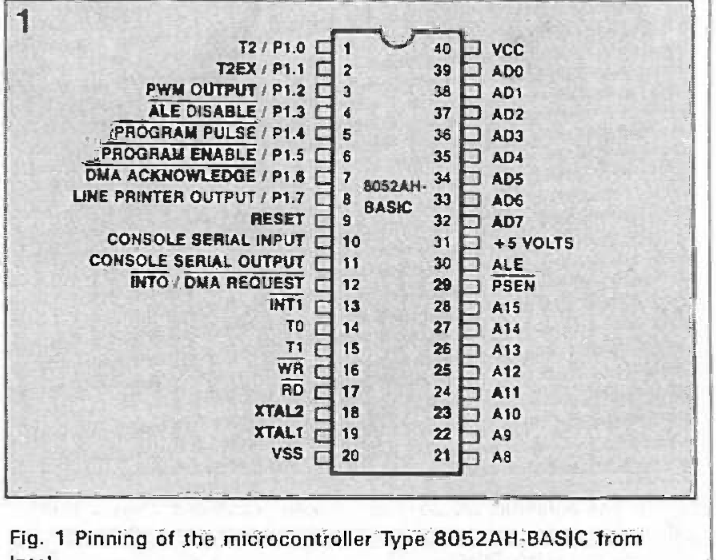

Fig. 1 Pinning of the microcontroller Type 8052AH-BASIC from Intel.

Features

The computer described features an on-board EPROM programmer, which is controlled direct by the 8052AH-BASIC CPU. This means that the processor can store its own programs in EPROM after debugging and testing. Once it is EPROM resident, the BASIC program is available for direct

2

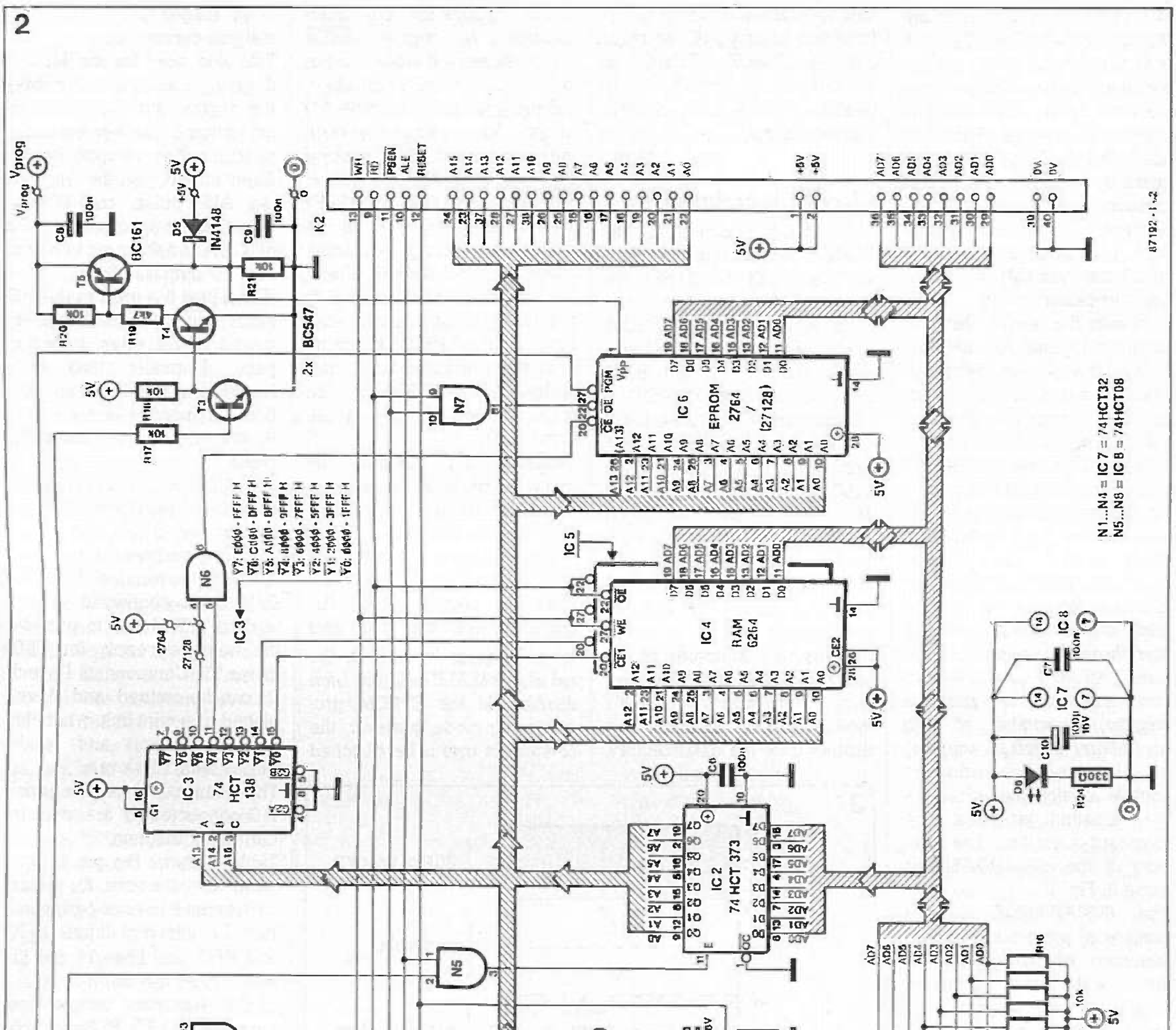

Fig. 2 Circuit diagram of the BASIC computer.

and autonomous execution by the processor. The EPROM contents form the token program listing rather than machine code obtained by a compiling process. The programming of EPROMs on the board is straightforward, and fully supported by BASIC instructions. A single EPROM can hold a number of programs, which can even call each other when necessary.

It should be noted that the BASIC computer has no keyboard and screen of itself. These communication functions are taken over by an external console (terminal), connected to the computer's bidirectional, serial I/O port.

As to the hardware configuration of the proposed BASIC computer, this is characterized by a high degree of flexibility, allowing the user to readily add, say, a UART (*universal asynchronous receiver/transmitter*), an ACIA (*asynchronous communications interface adapter*), a number of PIAs (*peripheral interface adapter*), or other peripheral circuitry such as an alphanumerical display, a sound generator, or a keyboard encoder. The pinning of the 8052AH-BASIC is given in Fig. 1.

The 8052AH-BASIC has a number of powerful timing instructions which, in conjunction with the interrupt statements, special registers, and instruction counters, afford excellent control of time critical I/O applications. A real time clock is also available in the form of function TIME, which offers a resolution of about 5 ms.

The Type 8052AH-BASIC is an 8 bit *microcontroller*, which means that it combines the functions of central processing unit (CPU), and peripheral circuits (I/O; DMA). The chip has an accumulator A, a register B, a status register PSW (*program status word*), an 8 bit stack pointer, a 16 or 2×8 bit data pointer DPTR, 4 8 bit ports for use as an I/O and/or address, data, or command bus, a double serial communication register SBUF, 3 register pairs TH0-TL0, TH1-TL1 and TH2-TL2, which together form the 3 16 bit timers T0, T1 and T2, an intermediate storage register pair RCAP2H-RCAP2L for a number of functions of timer 2, and, finally, an array of registers for various command functions: IP (*interrupt priority*), IE (*interrupt enable*), TMOD, TCON & T2CON for the timers, SCON (*serial control*) and PCON (*power control*).

Circuit description

The circuit diagram of the BASIC computer is given in Fig. 2. The 8 Kbyte BASIC interpreter is internal to the microcontroller, IC_1. EPROM IC_6 holds the user's BASIC programs. The minimum amount of RAM for the 8052AH-BASIC is 1 Kbyte starting at address 0000. In the present application, the RAM area is either 8 Kbyte (0000—1FFF) or 16 Kbyte (0000—3FFF), depending on whether 1 or 2 RAMs Type 6264 are fitted (IC_4; IC_5). Write and read operations are controlled direct by signals $\overline{WR}$ and $\overline{RD}$ respectively.

The memory structure of the 8052AH-BASIC is not in accordance with von Neumann's model: the program memory is distinct from the data memory, which explains the logic combination of signal $\overline{PSEN}$ (*program store enable*: control of read operations in an external program memory) with $\overline{RD}$ in gate N_7 to select the ROM memory area (2764 = 8 Kbyte from 8000 to 9FFF; 27128 = 16 Kbyte from 8000 to BFFF). This does not exhaust all the possible memory configurations for the 8052AH-BASIC, but forms a practical as well as efficient combination—see Fig. 3. In the EPROM programming mode, the microcontroller addresses EPROMs in the memory area starting at address 8000.

Decoder IC_3 divides the memory area in blocks of 8 Kbyte. AND gate N_6 makes it possible to combine 2 block select signals when the EPROM used is a Type 27128. Normally, octal latch IC_2 demultiplexes the data and lower address bytes with the aid of signal ALE (*address latch enable*). In the EPROM programming mode, however, the LS address byte is kept latched

3

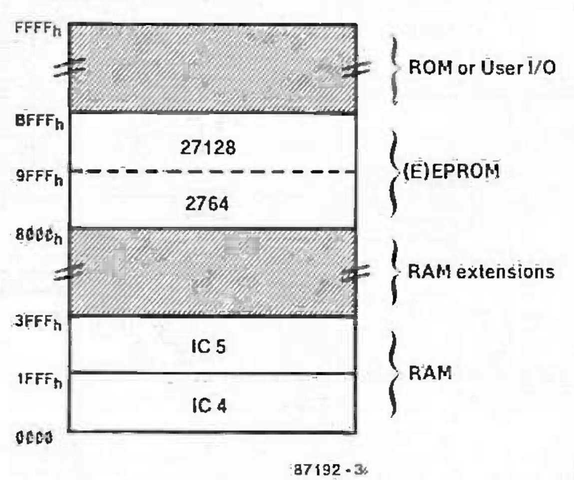

Fig. 3 Memory structure of the 8052AH-BASIC.

Table 1.

Connector K1:		Connector K2:			
Pin	Pin	Pin	Pin	Pin	Pin
1 NC	2 NC	1 +5 V	11 $\overline{PSEN}$	21 A1	31 D2
3 NC	4 NC	2 +5 V	12 RESET	22 A0	32 D3
5 I/O7	6 +5 V	3 NC	13 $\overline{WR}$	23 A14	33 D4
7 I/O6	8 +5 V	4 NC	14 NC	24 A15	34 D5
9 I/O5	10 $\overline{INT1}$	5 NC	15 A7	25 A8	35 D6
11 I/O4	12 $\overline{INT0}$	6 NC	16 A6	26 A9	36 D7
13 I/O3	14 T1	7 NC	17 A5	27 A11	37 A13
15 I/O2	16 T0	8 NC	18 A4	28 A12	38 A10
17 I/O1	18 ⊥	9 $\overline{RD}$	19 A3	29 D0	39 ⊥
19 I/O0	20 ⊥	10 ALE	20 A2	30 D1	40 ⊥

Table 1 Pinning of connectors K1 and K2.

much longer than during normal bus cycles.

This also goes for the MS address byte and the dataword—the normal duration of a programming cycle is of the order of 50 ms. The software has no direct control over the length of the ALE pulse, and this is, therefore, inhibited with the aid of N_1, N_5 and the logic low level on CPU output P1.3.

When port 0 is used in the I/O mode, pull-up resistors are required on the open drain outputs. Normally, this port functions as the data & address bus, but operates as an I/O port in the EPROM programming mode.

The TTL levels at the serial output, P3.1, of the microcontroller are converted into the corresponding positive and negative levels for the terminal. Rectifier D_1-D_2-C_1 is connected to the terminal's TXD line to provide the negative supply for TXD driver T_2. Components D_1 and D_2 can be omitted, and C_1 replaced by a wire link, when the terminal accepts and sends pulses with TTL levels.

The connections on the serial I/O connector, K_3, are given in the circuit diagram.

Table 1 shows the pin assignment on connector K_1, which carries the 8 lines of peripheral port P1, interrupt inputs $\overline{INT0}$ and $\overline{INT1}$, and lines T0 and T1, which form the external inputs of the respective timers. Line pairs $\overline{WR}$ and $\overline{RD}$, RxD and TxD, $\overline{INT0}$ and $\overline{INT1}$, and T0 and T1 together form port P3 of the 8052AH-BASIC. Apart from their normal use as I/O lines, the lines on port P1 may be used for special purposes. For example, P1.0 and P1.1 can provide trigger as well as clock pulses for timer T2. This is a standard function of the 8052, and not a particular feature of the BASIC interpreter. Lines P1.3, P1.4 and P1.5 are used for programming the majority of currently available EPROM and EEPROMs Type 2764 and 27128.

Output P1.6 is connected to input INT0 for ready implementation of a DMA (*direct memory access*) mechanism. Output P1.7 can act as a direct serial channel for driving, say, a printer, controlled with the aid of commands LIST# and PRINT#. There are more BASIC instructions for port 1: PWM, for example, offers control of the pulsewidth on output P1.2,

while instruction PORT1 enables direct read/write access.
The signal assignment on connector K2 is shown in Table 1. This connector carries lines AD0...AD7, A0...A15, and the command bus, and so enables ready connection of peripheral extension, or DMA, circuitry. It is possible to halt the processor in the *idle* mode, and so arrange for an external processor or microcontroller to temporarily gain access to the memory in the BASIC computer. The *idle* mode is initiated with the aid of the corresponding BASIC statement, and can be used for switching the microcontroller to the non-active state when no action on its part is required.
The clock oscillator is internal to the 8052AH-BASIC, and merely requires a quartz crystal and 2 capacitors. The indicated crystal frequency of 11.0592 MHz is required to ensure the correct timing for the serial channel, the real time clock, and the EPROM programming pulses. When it is intended to use, say, a 12 MHz crystal, the processor should be informed of this by declaring XTAL=12000000. It should be noted that any oscillator frequency other than 11.0592 MHz may result in reduced accuracy of the counter operations.
The computer is reset and initialized on power up either automatically (R22-C4) or manually (S1). Input $\overline{EA}$ (*external address*) is made permanently logic high because the BASIC interpreter is an *internal* memory area.

Programming EPROMs

The (E)EPROM programming facility of the present BASIC computer is, without doubt, one of its most attractive features. It is important to note that the computer is not just an EPROM programmer, but a data handling and storage system that can be customized as required for the application in question. While communicating with the user via the terminal, the 8052AH-BASIC can store edited, debugged and tested BASIC (sub)routines in EPROM to facilitate calling these as "tools" at any time. Before programming is effected, the microsoftware in the 8052AH-BASIC takes care of all the tokenizing of the object program to ensure compact storage. Depending on the programming mode, certain parameters are stored along with the program, and are instantly available when this is loaded and run. These program parameters include the baud rate, variable MTOP, an autoexecute flag, and a flag that enables skipping the memory initialization routine at power-on—this is particularly useful when the RAM is battery powered.
Finally, it is possible to use BASIC for loading an EPROM with an assembler program that is executed automatically after a RESET pulse.

With reference to the circuit diagram, when line P1.5 goes low, transistors T3, T4 and T5 ensure that the programming voltage reaches the Vpp terminal of the EPROM. The programming voltages for a number of EPROMs are listed in Table 2. The microcontroller places the LS address byte onto lines AD0...AD7, then disables ALE by making P1.3 logic low. The address byte remains latched in IC2 during the remainder of the programming cycle. The MS address byte is placed onto lines A8...A15, and the databyte onto lines D0...D7 of the EPROM to be programmed. Then, output P1.4 is made logic low, and the byte is programmed in the EPROM because $\overline{PGM}$ goes low while Vpp is applied. Instructions PROG and FPROG select a duration of the programming cycle of 50 and 1 ms, respectively. FPROG uses the intelligent programming algorithm, and may require raising the EPROM supply voltage from 5 to 6 V, which is *not* supported by the proposed circuit. Details on the intelligent programming algorithm can be found in reference [2]. In all cases, the duration of the $\overline{PGM}$ pulse is determined by the clock frequency of the microcontroller, and operator XTAL should be defined as as discussed previously.
Switch S2 enables blocking the 3 programming signals. This is done for reasons of security because port P1 can be used for purposes other than programming EPROMs.

Up to 255 BASIC modules can be held in a single EPROM, and each of these can call any of the others. The 8052AH-BASIC automatically assigns a number to each BASIC program before storing this in EPROM. The number is sent to the terminal for the programmer's reference. Loading and running a particular BASIC module is effected with the aid of commands ROM X followed by RUN. Variable X is the number of the relevant module. Modules can be copied from EPROM to RAM by means of command XFER.
The programmer has direct access to an extensive library of routines in the BASIC interpreter. Also, BASIC allows calling external machine code subroutines provided by the user. It should be noted, though, that writing (fast) machine code requires an 8051 assembler, and, of course, considerable experience in working at the assembly code level.

Table 2.

Manufacturer	Type	memory organization	Vpp
AMD	AM2764 AM2764A AM27128 AM27128A	8K × 8 8K × 8 16K × 8 16K × 8	21 V 12.5 V 21 V 12.5 V
Fujitsu	MBM2764 MBM27C64 MBM27128	8K × 8 8K × 8 16K × 8	21 V 21 V 21 V
Hitachi	HN482764 HN27C64 HN482764P HN4827128 HN27128P	8K × 8 8K × 8 8K × 8 16K × 8 16K × 8	21 V 21 V 21 V 21 V 21 V
Intel	2764 P2764 2764A 27C64 P2764A 27128 27128A P27128A	8K × 8 8K × 8 8K × 8 8K × 8 8K × 8 16K × 8 16K × 8 16K × 8	21 V 21 V 12.5 V 12.5 V 12.5 V 21 V 12.5 V 12.5 V
Mitsubishi	M5L2764 M5L27128	8K × 8 16K × 8	21 V 21 V
National Semiconductor	NMC27C64 NMC27CP128	8K × 8 16K × 8	12.5 V 12.5 V
NEC	μPD2764 μPD27C64 μPD2764C μPD27C64C μPD27128 μPD27128C	8K × 8 8K × 8 8K × 8 8K × 8 16K × 8 16K × 8	21 V 21 V 21 V 21 V 21 V 21 V
Rockwell	R87C64 R27C64P	8K × 8 8K × 8	21 V 21 V
SEEQ	2764 27128	8K × 8 16K × 8	21 V 21 V
SGS/ATES	M2764	8K × 8	21 V
Texas Instruments	TMS2564 TMS2764 TMS27128	8K × 8 8K × 8 16K × 8	25 V 21 V 21 V
Thomson-CSF	ET2764	8K × 8	21 V
Toshiba	TMM2764 TMM2764DI TMM27128	8K × 8 8K × 8 16K × 8	21 V 21 V 21 V

The type indications as given may be followed by an access time specification.

Table 2 Programming voltages for a number of EPROM types that can be loaded by the BASIC computer.

The practical use and operation of the EPROM programming facility is extremely straightforward. All that is required is to fit an EPROM in the socket for IC_6, apply the correct programming voltage, switch S_2 to PROG. EN, load the BASIC file in RAM, and issue command PROG. The other programming commands, (F)PROG1...(F)PROG6 enable storing auxiliary program information, including the baud rate indicator, and the autoexecute flag. The available options are described in the previously mentioned programming manual from Intel.

Construction

It should be reiterated that the computer described is intended mainly as an aid in developing software and hardware for automated processes and stand-alone, intelligent, controllers or data loggers, where timekeeping is an essential requirement.

The printed circuit board for the BASIC computer is double-sided and through-plated. The component mounting plan is given in Fig. 4.

It is recommended to fit good quality sockets for all ICs. The socket for EPROM IC_6 can be a type with turned pins, although a ZIF (*zero insertion force*) socket mounted as shown in the photograph of the prototype is probably the best solution. Be sure to purchase a microcontroller Type **8052AH-BASIC V1.1**. Connectors K_1 and K_2 are intended for extensions, and need not be fitted as yet. Initially, a single RAM, IC_4, is sufficient, since it offers a memory area of about 7 Kbyte for BASIC programs. Resistors $R_9 \ldots R_{16}$ incl. form an 8-way SIL network, but it is also possible to use 8 ordinary resistors, mounted vertically and commoned by a short length of wire connected to +5 V as shown in Fig. 5. The function of the LEDs, D_4 and D_6, is evident from the circuit diagram. The supply and programming voltage are applied to the circuit via soldering pins and mating sockets, insulated with the aid of heat shrink sleeving. *Do not confuse the Vcc and Vpp connections.* The PROG. EN switch, S_2, and the EPROM selector, S_3, may each be replaced by 3 pins and a mating jumper if it is not intended to frequently program EPROMs, or change between a 2764 and a 27128.

EPROM IC_6 is not required to make the circuit function. It is not fitted until it can be pro-

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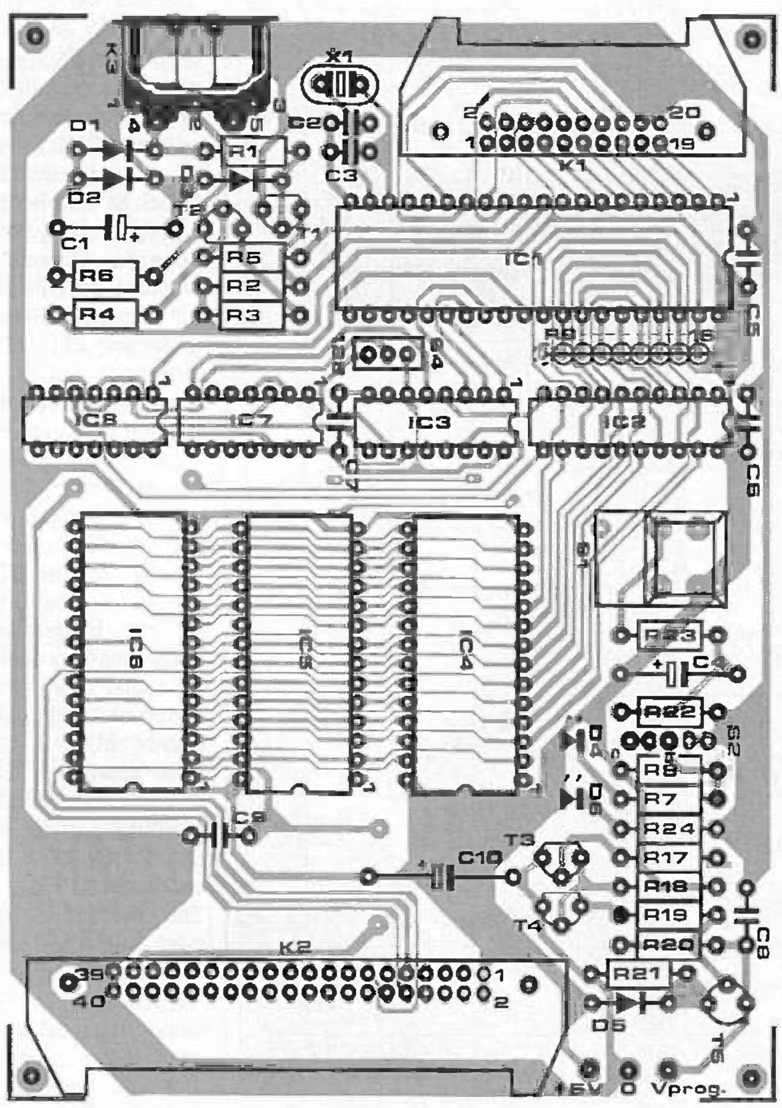

Fig. 4 Component mounting plan for the BASIC computer. The circuit board is available ready-made through the Readers Services.

Parts list

Resistors (±5%):
R_1;R_2;R_4;R_6;R_{19} = 4K7
R_3;R_{23} = 100R
R_6 = 1K8
R_7;R_{24} = 330R
R_8;R_{17};R_{18};R_{20};R_{21} = 10K
$R_9 \ldots R_{16}$ = 8-way 10K SIL network, or 8 10K resistors
R_{22} = 8K2

Capacitors:
C_1;C_4 = 10μ; 16 V
C_2;C_3 = 33p ceramic
$C_5 \ldots C_9$ incl. = 100n
C_{10} = 100μ; 16 V

Semiconductors:
D_1;D_2;D_3;D_5 = 1N4148
D_4 = green LED
D_6 = red LED
T_1;T_3;T_4 = BC547
T_2 = BC557
T_5 = BC161
IC_1 = 8052AH-BASIC VERSION 1.1*

IC_2 = 74HCT373
IC_3 = 74HCT138
IC_4;IC_5 = 6264 8Kx8 static CMOS RAM
IC_6 = 2764 or 27128 (see text)
IC_7 = 74HCT32
IC_8 = 74HCT08

Miscellaneous:
S_1 = Digitast SPST push button.
S_2 = miniature SPST switch.
K_1 = 20-way right angled IDC header with side latches.
K_2 = 40-way right angled IDC header with side latches.
K_3 = 5-way DIN socket for PCB edge mounting.
X_1 = 11.0592 or 11.059 MHz, HC18 enclosure.
28-way ZIF socket.
Jumpers and soldering pins as required.
PCB Type 87192 (available through the Readers Services).
Suitable ABS or metal enclosure.
Suitable power supply.

It is regretted that a ready-made front panel for this project is not available.

* Intel distrubutors are listed on InfoCard 505 in the March 1987 issue of *Elektor Electronics*.

The chip is also available from Universal Semiconductor Devices Limited • 17 Granville Court • Granville Road • Hornsey • London N4 4EP. Telephone: (01 384) 9420. Telex: 25157 usdco g. Fax: 01 348 9425.

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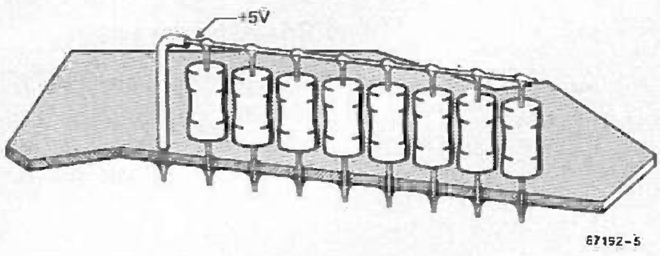


Fig. 5 Showing the use of 8 ordinary resistors instead of a SIL network.

grammed with BASIC modules, and only when the computer is turned off.

The power supply for the BASIC computer can be a simple type with regulated outputs for 5 V (500 mA), and the programming voltage(s).

Initially, the CPU and the memory chips are not fitted while the completed board is fed with Vcc and Vpp. Consult the circuit diagram and carefully check the presence of the supply voltage at all the relevant points. Make sure that there is no short circuit around pin 28 of IC_5, since the programming voltage is carried nearby. Switch off the power, carefully fit the CPU and the RAM(s) with the correct orientation, and switch the power on again.

Communication: the terminal

The serial data format for the BASIC computer is:

8 data bits, no parity, 1 stop bit.

Most terminals, consoles, or terminal emulation programs for computers can support this format.

The 3-wire connection between the BASIC computer and the terminal is shown in Fig. 6. At the terminal side, it may be necessary to hard wire a number of RS232 hanshaking lines—consult the relevant documentation. A solution that works in most cases is to connect the following pins in the 25-way RS232 connector:

4—5—8 and

6—20 (sometimes 6—20—22).

Where — denotes the connection.

The BASIC computer has an internal baud rate timing routine. Press RESET, wait a second or so, and press the space bar on the terminal. The message

*MCS-51(tm) BASIC V1.1
READY
>

is displayed on the terminal screen, and the BASIC computer is ready to accept commands.

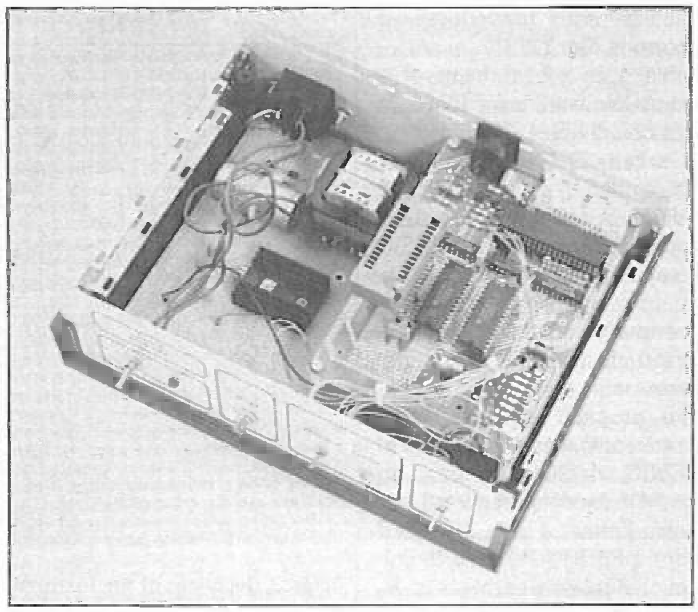
After RESET is pressed, the CPU initializes its internal RAM, and a number of pointers and registers. It then tests, initializes, and determines the size of the external memory area (IC_4 and IC_5). Next, the memory size is stored with the aid of operator MTOP (*memory top*), operator XTAL is defined (default: 11059200), and, finally, the CPU reads the data at address 8000 to check for a valid baud rate definition, programmed in EPROM IC_6. When a baud rate byte is found, it is stored in register T2CON. The computer then skips its automatic baud rate timing routine and operates at the preprogrammed serial speed, obviating the need for the terminal operator to press the space bar after actuating RESET on the BASIC computer.

The maximum baud rate is 38.4 Kbit/s, and timing characters other than 20_H (space) are not accepted.

To verify the correct operation of the system, type

PRINT XTAL,TMOD,TCON, T2CON <CR>

to which the computer replies



Inside view of a prototype of the BASIC computer.

6

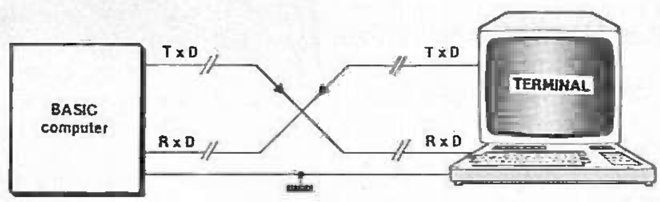


Fig. 6 The 3-wire connection between the BASIC computer and the terminal.

11059200 16 244 52

The system prompt > is displayed to indicate that the computer is ready to accept commands, which are not executed until <CR> is received. Actually, the 8052AH-BASIC starts tokenizing and storing the BASIC commands after receiving a carriage return ($0D_H$). Depending on the length of the line, and the complexity of the command(s), this takes some time, and *new characters must not be sent* until the CPU responds with the prompt, indicating completion of the storage process.

The BASIC computer is probably best programmed and controlled with the aid of a personal micro sporting an RS232 port. As to software, a terminal emulation or communication program in conjunction with a wordprocessor enables efficient editing and downloading of BASIC files. A general flowchart of a serial I/O routine to support the above

7

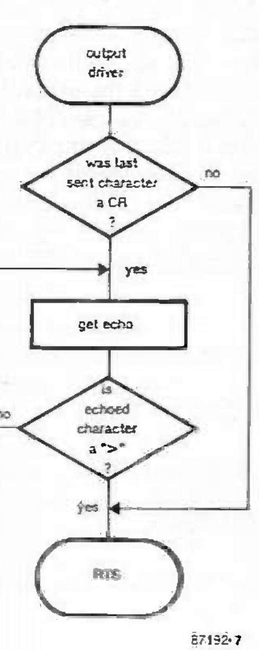


Fig. 7 The sending computer must wait for the > prompt from the BASIC computer before sending a new line of commands.

handshaking procedure is shown in Fig. 7.

Table 4 is a hex dump of a simple filehandler for IBM PCs and compatibles. The program is called SENDBAS.COM, and was written by H Peters. It loads (ASCII) BASIC files from disk, and sends these to the BASIC computer via serial port COM1:, in accordance with the previously mentioned prompt-based handshaking arrangement.

The program is loaded and written onto disk with the aid of DEBUG, which can be found on the DOS disk (use version 3.1 or later). Format a new disk, and copy DEBUG.COM onto it. Select the relevant drive, e.g. B:. Follow this instruction if you are unfamiliar with the operation of DEBUG:

DEBUG<CR>

Fill a 256 byte block with nulls:

F 0100 01FF 00<CR>

Name the program:

NSENDBAS.COM<CR>

Ready for entering the 256 bytes:

E 100<CR>

Enter the bytes (*not the addresses*) in Table 4, starting with B4. The first 2-byte address on each line is irrelevant in this case. Use the hyphen for corrections, and the space bar to proceed to the next byte. Type <CR> when the block is complete, and check the screen against the data in Table 4. If necessary, consult the chapter on DEBUG in your DOS manual.

Call up the block pointers:

RCX<CR>

and type

00FF<CR>

after the colon. Do the same with

RBX<CR>

and again

00FF<CR>

Write the .COM file to disk:

W<CR>

Leave DEBUG:

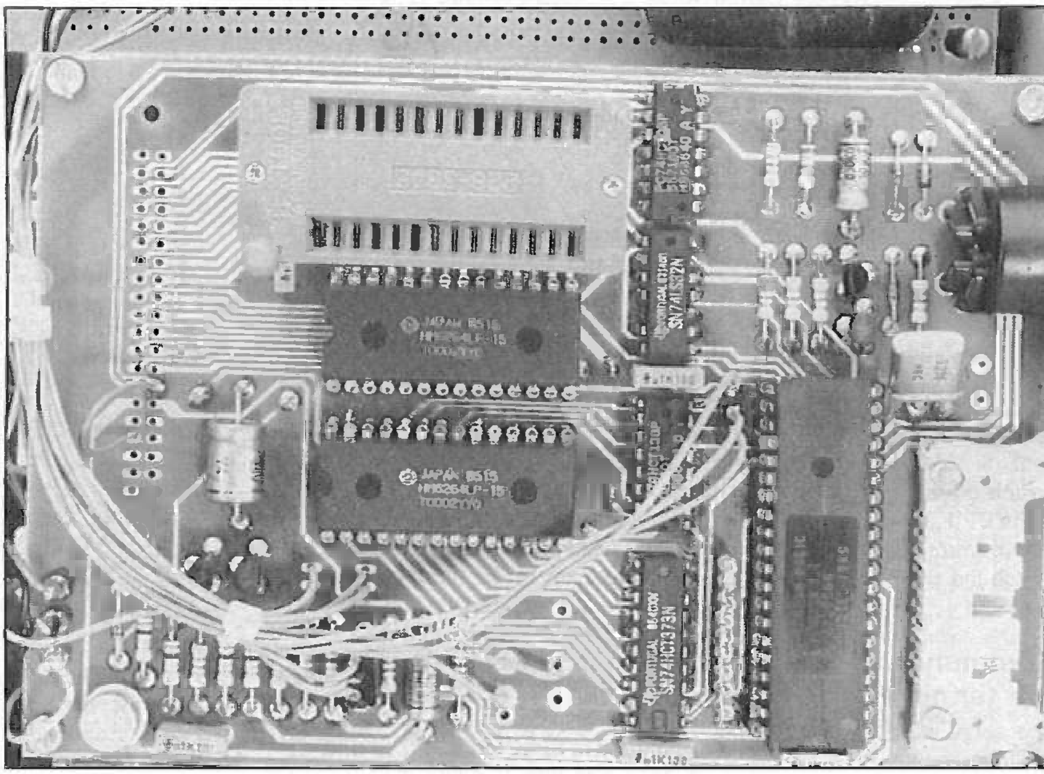
Q<CR>

The PC filehandler is now available on disk, and can be called with command SENDBAS. Test the program: the screen is cleared, and the text **ENTER FILENAME:** is displayed. Type <CR> to return to the DOS command prompt.

Table 3.

COMMANDS	STATEMENTS		OPERATORS	
RUN	BAUD	ONTIME	ADD (+)	DBY( )
CONT	CALL	PRINT	DIVIDE (/)	XBY( )
LIST	CLEAR	PRINT#	EXPONENTIATION (**)	GET
LIST#	CLEAR(S&I)	PRINT@ (V1.1)	MULTIPLY (*)	IE
LIST@ (V1.1)	CLOCK(1&0)	PH0	SUBTRACT (−)	IP
NEW	DATA	PH0.#	LOGICAL AND (.AND.)	PORT1
NULL	READ	PH0.@ (V1.1)	LOGICAL OR (.OR.)	PCON
RAM	RESTORE	PH1	LOGICAL X-OR (.XOR.)	RCAP2
ROM	DIM	PH1.#	LOGICAL NOT (.OR.)	T2CON
XFER	DO-WHILE	PH1.@ (V1.1)	ABS( )	TCON
PROG	DO-UNTIL	PGM (V1.1)	INT( )	TMOD
PROG1	END	PUSH	SGN( )	TIME
PROG2	FOR-TO-STEP	POP	SQR( )	TIMER0
PROG3 (V1.1)	NEXT	PWM	RND	TIMER1
PROG4 (V1.1)	GOSUB	REM	LOG( )	TIMER2
PROG5 (V1.1)	RETURN	RETI	EXP( )	XTAL
PROG6 (V1.1)	GOTO	STOP	SIN( )	MTOP
FPROG	ON-GOTO	STRING	COS( )	LEN
FPROG1	ON-GOSUB	UI(1&0)	TAN( )	FREE
FPROG2	IF-THEN-ELSE	UO(1&0)	ATN( )	PI
FPROG3 (V1.1)	INPUT	LD@ (V1.1)	=, >, >=, <, <=, <>	
FPROG4 (V1.1)	LET	ST@ (V1.1)	ASC( )	
FPROG5 (V1.1)	ONERR	IDLE (V1.1)	CHR( )	
FPROG6 (V1.1)	ONEX1	RROM (V1.1)	CBY( )	

Table 3 Overview of the instructions supported by the 8052AH-BASIC.



A close look at the component side of the populated board (prototype version)

Table 4.

```
A>DEBUG SENDBAS.COM
-D 0100 01FF
1E48:0100  B4 00 B0 02 CD 10 8C C8-05 10 00 8E D8 BB ED 00   ................
1E48:0110  53 E8 3B 00 7A 26 E9 94-00 5B 8A 07 43 53 3C 1A   S.;.z&...[..CS<.
1E48:0120  74 F4 3C 0A 74 16 B4 01-BA 00 00 CD 14 B4 02 BA   t.<.t...........
1E48:0130  00 00 CD 14 B4 02 8A D0-CD 21 EB DD B4 02 BA 00   .........!......
1E48:0140  00 CD 14 8A D0 B4 02 CD-21 3C 3E 75 EF EB CA B4   ........!<>u....
1E48:0150  09 BA B0 00 CD 21 B4 0A-BA CB 00 CD 21 BB CC 00   .....!......!...
1E48:0160  8A 07 3C 00 75 03 EB 45-90 BB CD 00 B9 1E 00 8A   ..<.u..E........
1E48:0170  07 3C 0D 74 06 43 E2 F7-EB 05 90 B0 00 88 07 B4   .<.t.C..........
1E48:0180  3D BA CD 00 B0 00 CD 21-8B D8 B4 3F B9 FF FF BA   =......!...?....
1E48:0190  ED 00 CD 21 8B D8 B4 3E-CD 21 B0 20 B4 01 BA 00   ...!...>.!. ....
1E48:01A0  00 CD 14 B0 0D B4 01 BA-00 00 CD 14 C3 5B CD 20   .............[. 
1E48:01B0  0D 0A 0A 0A 0A 20 20 20-20 20 45 4E 54 45 52 20   .....     ENTER 
1E48:01C0  46 49 4C 45 4E 41 4D 45-3A 20 24 1E 00 00 00 00   FILENAME: $.....
1E48:01D0  00 00 00 00 00 00 00 00-00 00 00 00 00 00 00 00   ................
1E48:01E0  00 00 00 00 00 00 00 00-00 00 00 00 00 1A 26 00   ..............&.
1E48:01F0  74 09 E8 40 E1 E8 1B F1-E8 BC E1 A1 D6 26 A3 04   t..@.........&..
-
```

87192-T4

Table 4 Hexdump of SENDBAS.COM, the filehandler for PCs and compatibles.

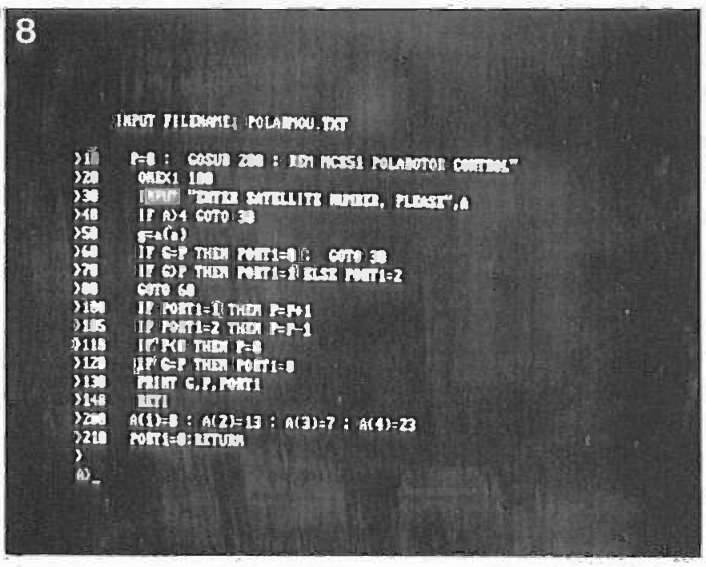


Fig. 8 SENDBAS.COM has completed sending a program to the BASIC computer via the COM1: port on a PC turbo XT. The baud rate is 1200.

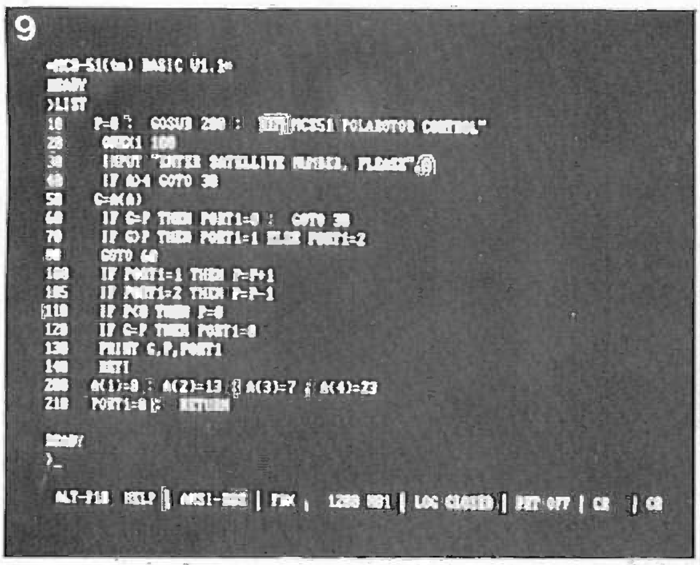


Fig. 9 The BASIC computer is on line again, and has received a program for controlling a polarmount satellite dish position system. Note the system's welcome message at the top of the screen, and the status line of PROCOMM® at the bottom.

SENDBAS.COM was tested in conjunction with PROCOMM® 2.4.2, a versatile communication program for PCs and compatibles. BASIC text files were prepared and stored onto disk in DOS text format using the wordprocessor WORDPERFECT 4.2. Other combinations of communication program and wordprocessor should also work, as long a the files for sending to the BASIC computer are written in DOS text (ASCII) format, i.e., without all the control codes specific to the wordprocessor used. As to the communication program, it is very practical if this offers a SHELL or DOS Gateway command to temporarily switch to DOS, start SENDBAS for loading the updated file, and return to the BASIC computer by means of EXIT. SENDBAS takes over the set baud rate, and awaits the > prompt from the computer before it sends a new line via COM1:. The writing of the file can be seen on the screen. After sending a file using SENDBAS, and EXITing DOS to return to the comms program, type a <CR> when the BASIC computer displays

READY
>

Type LIST to check the contents of the new program, and run it... The use of SENDBAS.COM on a PC-XT turbo is illustrated in Figs. 8 and 9.

A simple filehandler for the BBC micro is listed in Table 5. This program works in conjunction with the well-known wordprocessor VIEW, the micro's serial outlet and the communication program COMMUNICATOR, set up for VT52 emulation, XON/OFF, and, say, 9600 baud I/O. It is assumed here that the user is thoroughly familiar with these programs, and the way they are called up and exited. Test the communication between the BBC micro and the BASIC computer by pressing RESET and then the space bar as outlined above. Owners of a MASTER micro can avail themselves of the built-in terminal, obviating the need to purchase a separate communication program. Leave COMMUNICATOR, run BASIC, and enter the listing of Table 5. Run the program. It creates a small machine code routine called PRDR-52 (*printer driver* for 8052AH-BASIC), which is automatically saved onto disk. Select the computer's serial output channel by typing **FX5,2**. Call up VIEW (*W), and load or write the program (i.e. text file) for the BASIC computer. Install PRDR-52 on the serial port by typing **PRINTER PRDR-52** at the command level. The VIEW file is now sent to the BASIC computer at the specified baud rate. The fact that VIEW can not send but complete pages is of no consequence. Leave VIEW and run the terminal emulation program to control the BASIC computer direct. *Th*

Table 5.

```
   LIST
 10 MODE 7
 20 FOR ADDRESS=&4200 TO &4266
 30  READ BYTE
 40  ?ADDRESS=BYTE
 50 NEXT ADDRESS
 60 *SAVE PRDR-52 4200 4300 0400 0400
 70 END
 80 DATA &4C,&40,&04,&4C,&0F,&04,&4C,&26,&04,&4C,&3C,&04,&4C,&3D,&04
 90 DATA &48,&8A,&48,&98,&48,&A9,&02,&20,&EE,&FF,&A9,&02,&A2,&01,&20
100 DATA &F4,&FF,&68,&A8,&68,&AA,&68,&60,&48,&8A,&48,&98,&48,&A9,&03
110 DATA &20,&EE,&FF,&A9,&02,&A2,&00,&20,&F4,&FF,&68,&A8,&68,&AA,&68
120 DATA &60,&A0,&00,&60,&8D,&FE,&04,&48,&8A,&48,&98,&48,&AD,&FE,&04
130 DATA &C9,&0D,&F0,&09,&20,&EE,&FF,&68,&A8,&68,&AA,&68,&60,&20,&E7
140 DATA &FF,&20,&E0,&FF,&C9,&0A,&D0,&F9,&20,&E0,&FF,&C9,&3E,&D0,&F2
150 DATA &4C,&52,&04
>
```

87192-T5

Table 5 This program creates PRDR-52, the filehandler for the BBC micro running VIEW and COMMUNICATOR.

References:

(1) *Single-chip microcontrollers. Elektor Electronics*, September 1987, p. 18 ff.

(2) *MSX extensions — 5: EPROM programmer (2). Elektor Electronics*, April 1987, p. 52 ff.

THE DIGITAL AUDIO TAPERECORDER

Earlier this year, a number of Japanese manufacturers introduced a new type of personal taperecording system, which has become known as Digital Audio Taperecorder–DAT. Although this system ran into immediate problems with the combined might of the western world's record makers and composers' and music writers' organizations (which at the time of writing have still not been wholly resolved), it appears that it is here to stay.

There is as yet no standard for the DAT or the tape cassettes, although proposals have been submitted to the International Electrotechnical Commission. Data, standards, and specifications referred to in this article are as contained in those proposals.

Cassette

The information carrier is a magnetic tape of 3.81 mm width rolled on flangeless hubs installed in a cassette with a slider and a lid protecting the tape from accidental damages. The tape is a metal powder type or its equivalent.

Information is recorded on oblique tracks formed by helically scanning magnetic heads and can be erased by overwriting. Information is read by magnetic heads that follow the tracks with the aid of Automatic Track Finding–ATF.

The external dimensions of the cassette are 73×54×10.5 mm: it is thus somewhat smaller than the compact audio cassette.

Recorder mechanism

The mechanism of the recorder resembles that of a video cassette recorder–VCR–but it is somewhat smaller (roughly the same size as the mechanism of a Video-8 machine).

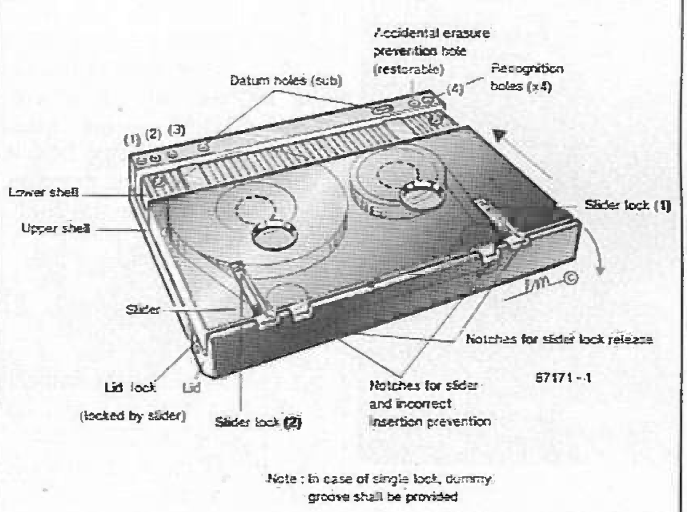
The rotary head drum has a diameter of 300 mm and rotates at a velocity of 2000 rev/min. The angle at which the tape lies around the drum is 90°. The normal tape speed is low: only 8.150 mm/sec. The resulting relative tape speed is, therefore, 3.130 m/sec (the tape speed in a VHS video recorder is 4.85 m/sec). Other tape speeds are: 4.075 mm/sec (half speed) and 12.225 mm/sec (wide track).

The track pitch is 13.591 μm in normal track mode and 20.410 μm in wide track mode. The track length is 23.501 mm (normal mode) and 23.471 mm (wide track mode).

The track angle (tape running) is 6°22'59.5" in the normal mode and 6°23'29.4" in the wide track mode. The azimuth angle of the two heads is ±20°±15' (see Fig. 3).

The above, and some other, data are summarized in Table 1. Since there are only two heads and the tape runs along only a quarter of the drum diameter

1



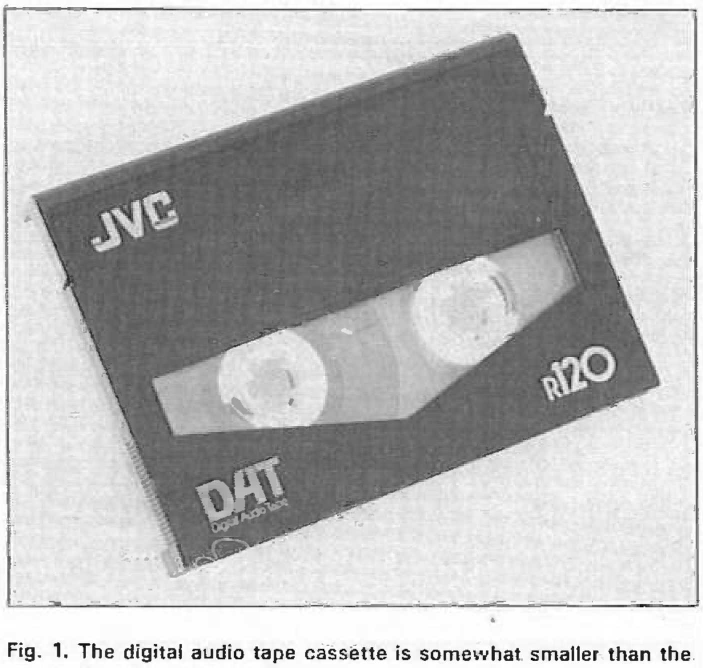


Fig. 1. The digital audio tape cassette is somewhat smaller than the compact audio cassette.

Table 1

Tape width	3.810 mm
Recording width	2.613 mm
Track centre	1.905 mm
Tape speed (normal)	8.150 mm/s
(half speed)	4.075 mm/s
(wide track)	12.225 mm/s
Track length	23.501 mm
Track pitch (normal)	13.591 μm
(wide track)	20.410 μm
Trank angle (normal)	6°22'59.5"
(wide track)	6°23'29.4"
Head azimuth	±20°±15'
Optional track 1	0.5 mm
Optional track 2	0.5 mm

Table 1. Tape specifications (normal mode).

(see Fig. 3), the heads will scan the tape for only half the total usable time. This means that the data have to be stored on the tape in time-compressed form: during reading they have to be expanded again. The output signal of the heads is shown in Fig. 4.

The small angle between the tape and the head drum gives the advantage that pull on the tape is small, and also that even during fast forward or rewind operation the tape can remain in contact with the drum. This is essential to facilitate finding a specific passage on the tape quickly (at 200 times normal tape speed). The pull on the tape is then about the same as that on normal video tape.

Recording parameters

Recording parameters are summarized in Table 2. Information is recorded on a main data area as well as on a sub data area, exactly as on a compact disc. However, the sub data area is about 4.5 times as large as that on a CD.

The composition of a single track is shown in Table 3. It is seen that the largest part of the available space is occupied by modulation and subcodes, but the track also contains synchronization data and Automatic Track Following—ATF—zones. These zones enable automatic tracking of the heads. The individual function blocks are separated by the Inter Block Gaps-IBG. This separation is necessary to enable writing in the sub data area without affecting the modulation data. In principle, only the main data and sub data areas are of importance to the user, because these are the parts that are audible to him.

From analogue to PCM

It is seen from Table 2 that the normal recording and playback sampling frequency is 48 kHz (the other sampling frequencies will be reverted to later). Sampling is carried out at a resolution of 16 bits. This means that every 21 μs a portion of the analogue input signal is translated into a 16-bit code. This happens simultaneously for the left-hand and right-hand channels. The digital data are subsequently processed in serial form. The data stream consists, therefore, of $48 \times 10^3 \times 16 \times 2 = 1.536$ Mbit/s.

2

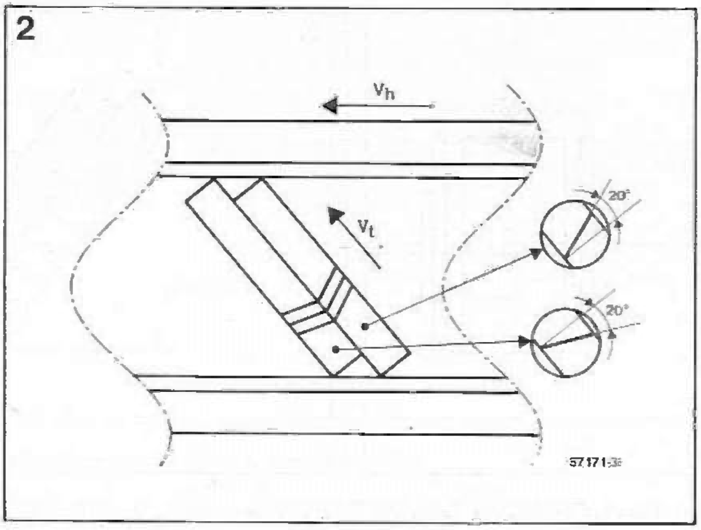


Fig. 2. Arrangement of the tracks on the tape.

3

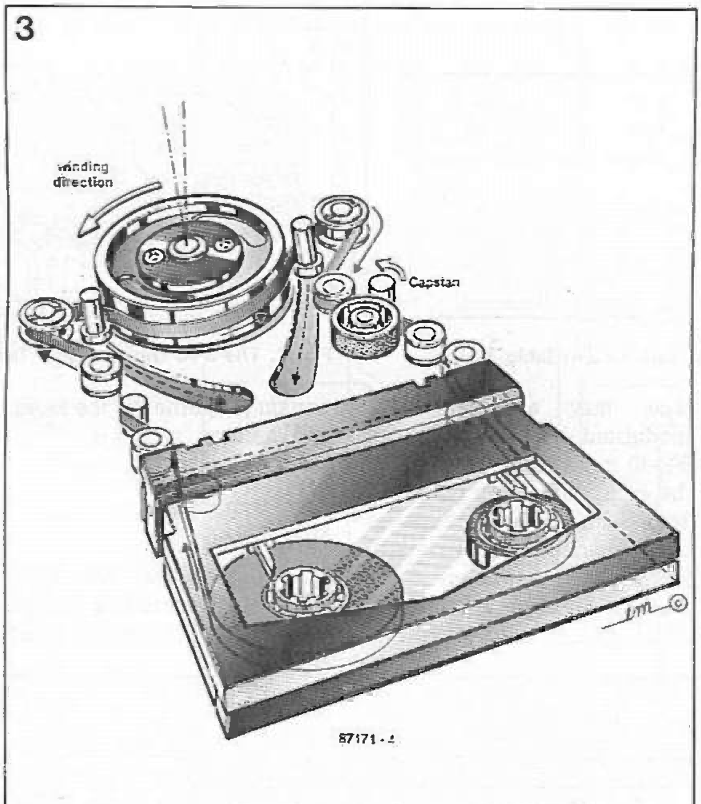


Fig. 3. Exploded view of a digital audio tape cassette.

Table 2

Number of channels	2 (optionally 4)
Sampling frequencies	48 kHz; 44.1 kHz; 32 kHz
Quantization	16 bits linear (optionally 12 non-linear)
Encoding	2 complement
Error correction	double Reed-Solomon code
Sub code	273.1 kbit/s
PCM capacity (each track)	4 kbit
ID codes	68.3 kbit/s
ID capacity (each track)	1 kbit
Transfer speed	2.46 Mbit/s
Information density	114 Mbit/in²

Table 2. Technical parameters of the DAT system.

Processing of PCM data

The PCM data are encoded according to the Reed-Solomon code, which is also used in CD technology. However, in contrast to the CD process, the DAT technique uses the product code of two Reed-Solom codes, which results in an inner and an outer code. The inner code contains the data bits and the parity bits derived from these according to a certain pattern. This encoded block is surrounded by the outer code, which forms its own parity bits form data contained in the inner code. After this, the data are interleaved, i.e., shifted in time, to enable reconstruction of a possibly lost data bit.

The Reed-Solomon coding and interleaving result in a data redundancy of about 37%, which causes the data stream rate to increase to some 2.45 Mbit/s. Added to this are the sub data information, such as the sampling frequency, the number of channels, copy protection, and so on, which finally gives a data stream rate of 2.77 Mbit/s.

The data thus composed are divided into blocks of 288 bits. The modulation zone of a track can contain 128 of these blocks, each comprising 32 bytes: a total of 4096 bytes. Of these, only 2912 bytes are real data: the remainder serve for error correction.

To increase the reliability even further, the data are divided into blocks, each of which contains the even samples of one channel and the odd ones of the other channel. These blocks are cross-interleaved onto the ± azimuth tracks as shown in Fig. 6. In this way, even when a complete track is lost, or a head malfunctions, reconstruction is possible by interpolation of the adjoining tracks.

Since the heads are in contact with the tape for only 50% of the time, the data can not be read or written in real time. The PCM data are, therefore, stored in a 2 x 64 kbit auxiliary memory at the sampling frequency, then read at a higher clock frequency, and subsequently writ-

4

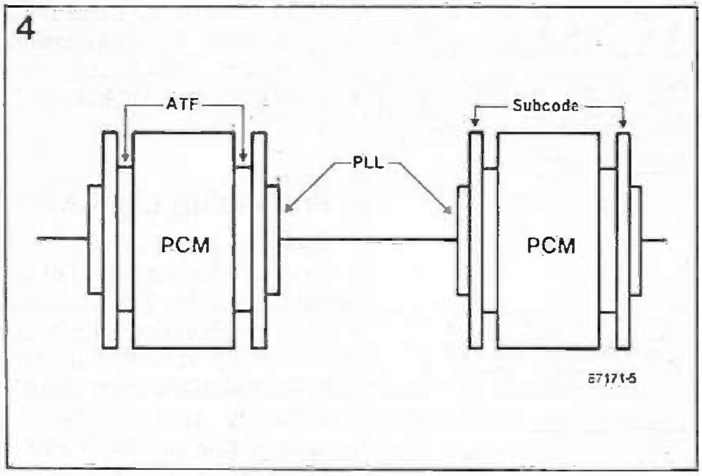


Fig. 4. The output signal of the heads consists of a series of bursts.

5

Sync 8 bit	ID 8 bit	block address 8 bit	Parity 8 bit	data 256 bit

87171-7

Fig. 5. The composition of the main data area in Table 3.

6

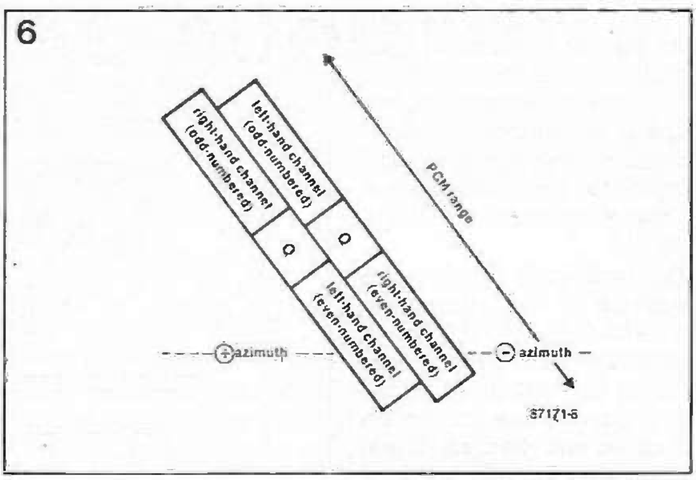


Fig. 6. Illustrating the cross-interleaving of the channels in the modulation range. Areas Q are separation zones between the data areas.

7

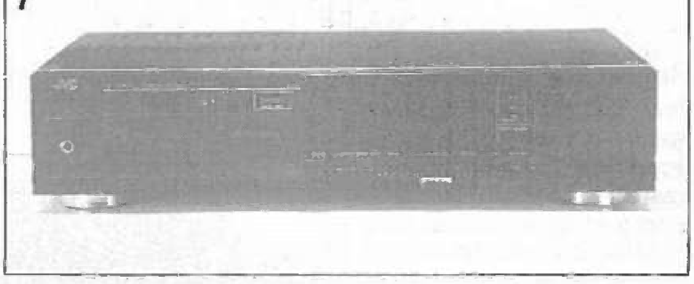


Fig. 7. The JVC Digital Audio Taperecorder.

ten onto the tape. In this manner, the rate of the original 2.46 Mbit/s data stream is increased to 7.5 Mbit/s.

Modulation of data

When writing the data onto the tape, they are not truly modulated, but subjected to an 8-to-10 conversion. Because of the consequent Non Return to Zero—NRZ—a signal edge is only generated if the bit is 1. In this way, the frequency spectrum on the tape is reduced, which is necessary in view of certain properties of the heads and the tape.

Playback

During playback, the operations of the recording process are carried out in reverse order. First, the clock frequency is extracted from the HF signal produced by the heads, after which the signal is reconverted from 10 to 8 bits. Subsequently, the cross-interleaving of the data has to be negated, for which the same 2x64 bit auxiliary memory is used. Here, the data are first written and then read again in the correct order. The sub data are separated from the remainder of the information and fed to the system control circuits.

Next, an error correction is carried out with the aid of the double-coded Reed-Solomon code. After this, digital sound data are available which can be processed in a manner similar to those in a CD player. These data are controlled by a digital-to-analogue converter, which may operate with twice or four times oversampling to avoid the necessity of steep-skirted analogue filters.

Table 3

Areas	Contents	Number of blocks
Marginal area	Margin 1	11
Sub area 1	Pre-amble 1 Sub data area 1 Post amble 1	2 8 1
ATF area 1	IBG 1 ATF 1 IBG 2	3 (2) 5 (7.5) 3 (1.5)
Main area	Pre-amble 2 Main data area	2 128
ATF area 2	IBG 3 ATF 2 IBG 4	3 (2) 5 (7.5) 3 (1.5)
Sub area 2	Pre-amble 3 Sub data area 2 Post amble 2	2 8 1
Marginal area	Margin 2	11

Note: The number in parentheses is for wide track mode.

Table 3. The format of a track (signal allocation) is in accordance with this table.

Sampling frequencies

So far, it has been assumed that the input signal is analogue, for which the sampling frequency is 48 kHz. This frequency is also used for the copying of other DAT tapes (but

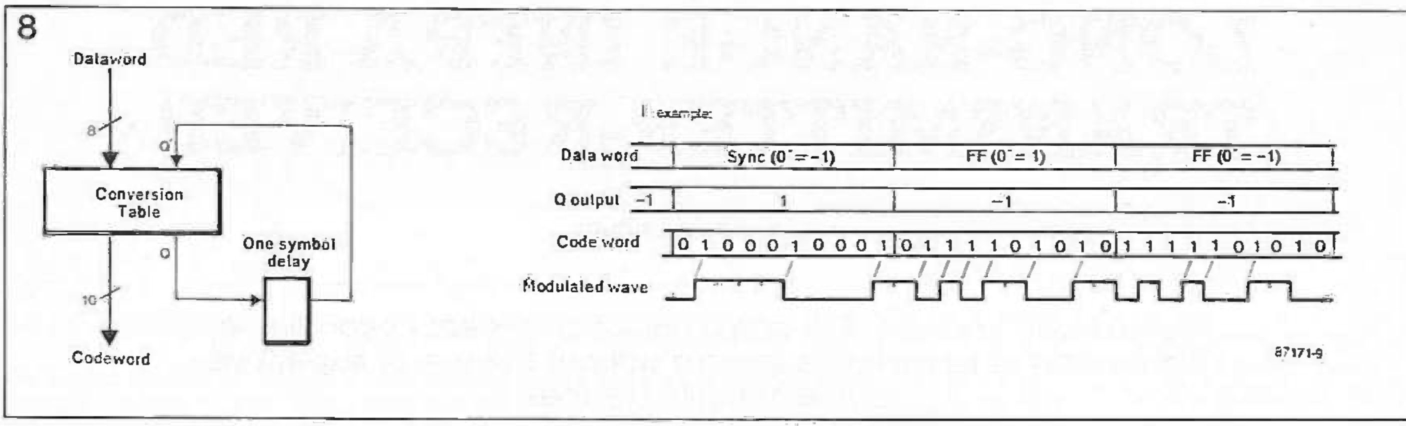


Fig. 8. In the NRZ process a signal edge is generated for each logic high bit.

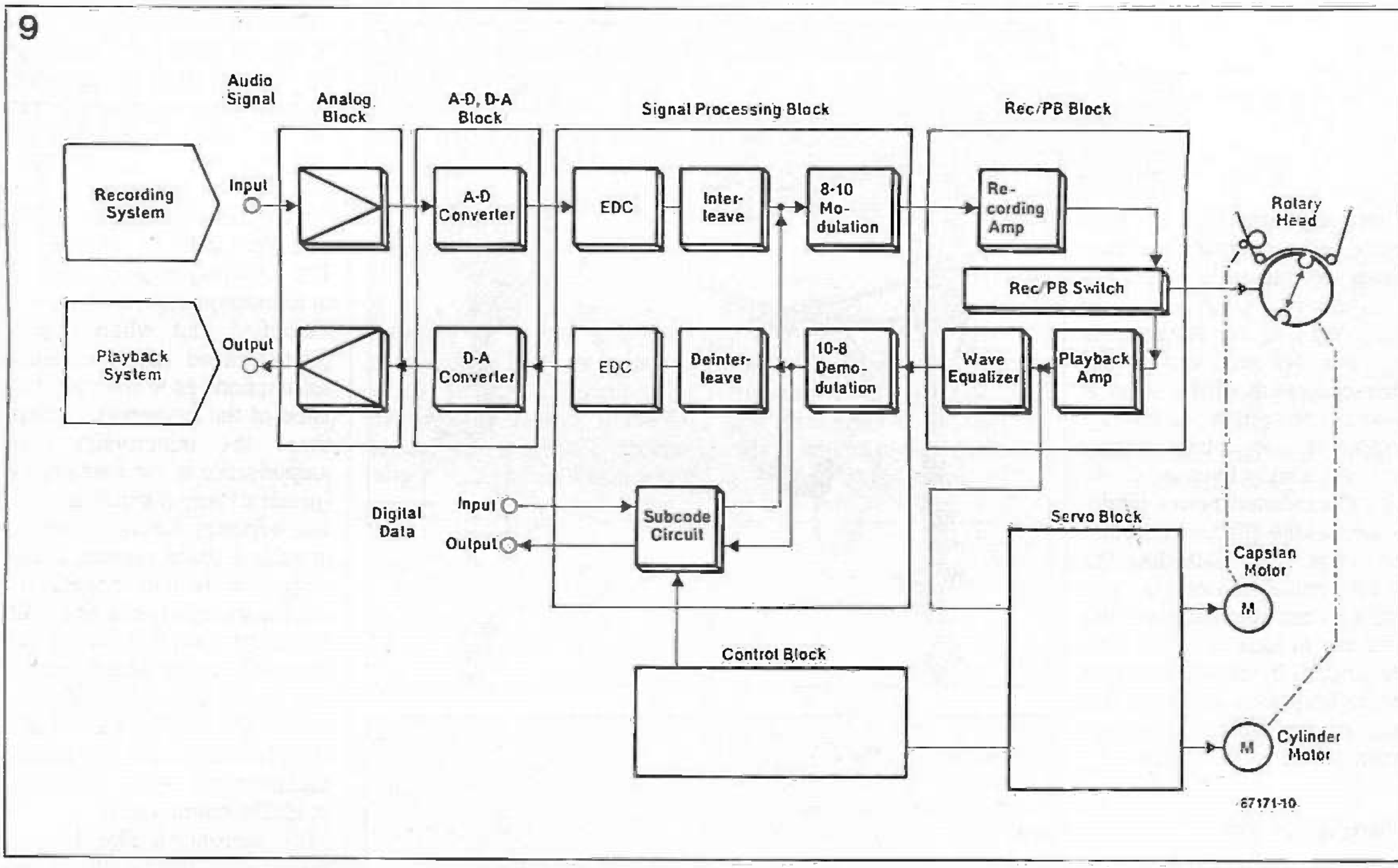


Fig. 9. Block schematic of a typical digital audio taperecorder.

not proprietary pre-recorded ones—see under).

The 32 kHz sampling frequency is used for 4-channel recording of analogue input signals. It is also intended for future recording of digital satellite channels. With this low sampling frequency, the frequency range is limited to 15 kHz.

The sampling frequency of 44.1 kHz (the same as that of compact discs) is provided for the playback of proprietary pre-recorded tapes. This enables makers of these tapes and CDs to use the same mother tape in the production process.

The DAT has a copy protection circuit that prevents the direct recording from compact discs. This is incorporated at the in-

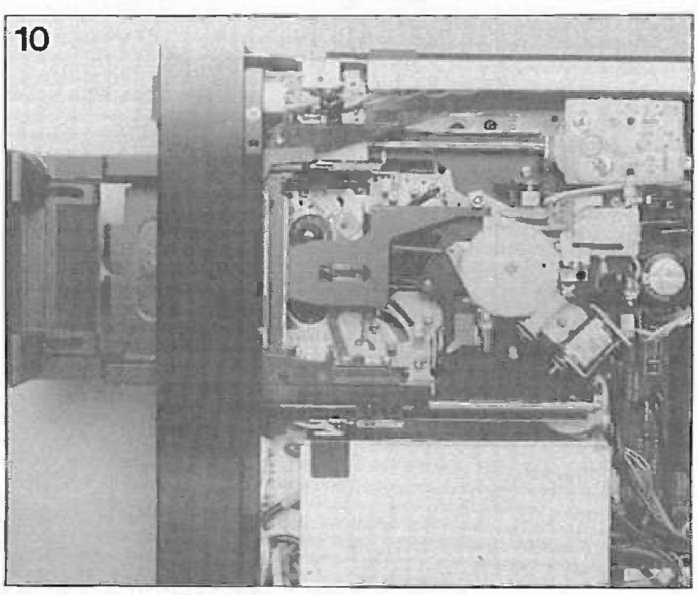


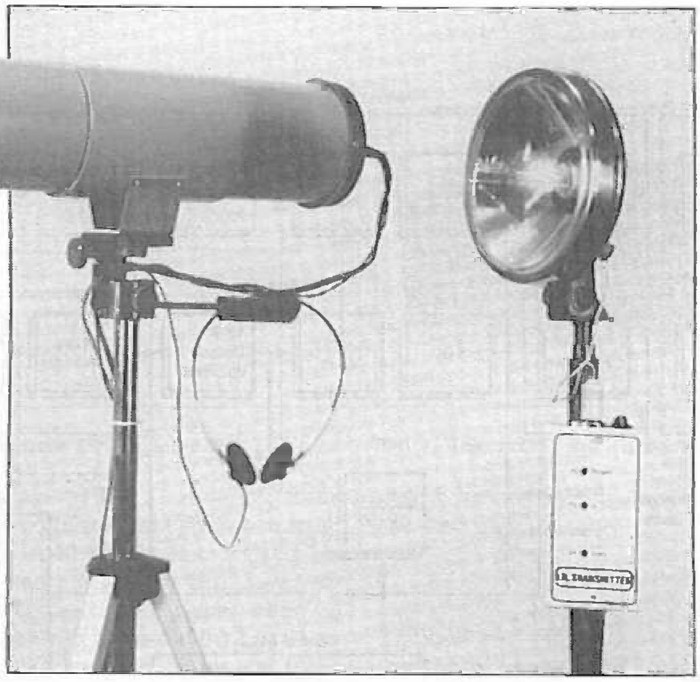
Fig. 10. Typical DAT recorder mechanism.

sistence of the record industry in the western world, backed by their respective governments. In view of the regrettable failure by governments to protect these industries against the nefarious copying of gramophone records, this decision must be welcomed by any sensible person. None the less, there have already been rumours that some DAT manufacturers are threatening to market DATs without copy protection. Fortunately, many governments have already countered these by prohibiting the manufacture or import of such recorders in their countries. It must be hoped that all western countries will be united in this determination.

LONG-RANGE INFRA-RED TRANSMITTER-RECEIVER

by J C Stekelenburg

This two-way, infra-red, FM, communication system covers line-of-sight paths of remarkable lengths without the use of expensive optoelectronic devices.



There are many who are convinced that infra-red components are only useful for remote control systems with a range of 10 metres or so. Powerful IR emitters are well out of the financial reach of the average home constructor, and their usefulness is often rightly queried simply because doubling the radiated power hardly increases the effective transmitter range. Notwithstanding the latest achievements in optoelectronic technology, the real key to long-distance communication in the infra-red part of the frequency spectrum is a well-known physical phenomenon: beam convergence.

Principles of telecommunication

Telecommunications engineers use calculated, i.e., hypothetical, models to assess and study the technical feasibility of point-to-point communication links in the available frequency bands. A general model of a link between an FM (frequency modulation) transmitter and receiver is shown in Fig. 1. At the transmitter side, the aerial gain is G_T, at the receiver side G_R. In the present case, the centre frequency used is 313 THz (terahertz, 10^{12} Hz), which means that the main component in the radiated spectrum has a wavelength of about 950 nm. This is slightly longer than the wavelength of the darkest shade of red visible to the human eye. The fact that infra-red *light* is transmitted and received makes it possible to use optical devices, such as reflectors and lenses, as "aerials".

Long-range IR transmitter-receiver

Technical specifications.

Transmitter.	
Modulation:	FM.
Preemphasis, τ:	50 μs.
Radiant power, P_T:	0 - approx. 10 mW.
Transmitted waveform	rectangular, duty factor = 0.5.
Supply voltage:	12 V.
Maximum current consumption:	approx. 125 mA.
Wavelength	950 nm.
Spectral bandwidth (-3 dB), $\Delta\lambda$:	±20 nm.
Maximum deviation (f_c = 100 kHz), Δf:	±50 kHz.
Sensitivity of line inputs:	250 mV_{rms}.
Receiver.	
Supply voltage:	12 V.
Maximum current consumption:	approx. 75 mA.
Deemphasis, τ:	50 μs.
Wavelength:	950 nm.
VCO range, f_0:	65 - 150 kHz.
VCO lock range, f_L:	$\pm \frac{2}{3} f_0$.
VCO capture range, f_c:	±17 kHz.

The following step-by-step link budget calculation is purposely simplified, and, where appropriate, based on reasonable assumptions as to the performance of the equipment. Sometimes the (electronic) term *amplification* is used where the (physical) term *magnification* or *convergence factor* is, strictly speaking, more correct. Reference is made to the denotations shown in Fig. 1, and the main technical specifications of the infra-red components used—see Fig. 2. The IRED (infra-red emitting diode) Type LD271 and the photodiode Type BP104 are inexpensive and generally available components.

With reference to Figs. 1 and 2, the radiant power, P_T, at the transmitter side is 10 mW into an aerial with an assumed power gain, G_T, of 20 dB ($\hat{=}$ 100×). The effective radiated power (ERP) is therefore +30 dBm, or 1 W.

Figure 2 shows that the photodiode Type BP104 generates a *noise equivalent power* (NEP) of 4.2×10^{-14} W $(\sqrt{Hz})^{-1}$. The effective radiant sensitive area, A, is 5.06 mm^2. The power gain, G_R, of the receiver aerial of radius r is calculated from

$$G_R = 10\log_{10}(\pi r^2/A) \qquad [1]$$

$$= 10\log_{10}(0.621 r^2) \text{ [dB]}.$$

With r given as 50 mm, G_R becomes approximately 32 dB. It is assumed that the receiver input has a noise factor, F_0, of 3

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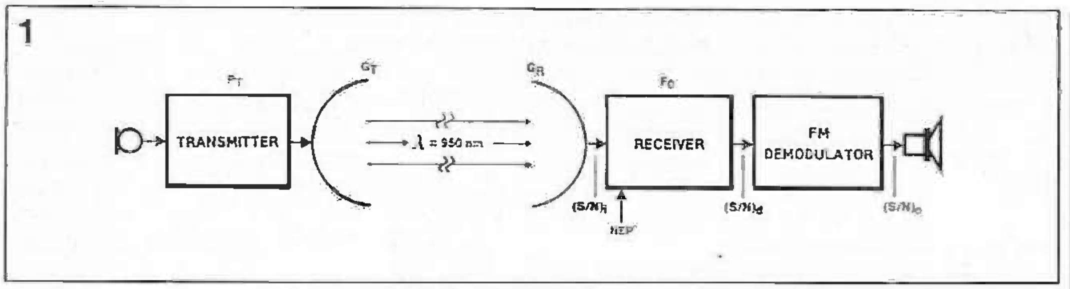


Fig. 1 A hypothetical infra-red communication system.

($\triangleq F_{dB}$ = 4.7 dB, this is a quite average value), while the transmitter is modulated with a single tone of frequency $f_{(m)}$, producing a deviation Δf. Also assuming that the pre-detection signal-to-noise ratio, $[S/N]_d$, is between 10 and 15 dB, i.e., above the detection threshold for FM signals, and that Δf = ±50 kHz, the output signal-to-noise ratio, $[S/N]_o$, of the ideal FM demodulator is calculated from

$$[S/N]_o = {}^3/_2(\Delta f/f_{(m)})^2[S/N]_d \qquad [2]$$

where

$$[S/N]_d = (1/F_0)[S/N]_i \qquad [3]$$

Returning to the technical specifications of the LD271, it is seen that the IRED used supplies a radiant intensity, I_e, of 10 mW per steradian (sr) at a continuous, forward, current of 100 mA. The light beam emitted by an IRED is cone-shaped, making it fairly difficult to calculate the radiant intensity received on the flat surface of the photodiode. Figure 3 shows that the distance x between the transmitter and the receiver is a function of the divergence of the transmitter beam. The radiant intensity on the concave area $A_{(TZ)}$ is 10 mW sr^{-1}, since α = 1 rad ≈ 57.3°. In order to avoid complex calculations for determining the ratio of the *flat* area A with respect to the *concave* area $A_{(TZ)}$, the beam width is assumed to decrease from 1 radian (α) to 0.1 radian (Ω). This enables considering the resultant beam area, $A_{(B)}$, flat, as well as A, which forms a part of it (see the front view in Fig. 3). It can be shown that I_e = 0.1 mW in 0.1 sr given that I_e = 10 mW sr^{-1}. Figure 3 shows that it is reasonable to consider the IR beam to have a flat area $A_{(B)}$ of radius r where it is incident on the photodiode D, so that

$$r = x \times \tan(\tfrac{1}{2}\Omega) \approx 0.05x \qquad [4]$$

$$A_{(B)} = \pi(0.05x)^2. \qquad [5]$$

Assuming no atmospherical attenuation over the distance x, area A receives an amount of incident radiant power, P_R, that is a portion of I_e within 0.1 sr, whence

$$P_R = I_e \times \frac{5.06\times10^{-6}}{(0.05x)^2} =$$

$$10^{-4} \times \frac{5.06\times10^{-6}}{(0.05x)^2} =$$

$$\frac{6.443\times10^{-8}}{x^2}\ [\mathrm{W}] \qquad [6]$$

This calculation is valid for transmission through a vacuum. The atmospheric attenuation factor for λ = 950 nm is approximately 4 km^{-1} (≙6 dB km^{-1}). Provided the calculations remain based on *factors* rather than *decibels*, the atmospheric attenuation can be taken into account by rewriting P_R as

$$P_R = \frac{6.443\times10^{-8}}{x^2 \times 4^{(x/1000)}}\ [\mathrm{W}] \qquad [7]$$

The signal-to-noise ratio at the receiver input, $[S/N]_i$, is simply the ratio of P_R (S, the signal) to NEP (N, the self-generated noise of the photodiode) within a given bandwidth. The amplification of P_R in the reflector (G_T, transmitter aerial) and the lens (G_R, receiver aerial) can be in-

2

LD271

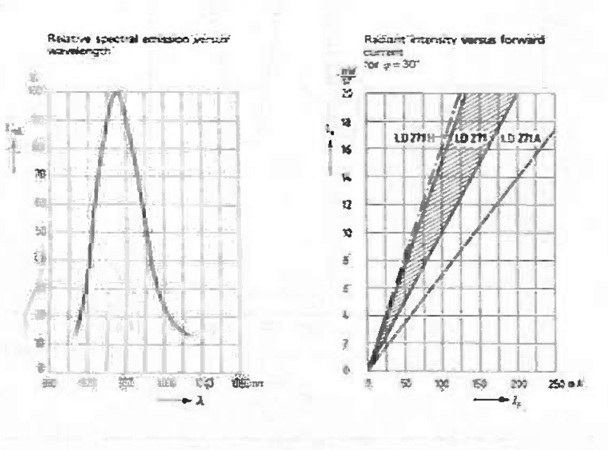
Characteristics (T_{amb} = 25 °C)

Wavelength at peak emission at I_{max}	λ_{peak}	950	nm
Spectral bandwidth at 50% of I_{max}	$\Delta\lambda$	±20	nm
Radiant intensity in axial direction at I_F = 100 mA, for half angle φ = 30°			
LD = 271 A	I_e	≥7	mW/sr
LD = 271	I_e	15 (≥10)	mW/sr
LD = 271 H¹)	I_e	≥16	mW/sr
Radiant flux (I_F = 100 mA) (typ.) total	Φ_e	16	mW
Half angle (limits for 50% of radiant intensity I_e)	φ	25	degrees
Switching times (I_e from 10% to 90%; I_F = 100 mA)	t_r, t_f	1	µs
Capacitance (V_R = 0 V)	C_0	40	pF
Forward voltage (I_F = 100 mA)	V_F	1.35 (≤1.7)	V
Breakdown voltage (I_R = 100 µA)	$V_{(BR)}$	30 (≥4)	V
Reverse current (V_R = 3 V)	I_R	0.01 (≤10)	µA
Temperature coefficient of I_e or Φ_e	TC	−0.55	%/K
Temperature coefficient of V_F	TC	−1.5	mV/K
Temperature coefficient of λ_{peak}	TC	+0.3	nm/K

BP104

Characteristics (T_{amb} = 25 °C)

Spectral sensitivity (V_R = 5 V) (λ = 950 nm)	S	40 (≥25)	µA·cm²/mW
Wavelength of max. spectral sensitivity	$\lambda_{S\,max}$	950	nm
Quantum yield (Electrons per photon) (λ = 950 nm)	η	0.92	Electrons/Photon
Spectral sensitivity (λ = 950 nm, V_R = 5 V)	S_λ	0.71	A/W
Rise and fall time of the photocurrent from 10% to 90% and from 90% to 10% of the final value			
(R_L = 1 kΩ; V_R = 0 V; λ = 950 nm)	t_r, t_f	125	ns
(R_L = 1 kΩ; V_R = 10 V; λ = 950 nm)	t_r, t_f	10	ns
Temperature coefficient for I_S or I_P, resp.	TC	0.18	%/K
Capacitance			
(V_R = 0 V; f = 1 MHz; E = 0)	C_0	48	pF
(V_R = 3 V; f = 1 MHz; E = 0)	C_3	17	pF
Radiant sensitive area	A	5.06	mm²
Dark current (V_R = 10 V)	I_R	2 (≤30)	nA
Noise equivalent power (V_R = 10 V)	NEP	4.2×10^{-14}	W/√Hz
Detection limit	D^*	5.4×10^{12}	cm√Hz/W



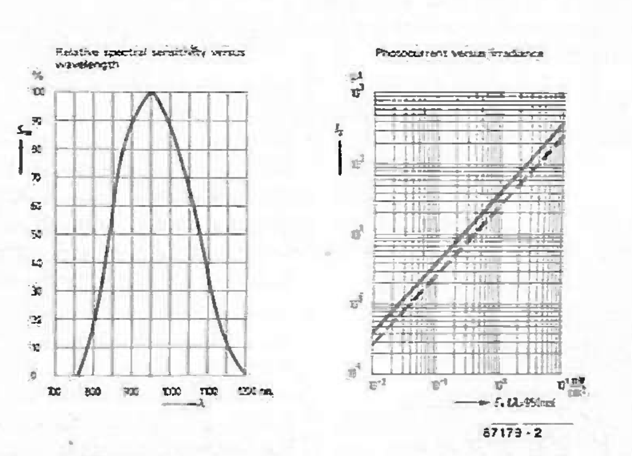


Fig. 2 Essential technical characteristics of the infra-red components used in the transceiver (*courtesy Siemens*).

cluded in the link budget, as well as NEP for $\Delta f = \pm 50$ kHz:

$$NEP = 4.2\times10^{-14}\times\sqrt{100{,}000} \quad [8]$$
$$NEP = 1.33\times10^{-11}\ [W].$$

So:

$$\frac{S}{N_i} = \frac{P_R}{NEP} = \frac{6.443\times10^{-8}\times G_T\times G_R}{1.33\times10^{-11}x^2 4^{(x/1000)}}$$

$$= 4844 G_T G_R x^{-2} 4^{-(x/1000)}$$

$$= 4844 G_T(\pi r^2/5.06)x^{-2}4^{-(x/1000)}. \quad [9]$$

Where x is in metres, and r in millimetres. In equation [9], the distance, x, is a double variable (it is squared as well as part of an exponent). This means that x can only be resolved with the aid of successive approximation, which will not be discussed here. Instead, 3 sample calculations are given to indicate the (theoretical) potential of the system.

It will be clear that the lens at the receiver side is of radius r, as shown in Fig. 3. This means that all radiant power within the specified solid angle Ω is captured and converged onto the photosensitive area of the IR diode D. Practical aspects of the reflector and the lens will be reverted to.

What is the maximum, theoretical, distance that can be covered by this system, so that the received signal is just about audible in the receiver?

An FM signal exceeds the noise threshold when

$$[S/N]_d \geq 10\ (\triangleq 10\ \text{dB}) \quad [10]$$

requiring that

$$[S/N]_i \geq 30\ (\triangleq 15\ \text{dB})\ \text{at}\ F_0 = 3. \quad [11]$$

Having defined this minimum requirement for the input signal strength, it becomes possible to propose 3 versions of the IR communication link:

1. No optical amplification ($G_T = G_R = 1$):

$$x \cong \sqrt{\frac{4844}{30}} \cong 12.7\ \text{m}. \quad [12]$$

2. Only a lens at the receiver side ($r = 50$ mm):

$$x \cong \sqrt{\frac{4844}{30}\times\frac{\pi(50)^2}{5.06}\times0.59}$$
$$\cong 384\ \text{m}. \quad [13]$$

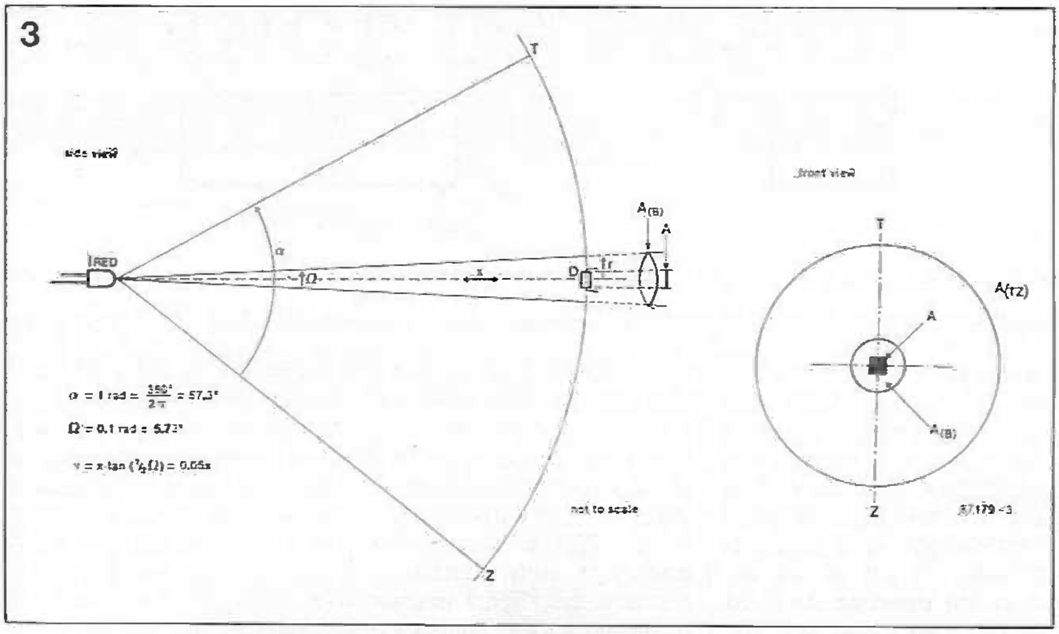


Fig. 3 The theorectical distance covered by the system is the length, *x*, of the conical infra-red light beam.

3. A lens at the receiver side ($r = 50$ mm), and a reflector at the transmitter side ($G = 100 \triangleq 20$ dB)—this is the full system. shown in Fig. 1:

$$x \cong \sqrt{\frac{4844}{30}\times\frac{\pi(50)^2\times100}{5.06}\times0.1}$$
$$\cong 1{,}625\ \text{m}. \quad [14]$$

The above calculations also enable a reasonable prediction to be made of the S/N ratio of the received AF signal at a distance of, say, 1,000 metres, with Δf given as ± 50 kHz and $f_{(m)} = 10$ kHz (option 3.):

$$[S/N]_i =$$
$$4844\times100[\pi(50)^2/5.06]\times4^{-1}\times10^{-6}$$
$$= 188 \quad [15]$$

whence

$$[S/N]_o =$$
$$\tfrac{3}{2}(50/10)^2\times\tfrac{1}{3}\times188 = 9403$$
$$\approx 40\ \text{dB}. \quad [16]$$

This is, theoretically, sufficient for receiving speech or music of reasonable quality. The previously given calculations enable determining the minimum system layout for a given range x. It should be remembered, however, that all calculated distances are entirely based on theory, representing the absolute, and in practice virtually unattainable, limits of the system.

Through the atmosphere

It goes without saying that some spare capacity should be designed into the system to ensure a reliable, noise-free link even when there is additional attenuation caused by fog, heavy rain, snowfall, or fading. The latter effect is essentially a variation in the refractive index of air in contact with the heated earth surface (reference [1]). This phenomenon gives rise to turbulence and convection currents in the atmosphere, beam deviation, and hence pronounced fading of the transmitted IR signal. Modulation of the signal strength in the range 1 to 200 Hz may also affect the quality of the received signal. This effect is caused by scattering of the signal, and fluctuations in the absorption of the air layers. A typical atmospheric absorption spectrum is shown in Fig. 4. The curve is derived from a wider spectrum analysis described in [1]. It shows the percentage transmission through 1 km of atmosphere at sea level. It is seen that the IRED LD271 outputs its peak intensity at a wavelength that forms the lower limit of a so-called *atmospheric window*, i.e., a frequency band in which the atmospheric attenuation is

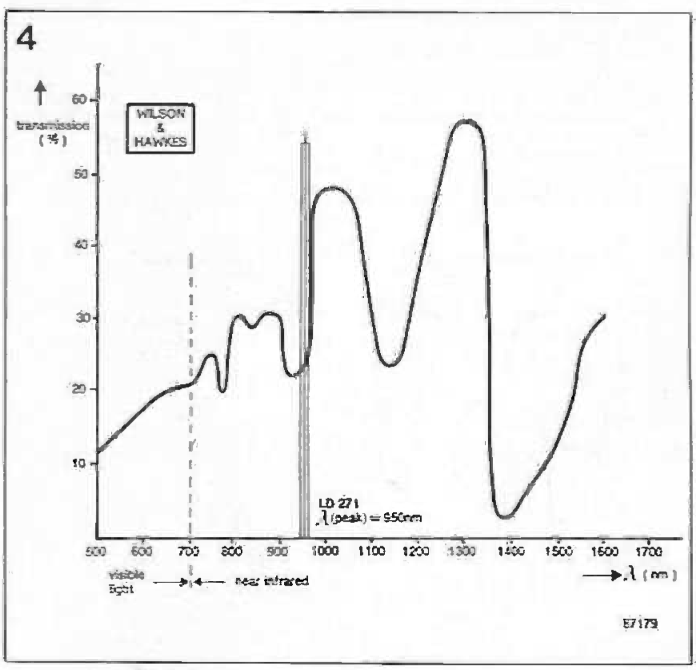


Fig. 4 Correlation between wavelength and percentage transmission through 1 km of atmosphere at sea level (*source: reference [1]*).

relatively low. Returning to the temperature coefficient of λ_{peak} stated in Fig. 2, it is readily seen that the signal strength at the receiver side may well rise somewhat along with the temperature of the IRED, since the transmitted signal can be thought to shift to the right in the spectrum.

Optical amplification

Radio engineers are familiar with the maxim "*the aerial is the best amplifier*". This is a proven truth, and fully applicable to the IR transceiver. The previously given transmitter ranges can only be covered with the aid of optical amplification, or, more precisely, beam convergence.

At the receiver side, it is best to use a lens with a relatively large area. Lenses in magnifying or reading glasses are ideal for the present purpose. Elementary aspects of the biconvex lens are shown in Fig. 5a. The well-known *lens equation* is written as

$$1/f = 1/u + 1/v \qquad [17]$$

where

f = the focal length
u = the object distance
v = the image distance

From this it can be deduced that

$$v = \frac{f \times u}{-f+u} = \frac{f \times u}{u-f} \qquad [18]$$

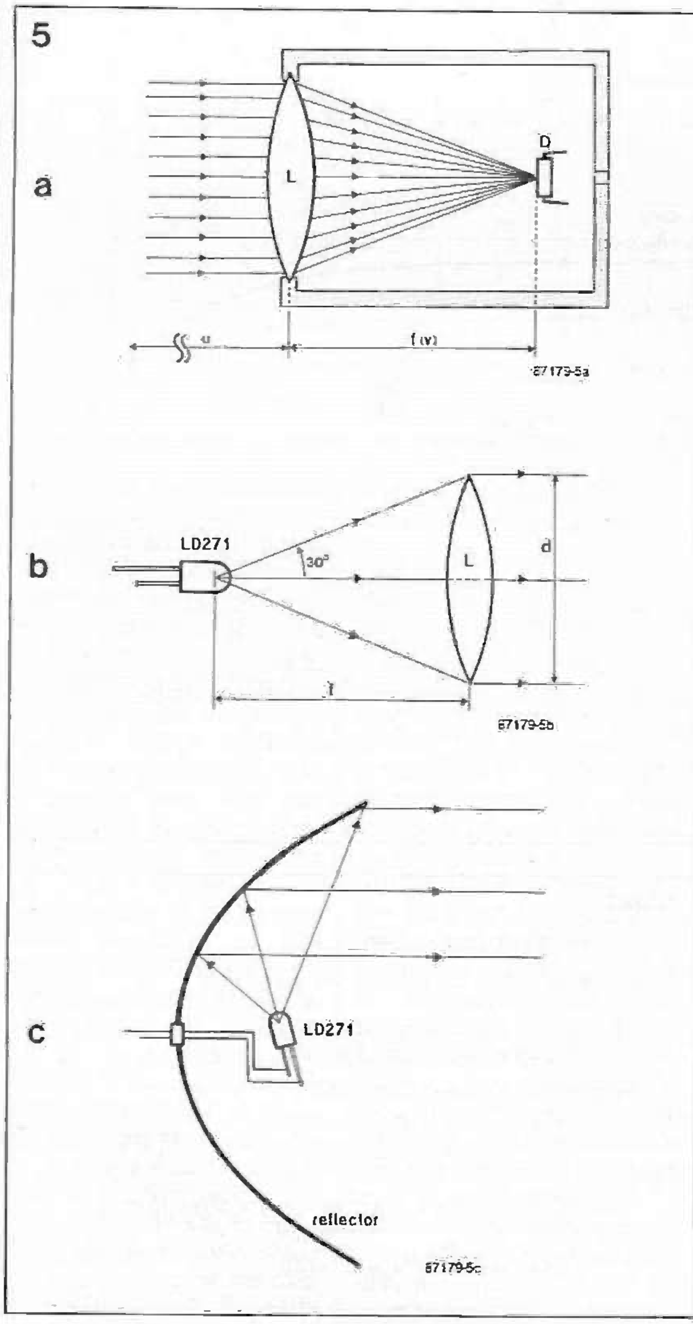


Fig. 5 Essential aspects of the optical components in the IR transceiver.

For the distances covered by the IR transceiver, f may be considered small relative to u (the object is at infinity), whence

$$v = \frac{f \times u}{u} = f. \qquad [19]$$

The lens and the photodiode are housed in a light resistant enclosure with a blackened inside surface. The photodiode should be accurately positioned in the focus when the distance between the transmitter and the receiver is greater than about 50 metres. An inverted, but otherwise sharp (*real*), image of the area viewed by the lens can be seen on the back of a piece of thin white paper when this is held in the focus. Directly incident light causes a marked increase in the noise output of the photodiode.

At the transmitter side, either a lens or a reflector can be used to ensure the required convergence of the IR light beam. The use of a lens is illustrated in Fig. 5b. The convex lens should be a so-called *condensing* type to ensure a short focal length with respect to the lens diameter. Condensing lenses have an extremely biconvex or planoconvex curvature, and are often used in slide projectors. The construction of the IRED Type LD271 is such that the half intensity angle is about 30° in the axial direction. In the context of the lens diameter, d, and with reference to Fig. 5b, this means that

$$\tan 30° = 1/\sqrt{3} = \tfrac{1}{2}d/f$$
$$f = d\tfrac{1}{2}\sqrt{3} = 0.87d. \qquad [20]$$

The beam convergence is optimum when the focal length of the lens satisfies $f \leq 0.87d$. Like the photodiode, the IRED is, of course, co-axially positioned in the focus.

The use of a reflector, i.e., a concave (parabolic) mirror, at the transmitter side is shown in Fig. 5c. Virtually all radiated light emerges as a parallel beam when the IRED illuminates the right section of the concave reflective area. The IRED is not fitted co-axially in the focus of the reflector because in this position it would obstruct the reflected beam, and so absorb a considerable part of its own radiant intensity. Moreover, there is usually a hole at the centre of the type of reflector used for this project...

Although a condensing lens gave excellent results in a test setup of the transmitter, it is none the less recommended to use a reflector simply because this is less expensive in most cases. Constructional aspects of the reflector and the lens as crucial components in the IR transceiver are discussed further on in this article.

Circuit description of the transmitter

The circuit diagram of the infrared, FM, transmitter is given in Fig. 6. Microphone and line signals are applied to low-noise opamp IC_1 via AF inputs M and L_L-L_R respectively. Stereo signals at the line inputs are made monaural with the aid of summing resistors R_{17}-R_{18}. Attenuation is effected in voltage divider R_{20}-R_{19}. The amplified signal is fed to filter/amplifier A_1 via C_{15}, modulation strength control P_1, and C_1. Opamp A_1 is configured as an active filter to obtain the required preemphasis of the modulation signal, before this is applied to the FM modulator. The computed transfer function of the active filter is given in Table 1. A second-order low-pass with a cut-off frequency of 10 kHz is required to keep the boosting effect of the preemphasis on higher frequencies within reasonable limits. This measure effectively prevents intermodulation with the—relatively low—carrier frequency of about 100 kHz. Without the filter, a 19 kHz pilot tone, for example, would be heavily amplified, causing annoying lisping sounds, noise, and spurious beat notes in the receiver. The 10 kHz filter is represented by the first 2 terms in the denominator of the last fraction in Table 1, so that

$$C_2R_3 = 1/(2\pi 10^4) = C_5R_5. \qquad [21]$$

The roll-off point at the lower end of the spectrum is determined by the term $(1+j\omega C_3R_4)$, which is dimensioned for a cut-off frequency of about 10 Hz. The standard preemphasis of 50 μs is created by C_4, which can be resolved from the numerator with the aid of the term f_{C4}, as shown in Table 2. The amplification of A_1 is approximately 6.6 ($\approx 1+R_5/R_4$).

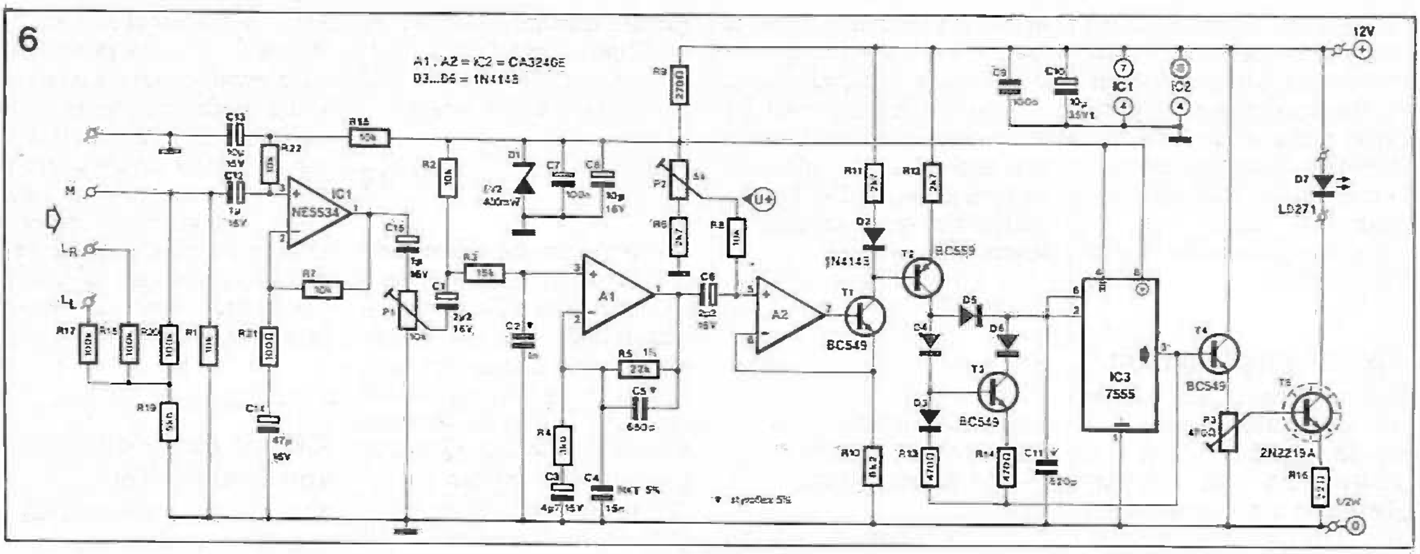


Fig. 6 Circuit diagram of the infra-red transmitter.

The asymptotes in the last fraction of Table 2 are called (A)...(E) for practical purposes. All terms are 6 dB/octave asymptotes. Terms (A) and (B) in the numerator represent *amplification* (U_o), terms (C), (D) and (E) *attenuation* (U_i). It is readily seen that (C) and (D) are virtually equal, and therefore represent an asymptote of $2 \times -6 = -12$ dB/octave.

The theoretical frequency curve of the filter set up around A_1 is shown in Fig. 7a. Asymptotes (C) and (D) are coincident and form the second-order roll-off above 10 kHz. Figure 7b shows the results of a test sweep carried out on a prototype of the IR transmitter. Curve A is the preemphasis, curve B the frequency response of the complete IR system, i.e., from the AF input on the transmitter, via an IR link of about 10 metres, to the AF output on the receiver. The results are acceptable given the simplicity of the circuits used.

Returning to the circuit diagram of the transmitter, C_6 passes the amplified and filtered AF signal to a V-I converter set up around A_2 and T_1. The high amplification, A, of the opamp ensures that U_+ is virtually equal to U_-, since

$$U_o = A/(U_+ - U_-) \text{ and } A \rightarrow \infty \qquad [22]$$

This means that $U_{(R10)} = U_+$, whence

$$I_{C(T1)} \approx I_{(R10)} = U_+/R_{10}. \qquad [23]$$

This shows that the collector current in T_1 is directly proportional to the voltage at the wiper of P_2 (U_+). In other words, the operation of the V-I converter is linear.

D_2 and T_2 form a current mirror. The voltages across the diode and the B-E junction of the transistor are equal when equal currents are carried. The voltage on R_{11} is, therefore, equal to that on R_{12}. It is readily seen that $I_{C(T2)} = I_{C(T3)}$ since $R_{11} = R_{12} = 2K7$.

The well-known timer Type 7555 comprises 2 comparators that cause an internal bistable to toggle at voltage levels $\frac{2}{3}V_{cc}$ and $\frac{1}{3}V_{cc}$. Timer IC_3 is fed from a stabilized 6.2 V rail. When $U_{(C11)} \leq \frac{1}{3}V_{cc}$ (=2.07 V), the output, pin 3, goes high

Table 1

Infra-red transmitter: transfer function of A_1.

Definition of terms used: $U_i = U_{C3}$ $\quad U_o = U_{C6}$ $\quad U_Z = 6.2$ V $\quad \omega = 2\pi f$ $\quad j^2 = -1$

$U_o = A(U_+ - U_-)$ $A \rightarrow \infty \Rightarrow U_+ = U_-$

$$U_+ = \frac{(1/j\omega C_2) \times U_i}{R_3 + 1/j\omega C_2} = \frac{1}{1 + j\omega C_2R_3} \times U_i$$

$$U_- = U_+ = U_o - I_5Z_5 \qquad (Z_5 = R_5//C_5)$$

$$= U_o - (I_{(R4)} + I_{(C4)})Z_5$$

$$= U_o - [U_+/(R_4 + 1/j\omega C_3) + U_+/(1/j\omega C_4)]Z_5$$

$$\frac{U_o}{U_+} = 1 + \frac{Z_5}{R_4 + 1/j\omega C_3} + j\omega C_4Z_5$$

$$= 1 + j\omega C_4Z_5 + \frac{j\omega C_3Z_5}{1 + j\omega R_4C_3} \text{ and } Z_5 = \frac{R_5/j\omega C_5}{R_5 + 1/j\omega C_5}$$

$$= 1 + j\omega C_4 \frac{R_5/j\omega C_5}{R_5 + 1/j\omega C_5} + \frac{j\omega C_3 \dfrac{R_5/j\omega C_5}{R_5 + 1/j\omega C_5}}{1 + j\omega R_4C_3}$$

$$= 1 + \frac{j\omega C_4R_5}{1 + j\omega C_5R_5} + \frac{j\omega C_3R_5}{(1 + j\omega C_3R_4)(1 + j\omega C_5R_5)}$$

$$\frac{U_o}{U_i} = \frac{1}{(1 + j\omega C_2R_3)} + \frac{j\omega C_4R_5}{(1 + j\omega C_2R_3) \times (1 + j\omega C_5R_5)} + \frac{j\omega C_3R_5}{(1 + j\omega C_2R_3) \times (1 + j\omega C_5R_5) \times (1 + j\omega C_3R_4)}$$

$$= \frac{(j\omega)^2(C_3C_5R_4R_5 + C_3C_4R_4R_5) + j\omega(C_3R_4 + C_5R_5 + C_3R_5 + C_4R_5) + 1}{(1 + j\omega C_2R_3)(1 + j\omega C_5R_5)(1 + j\omega C_3R_4)}$$

Table 2

Infra-red transmitter: preemphasis.

$\tau = 50\ \mu s = 50 \times 10^{-6}$ s $\quad \omega = 2\pi f$ $\quad j^2 = -1$

$$\frac{U_o}{U_i} = \frac{(1 + j\omega\tau)(1 + j\omega f_{(C4)})}{(1 + j\omega 1.5 \times 10^{-5})(1 + j\omega 1.496 \times 10^{-5})(1 + j\omega 0.01833)}$$

so that $\tau f_{(C4)} = (C_3C_5R_4R_5 + C_3C_4R_4R_5)$

$$\tau + f_{(C4)} = C_3R_4 + C_5R_5 + C_3R_5 + C_4R_5$$

$$f_{(C4)} = \frac{(C_3C_5R_4R_5 + C_3C_4R_4R_5)}{\tau}$$

$$C_4 = \frac{C_3C_5R_4R_5 - \tau C_3R_4 - \tau C_5R_5 - \tau C_3R_5 + 25 \times 10^{-10}}{\tau R_5 - C_3R_4R_5}$$

$$C_4 = 14.4 \text{ nF} \Rightarrow f_{(C4)} = 0.12162$$

$$\frac{U_o}{U_i} = \frac{(1 + j\omega\tau)(1 + j\omega 0.1262)}{(1 + j\omega 1.5 \times 10^{-5})(1 + j\omega 1.496 \times 10^{-5})(1 + j\omega 0.1833)} = \frac{(A)(B)}{(C)(D)(E)}$$

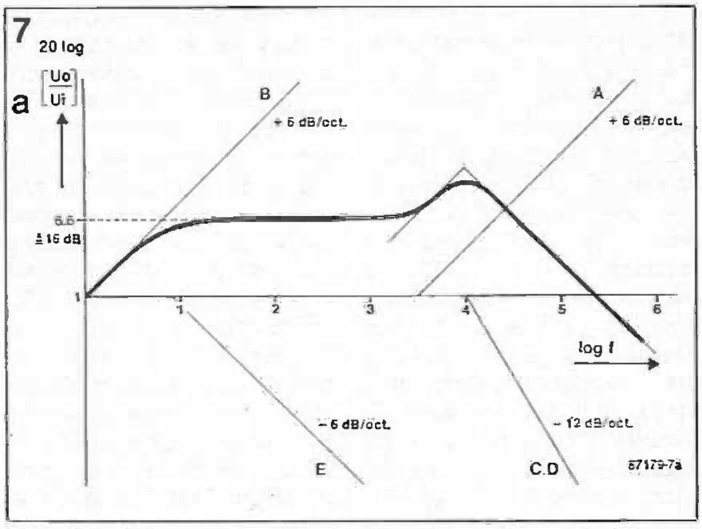


Fig. 7 Theoretical (a) and practical (b) frequency response of the transmitter. Curve B in Fig. 7b shows the overall response of the IR system.

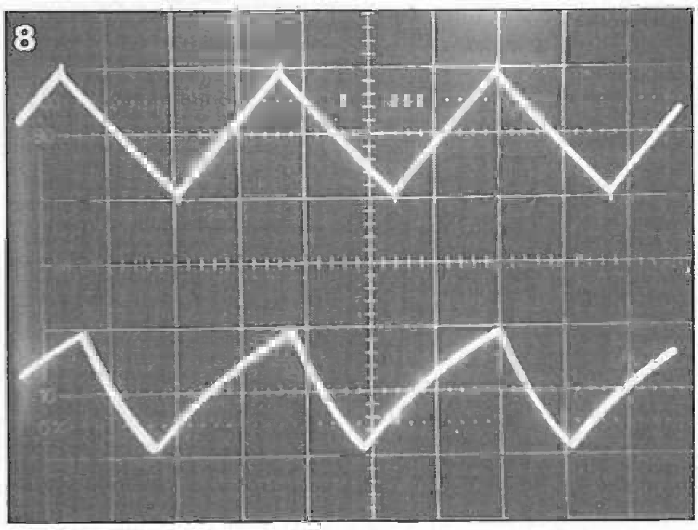
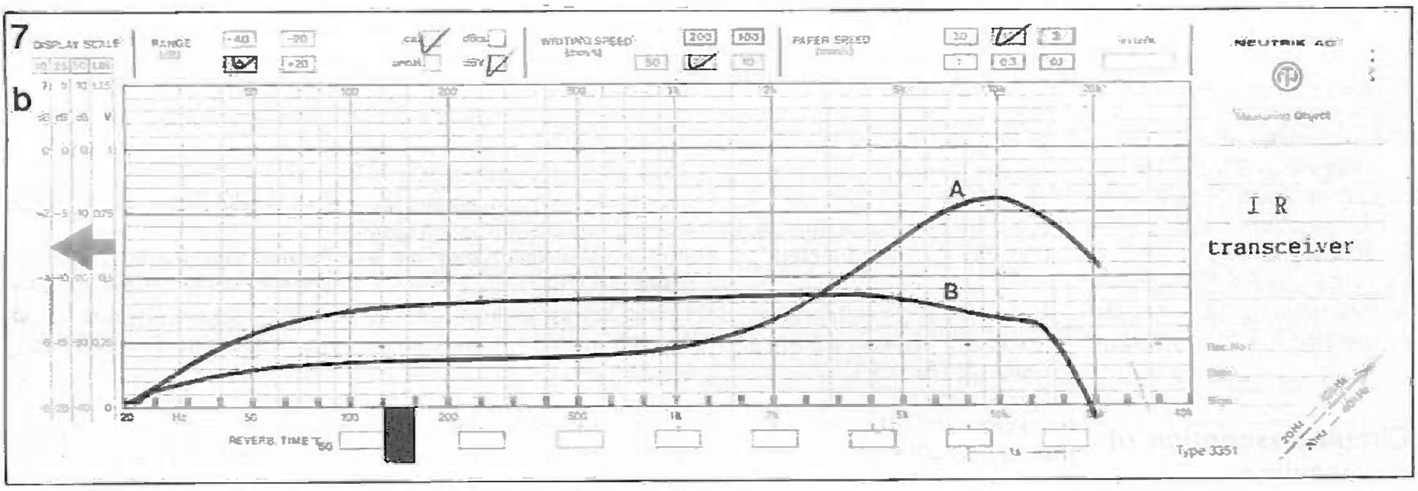


Fig. 8 The voltage on the timing capacitor in the 555 based CCO is triangular (upper curve) rather than exponential (lower curve) to achieve linear frequency modulation. $f_c = 100$ kHz.



(=6.2 V). The current through D_4 and D_6 is blocked, and $I_{C(T2)}$ flows into C_{11} via D_5. When the voltage on C_{11} exceeds ⅔V_{CC} (=4.13 V), the timer output goes low, $U_{C(T2)}$ becomes about 1.5 V, and D_5 blocks the current. In this situation, D_3 and T_3 form a current mirror, so that $I_{C(T3)} = I_{(D3)} = I_{C(T2)}$. Timing capacitor C_{11} is then discharged with the current $I_{C(T2)}$. The frequency of the triangular signal on C_{11} is a linear function of $I_{C(T1)}$, and, therefore, of U_+, and, therefore, of the instantaneous amplitude of the modulation signal superimposed on U_+. In brief, this is *frequency modulation*. The 7555 functions as a current controlled oscillator (CCO) thanks to the linearization of the—normally exponential—charge-discharge curve of the timing capacitor, C_{11}. The oscillogram in Fig. 8 shows the output of the CCO in contrast to that of a 7555 based oscillator in the standard configuration. IC_3, T_1, T_2 and T_3 thus form a voltage controlled oscillator (VCO), whose central frequency, f_c ($\approx$ 100 kHz) is determined by U_+ as

$$I = C(d_u/d_t) = U_+/R_{10}$$
$$d_u = 1/3V_{CC} = 2.07 \text{ V}$$
$$d_t = ½(1/f_c)$$
$$U_+/R_{10} = C_{11}[2.07/(½f_c)]$$
$$= C_{11} \times 4.13/f_c$$
$$f_c = U_+(1/4.13C_{11}R_{10}) \text{ [Hz]} \quad [24]$$

In practice, the modulation gradient of the transmitter is about 30 kHz/V when R_{10}=8K2 and C_{11}=820 pF. This means that f_c is about 100 kHz when U_+ is set to +3.3 V with the aid of P_2. A frequency deviation of ±50 kHz is achieved when the amplitude of the modulation signal superimposed on U_+ is 1.7 V_p. It was found that the toggle levels of the comparators in 555s and 7555s supplied by various manufacturers are subject to a relatively loose tolerance. Figure 9 shows the $f_c(U_+)$ curves of 2 7555s and a 555 fitted in position IC_3. The results obtained prove that the calculated modulation gradient of 30 kHz/V may not be achieved in all cases.

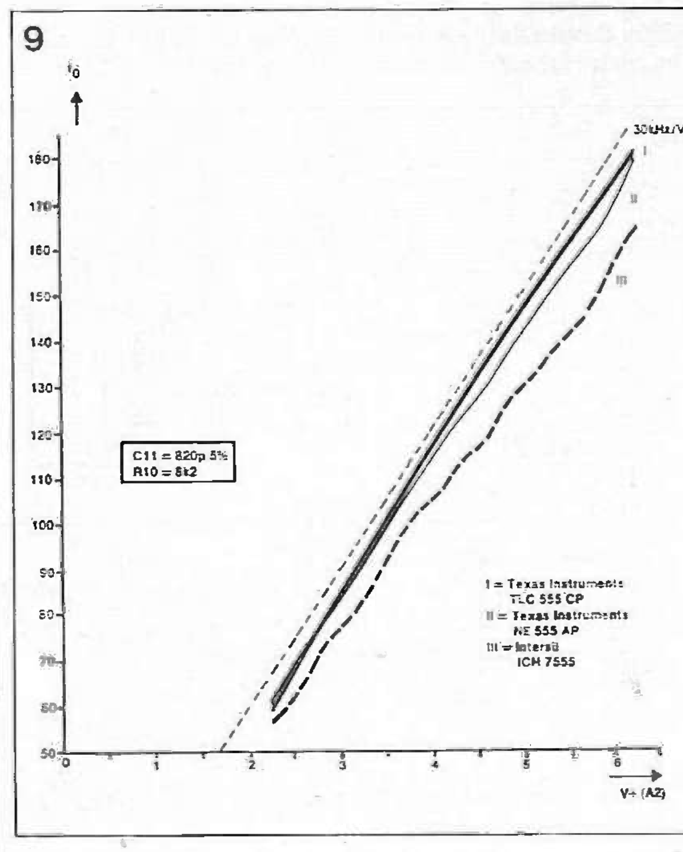


Fig. 9 Curves showing the modulation gradient of the transmitter with various timer chips fitted in position IC_3.

Although the modulation index, β, of the transmitter is conventional at

$$\beta = \Delta f / f_{(m)} = 50/10 = 5, \qquad [25]$$

the resultant deviation of ± 50 kHz (100 kHz_{pp}) is large relative to the carrier frequency of 100 kHz. This observation is important in view of the receiver design, and will be reverted to.

Emitter follower T_4 buffers the rectangular output pulses of the oscillator. Via the carrier power control, P_3, the signal reaches power output transistor T_5, which is capable of building up an emitter potential of about 4.5 V. Emitter resistor R_{16} carries a peak current of 200 mA, taken from the 12 V supply via IRED D_7, which is so pulsed at a duty factor of about 0.5 to supply its maximum radiant intensity of 10 mW sr^{-1}.

The transmitter is fed from a (rechargeable) 12 V battery, and consumes about 125 mA when set to maximum output power. Evidently, it is also possible to use a regulated 12 V; 1 A power supply when the IR transmitter is operated in a fixed location.

Circuit description of the receiver

The IR receiver is a simple design, just like the transmitter. The circuit diagram is shown in Fig. 10.

When P_R = 30NEP, i.e., $[S/N]_i$ = 15 dB, a photon current is generated with an equivalent power of 4×10^{-10} W. The energy, E, of a photon is expressed as

$$E = hc/\lambda = 2.07 \times 10^{-19} \text{ [J]} \qquad [26]$$

where

$h = 6.6262 \times 10^{-34}$ [J s^{-1}] (Planck's constant);
$c = 2.97 \times 10^{8}$ [m s^{-1}] (velocity of light);
$\lambda = 950 \times 10^{-9}$ [m].

This means that the received power, P_R, of 4×10^{-10} W corresponds to

$$P_R/E = 1.93 \times 10^{9} \text{ photons } s^{-1}. \qquad [27]$$

Figure 2 shows that the *quantum yield*, η, of the BP104 is high at 0.92 electrons per photon, so that the given photon current results in a density, D_e, of 1.77×10^{9} electrons per second. The electric current, I_F, is then calculated as follows:

1 coulomb (C) = $1/1.6 \times 10^{-19}$
= 6.25×10^{18} [electrons]
1 ampere (A) = 1 C s^{-1}
$I_F = D_e / 6.25 \times 10^{18}$ [28]
$= 2.83 \times 10^{-10}$ [A]
$I_{F(max)} = 2 I_F = 566$ pA.

This current corresponds to 32 μV on R_{23} (56 kΩ). The effective voltage at f_c = 100 kHz is $\frac{1}{4}\sqrt{2} \times 32 = 11.2$ μV. The signal from the photodiode is raised in a 4-stage direct coupled transistor preamplifier, T_6-T_9, which ensures an amplification of about 10 000. The preamplifier is a slightly modified version of the one discussed in reference[2]. The amplified signal is coupled out to limiter IC_4 via R_{31} and C_{20}. The resistor prevents load variations and feedback effects from upsetting the sensitive preamplifier. Negative feedback control P_4 enables finding the optimum signal-to-noise ratio for a wide range of input signal strengths. A high feedback level also allows suppressing to some extent the interference from nearby luminescent tubes or TV sets.

The well-known Type TBA120S FM demodulator comprises an excellent limiter circuit, which is used here to cancel the effect of the relatively strong AM noise on the received signal. In the present application, the quadrature detector in the chip is only used for driving the S-meter circuit.

This is set up around IC_6 and T_{11}, and enables evaluating the relative signal strength during the testing and setting up of the equipment. Preset P5 is adjusted for minimum visible meter deflection when no signal is received. The voltage at pin 8 of the TBA120S is smoothed by C_{26}, and rises with the signal strength. This causes the emitter voltage of T_{11} to fall, the collector current to increase, and the meter to deflect. The maximum coil current in M_1 can be set with the aid of P_6. Provided the preamplifier operates in its linear range, the meter indication is a direct measure of the received signal strength. It was already mentioned that the ratio of f_c to Δf is remarkably low in the proposed system. This fact makes it virtually impossible to use the quadrature detector inside the TBA120S for obtaining sufficient AF output. With f_c:Δf as low as 2, linear FM detection can only be achieved with the aid of a phase-locked loop (PLL) detector. The Type NE565 (IC_5) used here ensures a reasonable S/N ratio while requiring relatively few external components. The central frequency, f_0, is determined by $P_7 + R_{43}$ (R) and C_{27} (C):

$$f_0 = 1/3.7RC \text{ [Hz]}. \qquad [29]$$

Preset P_7 gives a VCO range of approximately 70 to 150 kHz, which is about equal to that of the transmitter. A 50 μs deemphasis network is formed by R_{41}-R_{47}-C_{30}. The resistors are dimensioned such that the demodulated signal at pin 7 of the NE565 is direct coupled to buffer T_{12}, obviating the need for an additional coupling capacitor. The on-board AF

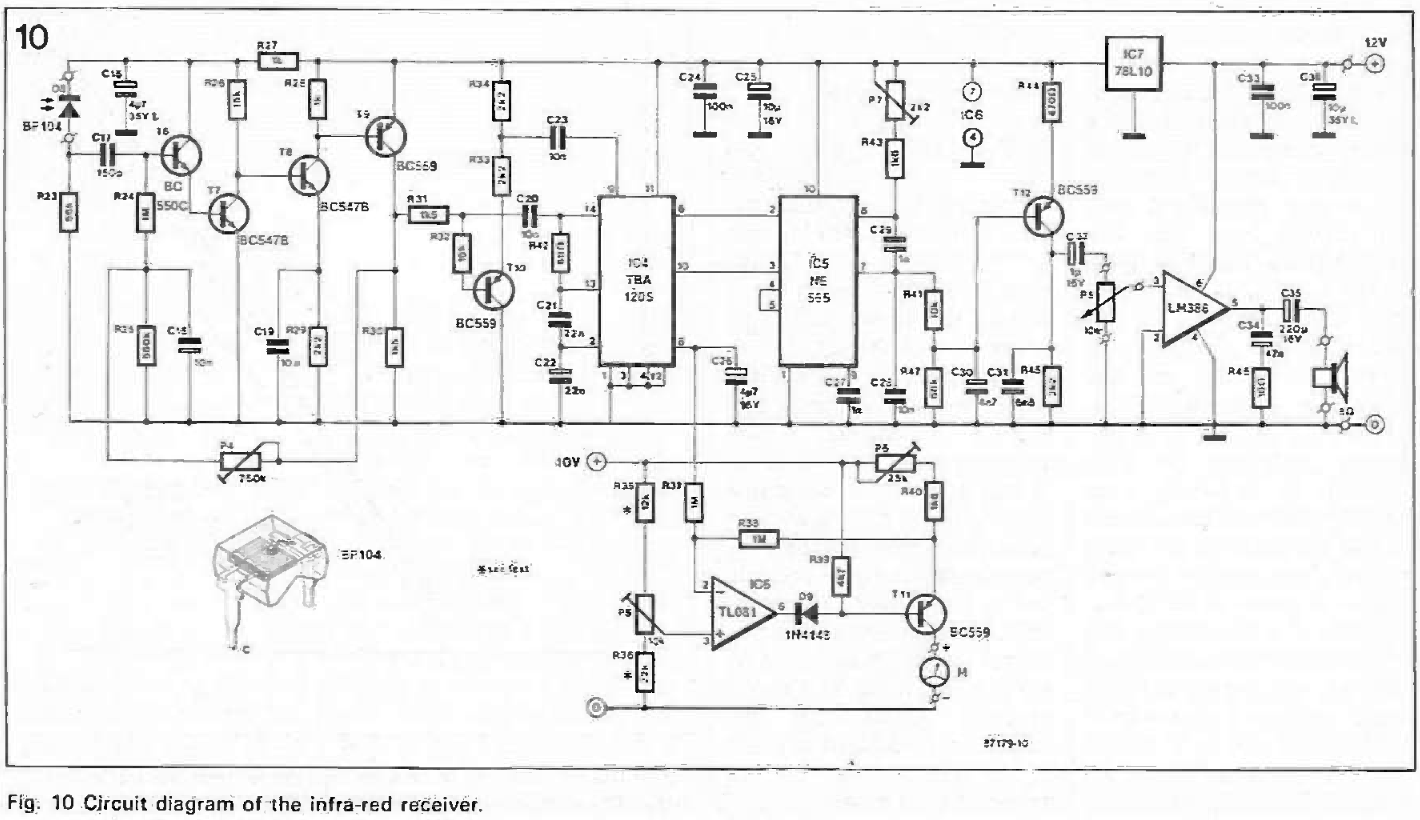


Fig. 10 Circuit diagram of the infra-red receiver.

power amplifier is a standard application of the Type LM386. Some 250 mW of AF power is available for driving a headphone set, or a miniature 4 or 8 Ω loudspeaker.

For portable applications, the receiver is fed from a 12 V battery. Current consumption is of the order of 35 mA. The transmitter and the receiver should not be powered from a common supply or battery. This is in view of the relatively high peak currents in the transmitter in combination with the high sensitivity of the receiver. The 100 kHz pulses are readily induced direct into the receiver, and so make the correct adjustment of the system virtually impossible. The preamplifier in the receiver is essentially a wideband type, and intermodulation problems may arise when it is used in the direct vicinity of powerful medium or long-wave transmitters.

Construction: the electronics

The track layout and component overlay of the printed circuit board for the IR transceiver

Parts list

Resistors (±5%):

R1;R2;R7;R8;R15;R22;R41 = 10K
R3 = 15KF
R4 = 3K9
R5 = 22KF
R6;R11;R12 = 2K7
R9 = 270R
R10 = 8K2
R13;R14;R44 = 470R
R16 = 22R; 0.5 W
R17;R18;R20 = 100K
R19 = 5K6
R21 = 100R
R23 = 56K
R24;R37;R38 = 1M0
R25 = 560K
R26;R32 = 15K
R27;R28 = 1K0
R29;R33;R34;R45 = 2K2
R30;R31 = 1K5
R35 = 12K*
R36 = 22K*
R39 = 4K7
R40;R43 = 1K8
R42 = 68R
R46 = 10R
R47 = 68K
P1;P5 = 10K
P2 = 5K0 or 4K7
P3 = 470R or 500R
P4 = 250K or 220K
P6 = 25K or 22K
P7 = 2K2 or 2K5
P8 = 10K logarithmic potentiometer

Capacitors:

C1;C6 = 2µ2; 16 V; radial
C2 = 1N0J; styroflex/polystyrene
C3;C26 = 4µ7; 16 V
C4 = 15nJ; MKT
C5 = 680pJ; styroflex/polystrytene
C7;C9;C24;C33 = 100n
C8;C13 = 10µ; 16 V; radial
C10;C36 = 10µ; 35 V; tantalum bead
C11 = 820pJ; styroflex/polystyrene
C12;C15 = 1µ; 16 V; radial
C14 = 47µ;16 V; radial
C16 = 4µ7; 35 V; tantalum bead
C17 = 150p ceramic
C18;C19;C20;C23 = 10n ceramic
C21;C22 = 22n ceramic
C25 = 10µ; 16 V; axial
C27;C29 = 1n0
C28 = 10n
C30 = 4n7
C31 = 6n8
C32 = 1µ; 16 V; axial
C34 = 47n
C35 = 220µ; 16 V; axial

Ceramic capacitors are plate or disc types with a lead spacing of 2.5 mm.

Semiconductors:

D1 = 6V2; 400 mW zenerdiode
D2...D6 incl.;D9 = 1N4148
D7 = LD271 or LD271H
D8 = BP104

IC1 = NE5534
IC2 = CA3240E
IC3 = 7555 or TLC555
IC4 = TBA120S (do not use T or U types)
IC5 = NE565 or LM565C
IC6 = TL081
IC7 = 78L10
IC8 = LM386
T1;T3;T4 = BC549B
T2;T9...T12 incl. = BC559B
T5 = 2N2219A
T6 = BC550C
T7;T8 = BC547B

Miscellaneous:

Suitable heat-sink for T5 *
PCB Type 87179 (not available through the Readers Services).
M = 100 µA...1 mA rectangular S-meter.
Loudspeaker; 8 Ω; 0.5 W.
2 off 5-way DIN sockets (180°).
1 off 2-way DIN loudspeaker socket.

* See text.

Readers wishing to make their own PCB for this project are advised that a true-size copy of the track layout is available on request. For details on ordering, please consult the Readers Services page in this issue.

11

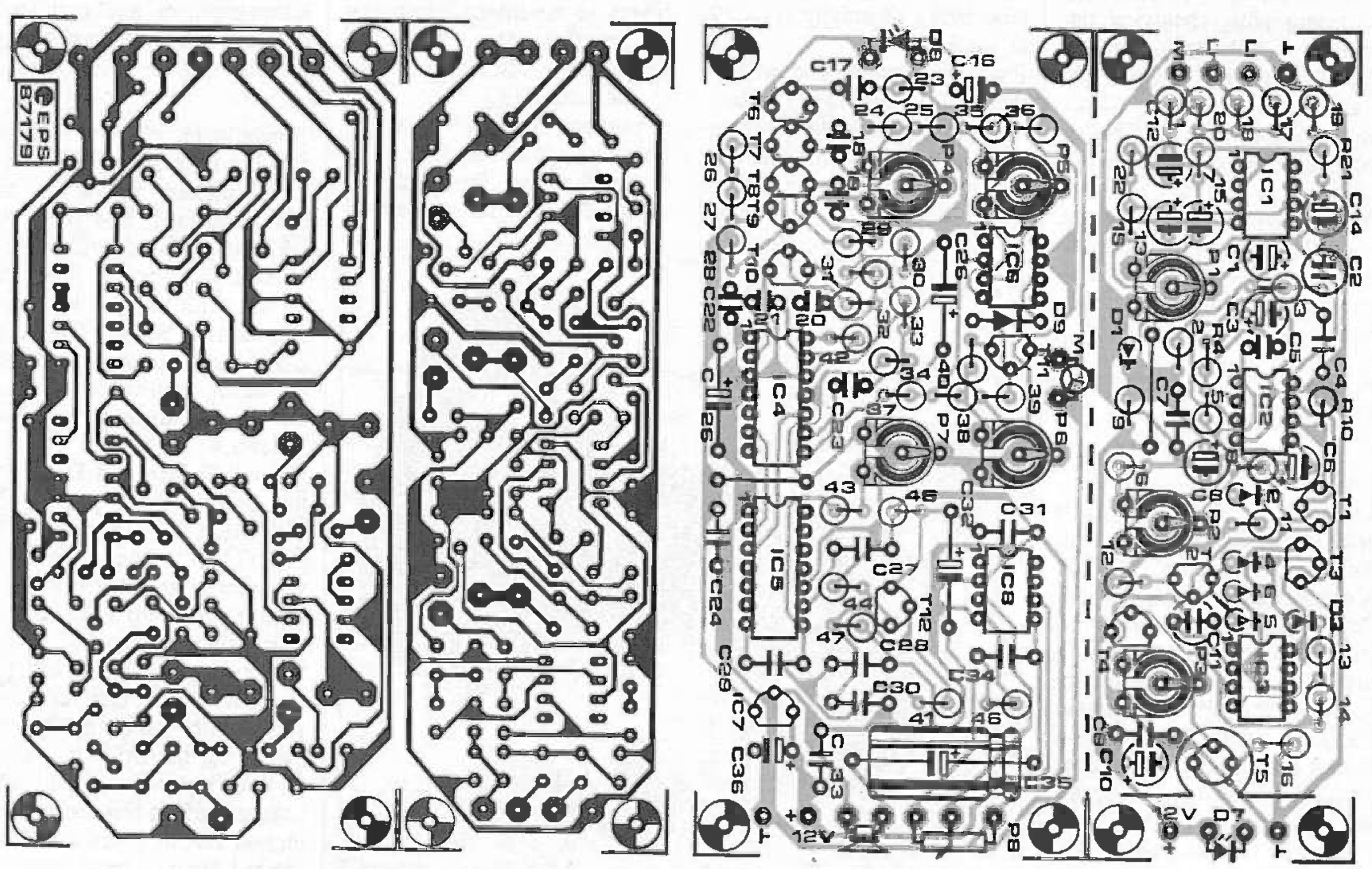


Fig. 11 Track layout and component mounting plan of the PCB for building the IR transceiver.

are given in Fig. 11. The board is cut in two along the dotted line to enable building the transmitter and the receiver separately. Commence the construction with populating the transmitter board, starting with the single wire link to the right of P_1. All resistors and diodes, and most capacitors, are fitted upright. Use sockets for all 3 ICs, and observe the correct orientation before these are plugged in. Also verify the polarity of the radial electrolytic capacitors, and the tantalum bead capacitor, C_{10}. Do not fit T_5 until a suitable heat-sink to is to hand. The Ω-shaped heat-sink used in the prototype transmitter was a type for cooling RGB and video output transistors on a salvaged TV chassis. A push-on TO18 or TO5 style heat-sink is only usable when the nearby soldering pins are kept short, and the enclosure of T_5 is well above the surrounding components. Temporarily fit the IRED direct onto the relevant soldering pins, *but do not cut off the leads as yet.*

The receiver board is also fairly densely populated. All resistors are fitted upright, and there is also a single wire link, namely in between IC_4 and IC_5. Use sockets for all ICs. Fit the photodiode straight onto the soldering pins, observing the correct polarity. Push-fit T_6...T_{10} incl. and the ceramic plate or disc capacitors as far as possible towards the PCB surface before soldering. Volume control P_8 is temporarily fitted direct onto the relevant soldering pins. Connect a small loudspeaker, and a suitable S-meter, to the relevant terminals on the board.

An initial test

Place the transmitter some 3 metres away from the receiver, and point the IR components at each other. Set the presets on the transmitter as follows: P_1 ¾ cw; P_2 to mid-travel; P_3 ¼ cw. Connect the +12 V and ⊥ terminals on the transmitter to a regulated 12 V supply, and apply a -20 dB; 1 kHz sine-wave to the L_L-L_R inputs. Power up the transmitter. The current consumption should not exceed 100 mA. Set U_+ to +3.5 V. Switch the transmitter off.

Turn the presets on the receiver board as follows: P_4 ¼ cw; P_5 and P_6 to mid-travel; P_7 ⅔ cw. Feed the receiver from a separate 12 V supply or battery. Switch on the power, and turn up the volume control until steady noise is heard. Some rattle may be audible if the photodiode "sees" sources of interference such as the light from luminescent tubes. Switch on the transmitter, and adjust VCO preset P_7 until the signal is heard. Optimize the reception by adjusting P_4; this is fairly critical. Reduce or increase the modulation strength as required. Verify that the transmitter power can be adjusted with P_3.

Block the incident IR beam with an available object, and measure the direct voltage at pin 8 of IC_4. Null the S-meter by adjusting P_5. Restore the IR link by removing the object, and reduce or increase the S-meter deflection by adjusting P_6 until the f.s.d. indication is reached. Due to the tolerance on the bias voltage on pin 8 of the TBA120S, it may be necessary to redimension R_{35} and/or R_{36} to ensure a narrow enough span of the sensitivity preset, P5. It should be noted that every change in the setting of feedback preset P_4 requires readjusting P_5. Thanks to the use of current source T_6, the S-meter can be almost any type with a sensitivity of 100 μA to 1 mA.

Properly aligned, and without the use of lenses or reflectors, the system should have a range of 6 to 8 metres. Verify this with the transmitter set to maximum power, and peak P_4 and P_7 for optimum reception when there is considerable noise on the received signal.

The optics

The lens for the receiver is a type removed from an inexpensive looking or reading glass, available from opticians or stationers. The quality of the glass is not important, and the handle is, of course, not used. A diameter of about 100 mm is convenient because it allows the lens to be fitted into a length of PVC draining tube, purchased complete with a suitable PVC end cap. Two 10 mm wide rings are cut from the tubing. A 10 mm wide gap is cut into each of these these rings to enable push-fitting them in the tube, where they keep the lens securely locked at either side, still allowing its position to be adjusted in accordance with the focal length. Provisionally fit the lens at one extreme of the tube and ascertain the focal length as indicated under *Optical amplification*. Most lenses with r=50 mm have a focal length of about 25 cm. Make a note of the empirically found focal length, and mark the envisaged, approximate, position of the photodiode on the outside of the tube. The receiver board is mounted lengthwise inside the tube, with the photodiode connected direct to the input pins.

A perspex disc with a central hole for the photodiode is cut to fit into the tube. The front side of this disc should be painted matt black, or covered with black cardboard.

The receiver board is held on a rectangualar piece of perspex fitted between the disc and the PVC end cap. The photodiode should be level with the front side of the blackened perspex disc, and exactly at the centre of the hole to ensure the correct position on the axis of the lens. The rectangular block of perspex is cut, glued to the disc, and screwed onto the end cap for additional stiffness of the receiver assembly. The end cap is drilled and cut to hold the volume control, the S-meter, and a 5-way DIN socket for connecting the headphones or the loudspeaker, and the power supply. The cap is secured to the tube with the aid of 3 screws, which, unlocked, should enable sliding the receiver assembly about 40 mm horizontally.

The tube is fitted on a photographer's tripod with the aid of a suitable mounting plate and bolt. As a finishing touch, an adjustable finder may be mounted onto it. The receiver assembly is shown in Fig. 12.

It should be noted that the use of infra-red rather than visible light results in an increase of about 2% in the stated focal length of the lens. The average beamwidth of the previously discussed receiver system is of the order of 2°.

12

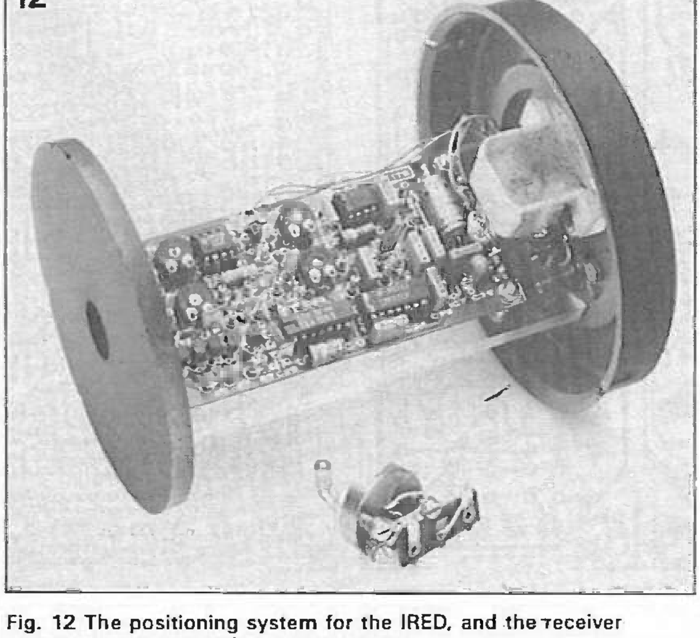


Fig. 12 The positioning system for the IRED, and the receiver assembly ready for fitting into the tube.

The reflector at the transmitter side is a round headlight or fog lamp picked up at a car breaker's yard. The reflective area should be smooth and unstained. Rectangular reflectors for use with halogen lights are less suitable. Select a fairly concave lamp that is complete with an intact, non-coloured glass cover, a bulb and mounting hardware.

Consult Fig. 5c and Fig 12 for the suggested way of mounting the IRED. Never attempt to clean the reflective surface with anything but a dry cloth. Remove the bulb and carefully break and remove the glass. With some mechanical skill, the bayonet fitting can be converted into the positioning system for the IRED. It is possible, for instance, to divide the copper surface of a piece of unetched circuit board into 3 insulated areas; 2 small ones for connecting the IRED terminals to the wires to the transmitter, while the larger area is used for fitting 3 spring-loaded, M30×3 adjustment screws, which are accessed at the rear side. Before mounting the IRED onto this plate, the beam must be converged with the aid of a standard red, 5 mm LED, which is temporarily powered from a 12 V supply via a 1 kΩ series resistor. Place the reflector assembly in a darkened room, and find the LED position that results in a clear red spot projected onto a vertical surface at a distance of 6 to 8 metres. Make the spot as bright and sharply defined as possible by adjusting the inclination of the LED with respect to the axis of the reflector. The LED can then be replaced by the IRED, which should have *exactly* the same position. The author's prototype mounting system is shown in front of the receiver assembly in Fig.12. Replace the glass cover, and re-assemble the lamp. Provide a mounting system for fitting it onto a photographer's tripod, or build a wooden cross for placing the reflector securely onto a horizontal surface. The elevation system of the lamp should be retained and kept operational.

The transmitter board can be fitted in a suitable ABS enclosure for securing onto the vertical rod of the tripod. Do not forget to drill holes in the top or bottom lid to enable accessing the presets. The transmitter input is a 5-way DIN plug, the output to the IRED a 2-way DIN plug as used for loudspeakers. Drill additional holes to prevent overheating of T_5. The zener diode, D_1, also gets fairly warm, but requires no cooling. The relatively thick supply wires are secured with a strain relief and fed through a grommet.

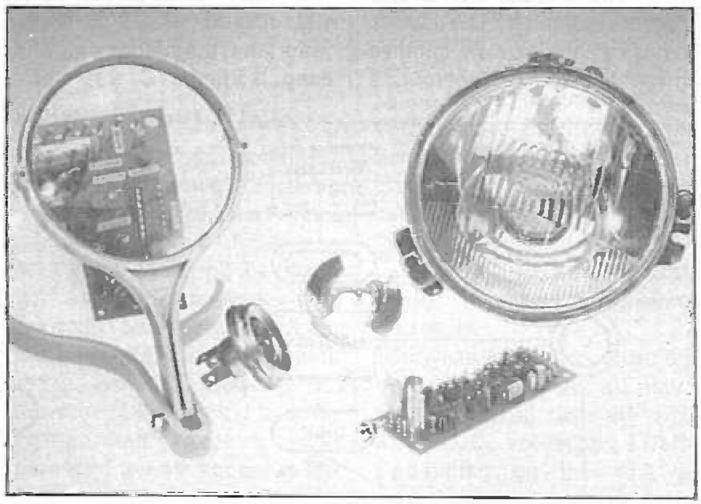
Field trials, duplex operation, applications

Find a line-of-sight path of about 50 metres for an initial trial, and increase the distance covered with, say, 10 metres at a time. The reflector and the lens have extremely narrow beamwidths, and their aiming requires some experience. Carefully slide the receiver assembly in the tube, and adjust the IRED position, until reception is optimum. For distances over 1,000 metres it is recommended to use field-glasses and, if possible, a set of PMRs for maintaining the contact. A well-aligned finder fitted on the receiver will soon prove indispensable. Never aim the receiver tube at the sun when this is bright; the destruction of the photodiode will be immediate.

Two-way communication is possible with a complete transceiver at both ends. Provided the reflector is placed ahead of (but not in front of) the local receiver, it is not even necessary to use different frequencies.

Applications of the present transceiver include wireless car security systems, and permanent, wireless, intercoms between homes. A security system can be set up for the home by placing plane mirrors at suitable locations. The transmitter is powerful enough to project an invisible beam all around the house. In this application, the disappearance of the carrier could be detected by the sounding of an alarm. It may not always be necessary to use a reflector and lens of the size indicated above. Even the plastic reflector from a pocket torch, in combination with a 40 mm lens, will enable communication over considerable distances. Convex or plane mirrors could be used for changing the direction of the IR beam. More powerful IREDs, and perhaps even lasers, in combination with more sensitive photodiodes may increase the distances covered without the use of lenses or reflectors, but care should be taken to select a combination for the same wavelength.

Finally, the maximum distance covered with prototypes of the transmitter-receiver was 1,750 m in a single-way link, and 1,350 m in a duplex link. The author is interested in hearing about your experiences with the system through *Elektor Electronics*. D;FYZ,Bu



Various components for building the infra-red transceiver.

References:

[1] *Optoelectronics: An Introduction.* J Wilson and J F B Hawkes (Prentice Hall).
[2] *Single channel infra-red remote control system.* Elektor Electronics, January 1982.

A good general introduction into optoelectronics can be found in:
Optoelectronic components. Siemens handbook, ed. 85/86.

PEOPLE

Major General Gordon Oehlers, who spent 30 years in the Royal Signals, is to become British Telecom's Director of Security and Investigation. Gordon Oehlers, CB, CEng, FIEE, MIERE, (54), comes to British Telecom from the Ministry of Defence where he was Assistant Chief of the Defence Staff (Command, Control, Communications, and Information Systems).

Mr David Hopkins, Managing Director of Dorman Smith Switchgear Ltd, has been elected President of the Electrical Installation Equipment Manufacturers' Association (EIEMA). Mr John S. Hurn, Managing Director of Duraplug Electricals Ltd, is the new Deputy President.

Mr Ray Wigg, Director of International Operations, MK Electric Ltd, has been appointed Chairman of BEAMA's International Trade Policy Committee. Mr John P. Harbord, Regional Director India, GEC Turbine Generators Ltd, has been appointed a member of the committee.

Mr S.C. Vaughan, BSc, CEng, MIProdE, has been appointed the new Vice Chairman of the Machine Tool Trades Association's Exhibition Committee.

Amphenol's Military and Aerospace Division at Whitstable have announced the appointment of Tony Bright as Sales Manager, Military and Aerospace products.

Highlands Electronics Ltd have appointed John Bergin to the new position of Sales Executive with special responsibility for connectors.

THE UNIX OPERATING SYSTEM

Now that the US and the EEC are endorsing the UNIX operating system, and the X/Open Group of European and American computer manufacturers are basing their common standards on UNIX, it seems timely to have closer look at this system.

To begin with, it is useful to state that UNIX is no more and no less than a computer operating system, that is, a program that enables users to *operate* the computer according to an agreed set of commands and utilities. Therefore, UNIX

- is not the latest programming language;
- has essentially nothing to do with graphics assisted programming;
- has provisions for manipulating the computer memory, whether resident as hardware, or in the form of a magnetic storage device (tape; hard disk).
- forms the lowest command level for loading and running higher language interpreters and compilers (C; Cobol; Fortran).

UNIX in its most elementary form is fairly crude, and has none of the user friendly features offered by currently available PC operating systems as, say, PC Boss, GEM, POWER, or MS Windows. It is an operating system intended mainly for minicomputers and mainframes that communicate with a number of users via terminals. The system is, therefore, said to have *multi-tasking* and *multi-user* capabilities, and the operating speed of the computer depends on the *processor load* caused by the users accessing and manipulating various data fields, utilities and programs in the memory. One of the most important points about UNIX is its portability, which means that it can be installed on any (big) computer running the C programming language—more about this later. The recently introduced fast PC ATs, hard disks, 80286 and 80386 based PCs, RISC (reduced instruction set) computers, transputers, and the absence as yet of a supporting disk operating system (DOS) from MicroSoft, have furthered the interest in UNIX, which, in its most rudimentary form, has long been the exclusive domain of academic and scientific institutions. Whence, then, the interest in a fairly primitive operating system when existing DOS versions support full-screen command editors, turnkey and ready-programmed utilities for complex file operations, and computer control direct from a keyboard? Surely, these are preferable to a terminal and a serial link to and from the computer? The answer to this is, paradoxically, another question: if the latest computers are so fast, and come with so much memory at affordable cost, why not share their capabilities between several users?

The story of UNIX

The evolution of UNIX is shown simplified in Fig. 1. In 1969, two programmers at the Bell Laboratories, K Thomson and D Ritchie, decided to develop a time sharing system for the PDP-7 computer. The program was written in assembler code, and named MULTICS. Some years later, the higher programming language C was developed, and applied to MULTICS to make this portable to other systems. The resultant operating system was called UNIX, and Bell Labs distributed it to many non-profit institutions, including the University of California, Berkeley. Due to various political and economic reasons, UNIX was further developed in numerous other, mainly academic, institutions, and all standards seemed to be lost for a time. Reseachers at UC Berkeley, however, once more applied the latest version of C to UNIX, and came up with the so-called *C shell*, which gave greater flexibility than the

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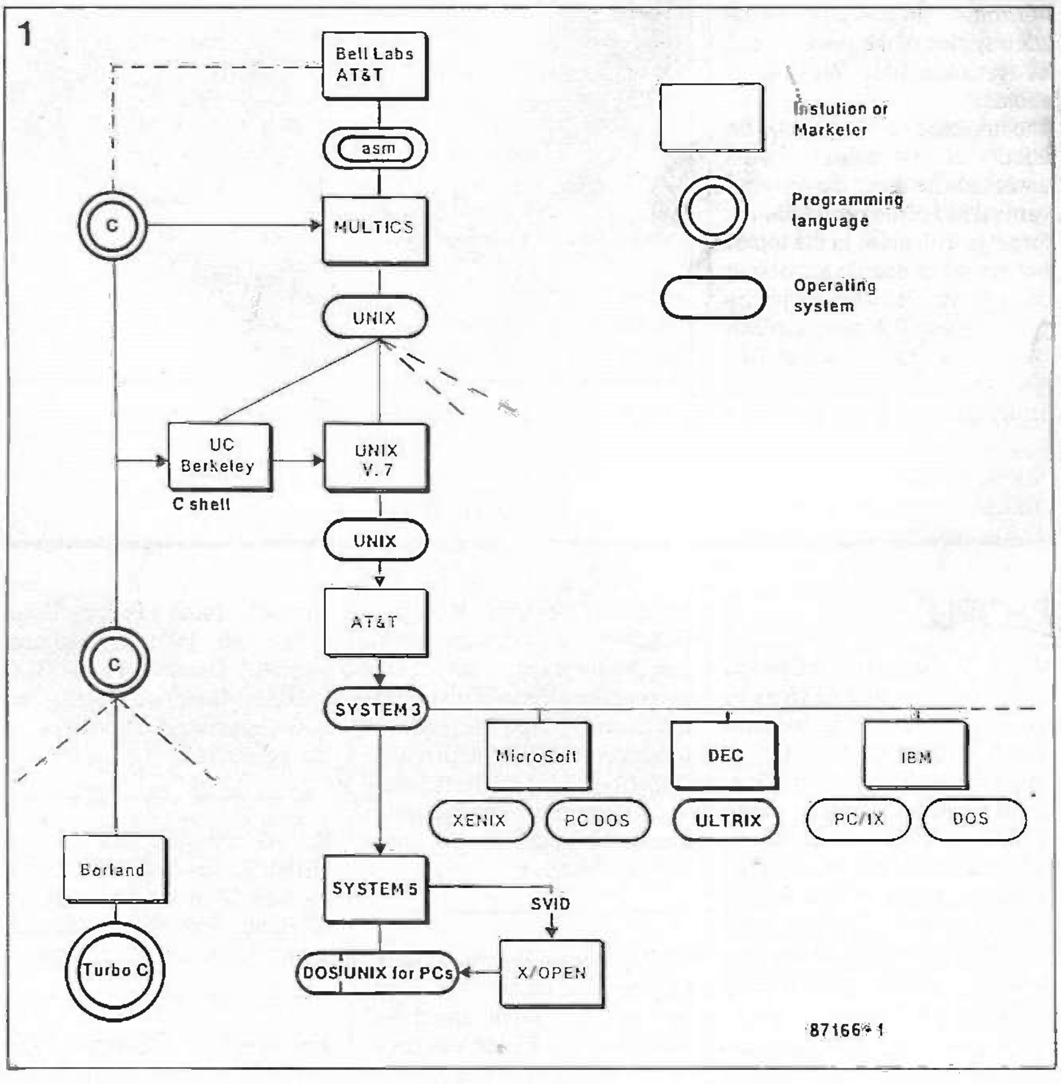

Fig. 1 The history of UNIX is one of many derivatives, licence holders and marketers.

earlier Bourne shell in implementing the system on a mainframe. The shell of UNIX is the part of the software that translates the user's commands into workable code for the *kernel*, which forms the system's "brain". The programs that run under UNIX have direct access to the kernel. Programmers at AT&T reworked UNIX using the C shell, and eventually released SYSTEM 3. They also agreed to support licence holders for this product, and worked on further improvements as to compatibility with previous releases. Microsoft, DEC and IBM were among the many marketeers to use UNIX as the basis for a new operating system. While DEC and IBM worked on software and hardware for mainframes, or, in any case, large computers, Microsoft came up with a version of UNIX that could be implemented on 8086 and 8088 based machines, in other words, the (IBM compatible) personal computer. XENIX is a fairly large operating system, requiring at least 512 Kbytes of RAM, and a 10 MB hard disk. It is a multi-user and multi-tasking system that runs PC DOS as a subset or concurrently. Obviously, the speed of XENIX is not up to that of a mainframe, even if the processor load is relatively light.

PC/IX is marketed by IBM, and is not a true version of UNIX in that it supports but one user. It can, however, run multiple tasks, and supports the DOS functions. Contrary to XENIX, PC/IX uses the Bourne shell.

With the arrival of the previously mentioned new generation of fast PCs, the need arose for a single, standardized, version of UNIX, which at that time existed in a multitude of derivatives. For the first time since the development of MULTICS, written in assembler code, the hardware configuration of the computer running UNIX became a major issue—remember that UNIX in the form of a C file required compiling and adapting certain "modules", particularly in the shell, to suit the particular hardware used; this was all for the sake of portability, which enabled programs written in higher languages, such as Fortran or Cobol, to be loaded and run on many types of computer. It can be argued, therefore, that UNIX owes some of its popularity in the professional fields to the programming language C, which has, meanwhile, developed into many different versions, the best known of which is probably Borland's Turbo C.

Three years ago, a number of computer hardware manufacturers teamed up to form the X/Open Group, which includes Bull, Ericsson, Nixdorf, Olivetti, ICL, Philips, DEC, Unisys, Hewlett Packard, and Siemens. Recently, AT&T also became a member, while Gould and Honeywell are bidding for acceptance in the group.

The aim of the X/Open group is to set the hardware standard for the UNIX operating system, and, possibly, to arrive at a complete integration of UNIX and DOS. The starting point for the Group's proposals is UNIX System 5, and the associated *System V Interface Definition* (SVID) from AT&T. The new version of UNIX will be called POSIX (*portable* UNIX).

Working with UNIX

The scope of this introductory article does not allow detailing every aspect of the UNIX operating system. None the less, some idea will be given how a user communicates with the computer through UNIX, or, more precisely, the UNIX shell. Via the terminal, console or PC, the user must first log into the system and state a valid password to gain access to the files and/or programs in (sub)directories he is authorized to work with. Some of the simpler utilities in UNIX are resident, i.e., always available irrespective of the file or directory currently opened. As an example, Fig. 2 shows the directories available to user Henry2, who operates one of the terminals in the system. Henry2 has access to files in the directories set up for Fortran, Wordprocessing, Desktop Publishing (DTP), and Computer Assisted Design (CAD), but not to Accounting. Each of the directories shown is divided in a number of subdirectories, and files can be transported between them. So far, the system looks very similar to a DOS tree structure. In principle, there is no limit on the number of directories, provided there is enough space on the hard disk. Several users may access the same file simultaneously, and programming tasks may be carrried out in the background, that is, the user starts the relevant command sequence, and the computer determines the appropriate moment for dealing with it and presenting the output. So-called *pipes* and *filters* can be set up to feed the output of one command to the input of the next. Using command tee, it is even possible to specify the location of a tee fitting in pipe. This enables feeding data in parallel to two files or command sequences simultaneously.

UNIX has a number of built-in editors, which are all much more powerful than the well-known DOS line editor, EDLIN. Depending on the data involved, and the type of terminal, the user selects the line editor (ed or ex), the screen editor (vi), or the stream editor (sed) before calling up a file or running an application program. UNIX has commands and utilities for scanning, concatenating, deleting, copying, dating, sorting, comparing, locking, filtering, encrypting and copying files. If a particular file operation is expected to cause a considerable processor load, it can be carried out in the background, or even in the absence of the operator. In most UNIX based systems, there is a central system controller who assigns the priority levels to the users, and determines whether or not they have access to certain directories. Usually, the controller's own terminal has the highest priority, and is located near the computer. The controller's task is to monitor the processor load, and, if necessary, redirect commands to the background level.

2

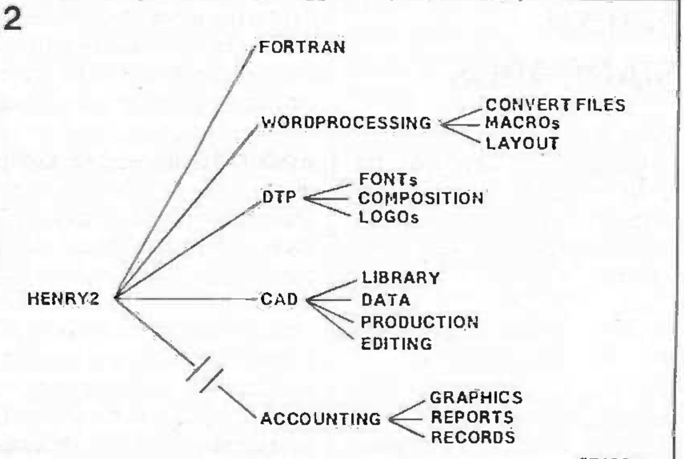

Fig. 2 Example of directories and subdirectories that can be accessed by a user in a UNIX system.

Unix and MS-DOS: competition or integration?

It is interesting to note that the term DOS has become a synonym for *computer operating system*, whereas, strictly speaking, it is only a *disk* operating system. UNIX is a computer operating system in the true sense of the word, and DOS, therefore, forms a part of it.

As already stated, the new 32-bit microcomputers are definitely fast and powerful enough to carry a "heavyweight" operating system such as UNIX, if this is supported by the hardware standards proposed by the X/Open Group. But what is the future of such a standard if IBM is not a member of the group? Every PC user knows that there exists a massive amount of software running under MS-DOS, and fears may arise that this is incompatible with the PC version of UNIX that will eventuallye volve from the Group's activities. Fortunately, IBM considers it "consistent to support Posix as a standard as well as enhancements to it", to quote the company's market development manager, Mr Art Goldberg. IBM, in co-operation with Interactive Systems, has already introduced a UNIX computer for professsional applications: the Type 6150 PC RT UNIX. For 80386 applications, the companies have developed

a virtual machine monitor called VP/ix. This makes it possible to support multiple DOS users under UNIX. Recently, AT&T licensed Microsoft to develop a 80386 based version of UNIX, as a follow up of XENIX.
The Model 80 in the recently launced Personal Series 2 computers from IBM can run the proprietary Operating System 2 (OS2) as well as DOS version 3.3. OS2 is similar to UNIX and XENIX in that it allows running programs in the background. Nevertheless, IBM have tentatively announced their own version of UNIX for the Model 80.

A lot is happening in the current computer scene, and the announcements of major computer manufacturers and software houses concerning UNIX follow in rapid succession. It will take some time, though, before UNIX will be available to the user of a personal computer that is not part of a network. Meanwhile, the development of suitable LANs (local area networks) is an important aspect in the discussion on software for multi-user systems. It is not unlikely that the work of the X/Open Group will provide a strong impulse for the standardization of networks with, say, to 16 users.
As usual in the computer business, the users are after standardization and cost effectiveness, and the manufacturers after increasing their sales. Numerous events in the past have shown that these interests are at best...incompatible.

```
UNIX(r) VAX11/750
#
login:_ henry2
password:_intime
%_who

William tty03 Nov 5 08:15
Anita console Nov 5 08:31
Steve   tty13 Nov 5 09:12

%_write william
pascal programs ready for testing on tty30
o
yes send as \bin file please
oo

%_cd reports
%_ed newdoc
?newdoc
                                   87166
```

A typical programming or file editing session under UNIX starts with the login procedure.

For further reading:

Unix on the IBM PC, by William B Twitty. Glentop Publishers, ISBN 1 85181 061 7.

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IBM, IBM PC and PC/IX are trademarks of International Business Machines Corporation.
UNIX is a registered trademark of Bell Laboratories.
XENIX , MS Windows and MS-DOS are registered trademarks of Microsoft Incorporated.

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CMOS Circuits Manual

by R.M. Marston
ISBN 0 434 91212 3
190 pages — 216×138 mm
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CMOS Circuits Manual is intended as a single-volume guide to the user, and is specifically aimed at the practising design engineer, technician, and experimenter, as well as at the electronics student and amateur. It deals with the subject in an easy-to-read, down-to-earth, non-mathematical, yet comprehensive manner. It starts by explaining the basic principles and characteristics of the CMOS family and goes on to describe circuits ranging from simple inverters and gates to complex counters and decoders, with a large number of clock and pulse generator designs.
William Heinemann Ltd
22 Bedford Square
LONDON WC1B 3HH

BRITISH STANDARDS

There are a number of new or reissued British Standards, the more important of which (for electronics/telecommunications engineers) are listed below.

BS6865: time and control codes for video tape recorders.
This standard is identical with IEC461:1986 and will help overcome the absence of a standard digital code format and modulation method for timing and control purposes of television tape machines and/or associated separate audio recorders. BS6865 is priced at £25.60 (£10.24 to BSI subscribing members).

BS6758: Type C helical video tape recorders.
This standard applies to magnetic video recording and/or reproduction using 25.4 mm tape on Type C helical video tape recorders suitable for broadcast applications. The object of the standard, which is identical with IEC558:1982, is to define the electrical and mechanical characteristics of equipment which will provide for interchangeability of recordings.

BS6840: Sounds system equipment.
This standard will consist of 16 parts, of which eight are still in preparation. It applies to sound systems of any kind, and to the parts of which they are composed or which are used as auxiliaries to such systems.
The standard deals with the determination of the performance of sound system equipment, the comparison of these types of equipment, and the determination of their proper practical application, by listing the characteristics which are useful for their specification and laying down uniform methods of measurements for these characteristics.

BS5942: High fidelity audio equipment and systems; minimum performance requirements.
This standard applies equally to monophonic, stereophonic and multichannel equipment and systems. It consists of 10 parts in which the requirements for the individual units of a system are given: (1) General; (2) Radio tuner units; (3) Record playing equipment and cartridges; (4) Magnetic recording and playback equipment; (5) Microphones; (6) Amplifiers; (7) Loudspeakers; (8) Combination equipment; (9) Magnetic tapes for audio recording; (10) Headphones.

All British Standards are available from
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NEW LITERATURE • NEW LITERATURE

Television and Video Engineers' Pocket Book

by Eugene Trundle, MSERT, MRTS, MISTC
ISBN 0 434 90197 0
323 pages — 190×108 mm
Price £9.95 (hardback)

This is a gem of a book, written by a television/video service engineer for practising service engineers. As would be expected, therefore, it is thoroughly practical in its approach to the myriad of fault symptoms service engineers everywhere are regularly confronted with.

The book is aimed primarily at engineers working on System I equipment, but it has not overlooked the other systems in use (NTSC, SECAM, and PAL-Europe), so that it can be used by service engineers throughout the world.

Another attraction of this thoroughly recommended book is its price, which should make it possible for every hard-working, low-earning service engineer to acquire his own copy.

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Antennas: Volume 1 – General Principles

by E. Roubine & J.C. Bolomey
ISBN 0 946536 06 6
218 pages — 235×160 mm
Price £27.50 (hardback)

This work, based on lectures given by its authors at the École Supérieure d'Électricité, is intended to give engineers and students of electrical/electronic engineering a thorough grounding in the theory of antennas and their applications.

Part 1 is a synopsis of classical electromagnetism on which the theory of antennas is based, supplemented by a discussion of the basic elements of optics. Part 2 deals with fields and radiated power, gain, impedance, coupling, and other aspects common to all antennas. Much space is given to the subject of reception and to numerical methods.

Volume 2 is devoted to applications and is roughly divided between large and small antennas, based on state of the art themes which provide plenty of scope for instruction. This volume is due to be published in a few months's time.

The authors are not only lecturers at one of Europe's foremost Schools of Electrical Engineering, they are also practising engineers. The present work is, therefore, an integrated discourse that will be of practical use to anyone working with antennas.

This book, ably translated from the French by Meg Sanders, could well become a standard work on antennas.

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Electronic instruments and measurement techniques

by F.F. Mazda
ISBN 0 521 26873 7
312 pages — 245×170 mm
Price £37.50 ($69.50) (hardback)

Not so long ago, an electronics engineer's complete range of test instruments normally consisted of an AVO meter, an oscilloscope, and possibly some kind of signal generator. These were sufficient for the majority of manufacturing, servicing, or even development tasks.

Things have changed considerably, and nowadays the field of electronic measurements and instrumentation is vast. This book attempts to cover all the major areas: it gives an understanding of the principles involved in electronic measurements, and describes the fundamental aspects of the instruments and their basic operations.

The book is divided into three parts: the first deals with the fundamentals of measurement; the second describes general purpose instruments; and the third deals with measurement techniques of a specialized nature. It also includes a chapter on optoelectronic measurements, including a description of optical units, optical measurement techniques, and fibre optic systems.

This is a very welcome work on an important field and should prove useful for many years to come to practising engineers, students, and serious enthusiasts alike.

Cambridge University Press
The Edinburgh Building
Shaftesbury Road
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An Introduction to Antenna Theory

by H.C. Wright
ISBN 0 85934 173 9
86 pages — 178×110 mm
Price £2.95 (softback)

A lovely little book that gives a good introduction to the basic concepts of receiving and transmitting antennas, without becoming too mathematical. Apart from dealing with most aspects of antennas, the book also includes a list of experimental papers and a list of recommended further reading. Good value for money.

As a footnote, readers may be interested to know that they will receive, free of charge, a copy of the new 1988 Babani catalogue by just sending their name and address to

Bernard Babani (Publishing) Ltd
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LONDON W6 7NF

Video Handbook (Second Edition)

by Ru van Wezel
ISBN 0 434 92189 0
455 pages — 240×160 mm
Price £30.00 (hardback)

The *Video Handbook* presents in one volume most of the information needed to understand video. It is a thoroughly practical book intended for technical personnel in video/television production companies, students, and serious enthusiasts. Theoretical considerations have been kept to an absolute minimum.

Early chapters cover television standards, transmission, the structure of the complete video signal, cameras and tubes, including a build-it-yourself monochrome camera. The master control desk is dealt with in detail, including trick effects such as wiping and keying, and a simple self-build control is described.

Later chapters cover transmission and reception systems, cables, video recording and editing (open reel and cassette) and audio recording and playback. A chapter is devoted to community TV production techniques, including lighting, composition, scenario, and make-up.

Final chapters round off the coverage with measurements, design criteria, diagrams, test patterns, and print layouts.

This excellent and comprehensive book has one flaw, however, which may detract from its usefulness in many countries: it does not deal with the SECAM, NTSC, or even the PAL-Europe standard. A pity, and it must be hoped that this deficiency is put right in the 3rd Edition.

William Heinemann Ltd
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THE INMOS TRANSPUTER AND OCCAM

A brief introduction to the higher programming language tailored to supporting the transputer's concepts of concurrency and parallel processing.

Traditionally a computer is set up according to John von Neumannn's model: a central processor fetches instructions from a memory, and manipulates data accordingly. Whatever its speed and internal architecture, the processor can only handle a single instruction at a time. This is even true in multi-user and multi-tasking systems such as UNIX and concurrent MS-DOS, where the processor is apparently engaged in several tasks at a time, but in reality assigns time slots to portions of the relevant task(s). Obviously, the faster the processor, the less users are aware of the time sharing process.

The transputer is a radical departure from the von Neumannn concept. Transputers are optimized for true concurrency. Parallel processing of data and instructions is achieved by synchronized, very fast point-to-point communication channels between processes as well as individual transputer modules. There is, in principle, no limit on the number of transputer modules that can be connected to form a computer. In contrast to other processors, transputers enable defining the speed of the system simply by adding as many modules as required. Currently, the IMS T800 transputer from Inmos is the fastest single chip microcomputer available. In the so-called Whetstone benchmark test, the 20 MHz version outperforms all of its 32 bit competitors, including the Fairchild Clipper, the National Semiconductor NS32332—32081 and Motorola's MC68020—68881. Note that the latter 2 are combinations of a microprocessor and a floating point arithmetic co-processor; the transputer has both of these on a single chip. The calculation performance of the IMS T800 is equal to that of the VAX 8600 scientific computer from DEC, while a network of 10 IMS T800 modules offers the speed and processing power of the Cyber 205 supercomputer from Control Data Corporation. Clearly, the hardware concept of true parallel processing implemented in the transputer guarantees a yet unheard of computing power, but at the same time calls for supporting software that exploits the concurrency, and so enables gaining most benefit from the transputer architecture. The answer was given by Inmos themselves in the form of the higher programming language Occam.

Concurrency in software

Before introducing the higher programming language Occam, it is useful to note that a transputer can also run existing scientific programming languages including C, Fortran and Pascal thanks to the availability of suitable compilers. Interestingly, some software houses have applied the parallel programming constructs available in Occam to implementations of existing higher programming languages, with the aim of optimizing speed and performance.

1

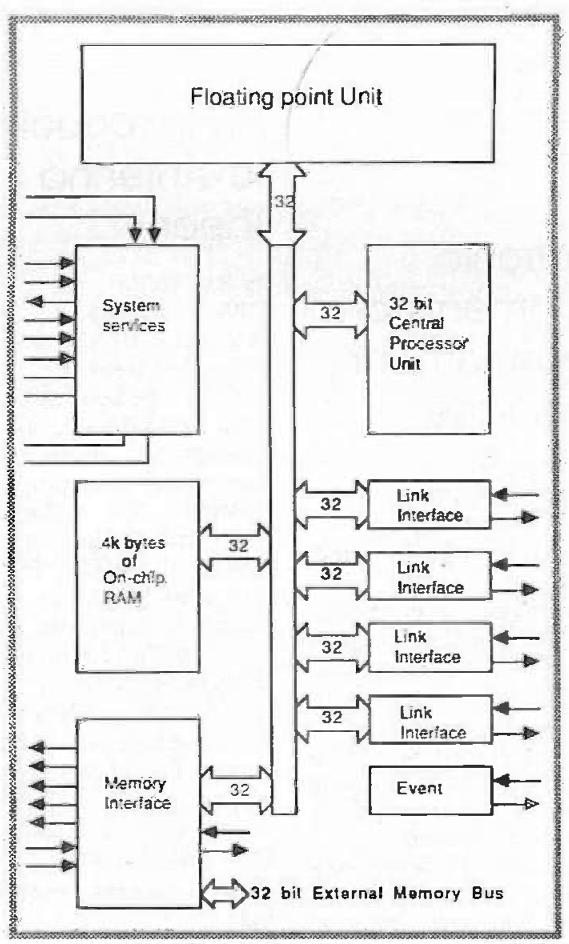


Fig. 1 Block diagram of the IMS T800 transputer module from Inmos.

Occam is not just a new programming language, it is the framework for designing concurrent, transputer-based, systems. As such, it is similar to Boolean algebra as the framework for designing with logic gates. Abstract logic functions can be realized, i.e., built using the actual gates, while the function of a number of these can be analysed in turn by the corresponding Boolean notations. Similarly, a process in a computer can be thought of as a black box, with inputs and outputs. Processes can be connected together by channels to build more complex, concurrently operating, systems. A collection of processes is in itself a larger process with internal and external concurrency. The transputer has a scheduler which enables any number of concurrent processes to be executed together, sharing the processing time. Occam has provisions for supporting this hardware concurrency, and is stated to be as efficient as hand coding, obviating the need for an assembly language. The central processor in the transputer is so fast that procedure calls, process switching and interrupt latency all have a duration in the sub microsecond region. Processes waiting for communication or a timer function do not consume CPU time. The floating point unit in the IMS T800 is a 64-bit type to ANSI-IEEE 754-185, operating fully concurrent with the processor at more than 1.5 MFLOPs. Data between processes is transferred via links, which are either unidirectional or bidirectional. The 4 available links are synchronized DMA block transfer mechanisms operating at a speed of 20 Mbit/sec, with 10 and 5 Mbit/s also allowed for compatibility with other Inmos transputers (IMS T212, IMS T414). The internal 4 Kbyte memory can be accessed at 120 Mbytes/s, and the IMS T800-30 can directly address an external memory area of 4 Gbytes at a rate of 40 Mbytes/s. The block diagram of the IMS T800 transputer is given in Fig. 1.

There exists a remarkable architectural relationship between Occam and the transputer. With the introduction of Occam, Inmos, like no other semiconductor manufacturer, have succeeded in gearing software to hardware, and vice versa.

In Occam, there are 3 primitive processes, namely input, output, and assignment. Each of these can be performed in 3 ways: sequentially, in parallel, or alternatively. The latter term simply means that whichever data is first available is first processed. Parallel processes are set up by defining channels through which the data is routed. At first sight, Occam programs look very similar to, say, C or even Forth. This is because the writing down of instructions on paper is in fact a sequential process: we can not express concurrency by writing 2 or more instructions over another, since this would make the text illegible. Thus, although the program is still made up of lines of instructions, these are not necessarily executed in the indicated order, or in the order indicated by the instructions themselves (as is the case with, for example, GOSUB, ONERR, or GOTO in BASIC). Also note the complete absence of line numbers.

The structure of an Occam program reflects the hardware concept of parallelism, but the programmer need not bother where and how the actual processes are executed in the transputer. Concurrent programs are by no means easy to write and debug. And yet, Occam is readily learnt once its formal description is known.

The principles

Two brief examples will be given of hypothetical Occam programs reproduced from reference [1]. The first is given in Fig. 2. The protocol of channels comm1 and comm2 is defined as integer transfer with the aid of statement **CHAN OF INT**. **PAR** defines parallel processing, i.e., the data obtained from the communication process first finished is first dealt with by the processor. The communication processes themselves are defined as sequential by instruction **SEQ**. Variables **x** and **y** are integers. Notice the indentation levels that indicate which statements belong to **SEQ** and to **PAR**. The program shown illustrates the central principle of Occam programming; the **PAR** statement defines that the written order of the component processes is irrelevant, as they are all performed at the same time, i.e, *concurrently*. The idea of several things happening simultaneously in computer programs may be new to many programmers. **PAR** causes component processes to start at the same time, and the programmer need not bother which of these is completed first.

The exclamation mark ! denotes output, and the question mark ? input on a channel. It is seen that integer 2 is first output on comm1, before comm2 is allowed to receive variable **x**. At the same time, however, comm1 receives variable **y** before comm2 is allowed to send integer 3. The effect is that each process sends a value to the other: **x** becomes 3, and **y** 2. Note that the order of the **!** and **?** in each **SEQ** process is important to prevent them waiting for each other's output indefinitely.

The next example is a program for digital volume control on an amplifier. It is assumed that there are 3 buttons, called **louder, softer** and **off**, which are arranged to pass their current status to an Occam channel. A fourth channel, **amplifier**, transmits the required value to the volume control chip.

The program of Fig. 3 is fairly easy to read and understand. First, the **minimum** and **maximum value** of the volume setting are declared as 0 and 100 respectively. Variables **volume** and **any** are defined as integers. The **ALT** statement indicates alternative processing as long as the WHILE statement is true. In this example, each of the processes that belong under **ALT** are "scanned" for activity, i.e., there is immediate action on part of the program and the transputer hardware when either **louder, softer,** or **off** is actuated. For instance, if the **softer** button is pressed, the *sequential* process of decreasing the value assigned to **volume** is started, but this does not mean that the other **ALT** processes are not continuously interrogated for activity. The program terminates when the **off** button is pressed, since this ends the validity of the WHILE statement.

2
```
CHAN OF INT comm1, comm2:
PAR
  INT x:
  SEQ
    comm1 ! 2
    comm2 ? x
  INT y:
  SEQ
    comm1 ? y
    comm2 ! 3
```

Fig. 2 Illustrating how Occam makes the distinction between parallel and sequential constructs.

3
```
VAL maximum IS 100 :
VAL minimum IS 0 :
BOOL active :
INT volume, any :
SEQ
  active := TRUE
  volume := minimum
  amplifier ! volume
  WHILE active
    ALT
      (volume < maximum) & louder ? any
        SEQ
          volume := volume + 1
          amplifier ! volume
      (volume > minimum) & softer ? any
        SEQ
          volume := volume - 1
          amplifier ! volume
      off ? any
        active := FALSE
```

Fig. 3 This Occam program controls the digital volume input on a hypothetical AF amplifier.

Conclusion

The previously discussed programs illustrate only a few of the many instructions and statements available in Occam. It is beyond doubt that Occam is currently the only language that enables profiting from the concept of parallel processing in a network of transputers.

Inmos have a vast range of products to aid in learning to work with transputers. As to hardware, there are, for instance, memory extension modules, a chip with a very fast colour lookup table (CLUT), link switch and adaptor modules, and, most importantly, development and evaluation systems. These are available for various computers, including the VAX/VMS, and the IBM PC XT/AT. Also available are complete evaluation modules composed of a rack, a busboard, a power supply, and cards with an option for fitting a number of IMS T414 or IMS T800 transputer modules. Clearly, Inmos, in contrast to many of its (would-be ?) competitors, deserves credit for presenting hardware and supporting software for a computer concept that is both completely new and close to real life, since it is based on concurrent rather than sequential processing. *Bu*

Reference:

[1] *A tutorial introduction to OCCAM programming,* by Dick Pountain.

More information on transputers and Occam can be found in:

The transputer family: Product Information.
Inmos Spectrum.
IMS T800 Architecture.

All publications are available from Inmos Limited • 1000 Aztec West • Almondsbury • Bristol BS12 4 SQ. Telephone: (0454) 616616. Telex: 444723.

SSB RECEIVER FOR 20 AND 80 M

Experienced DXers as well as novice SW listeners will appreciate this compact, sensitive, and relatively simple to build single-sideband receiver for the popular 20 and 80 metres bands.

The 80 m band extends roughly from 3.5 to 4.0 MHz, and its propagation characteristics enable "local" communication over distances up to about 1,000 km. The 20 m band (14 to 14.5 MHz) is ideal for global communication, provided the right "paths", i.e., tropospheric propagation modes, are available and "open". Very long distances can be covered using low power transmitters, but some knowledge is required of the maximum usable frequency (MUF) in the direction of reception at a given local time.
Sections of both the 20 and the 80 m band are assigned to radio amateurs, but the exact band limits are not the same throughout the world.
Actually listening to radio amateurs and utility stations in these bands is undoubtledly the best way to learn about their pecularities as to optimum propagation conditions for different regions of the world.
The receiver discussed in this article is a straightforward design, with manual control.

Block diagram

When the band switch is set as shown in the block diagram of Fig. 1, the aerial signal is fed to a bandpass filter dimensioned for 14 to 14.5 MHz. A 9 MHz notch filter is fitted at the input to prevent strong signals at this frequency causing break-through, interference or inter-modulation in the intermediate frequency (IF) section of the re-

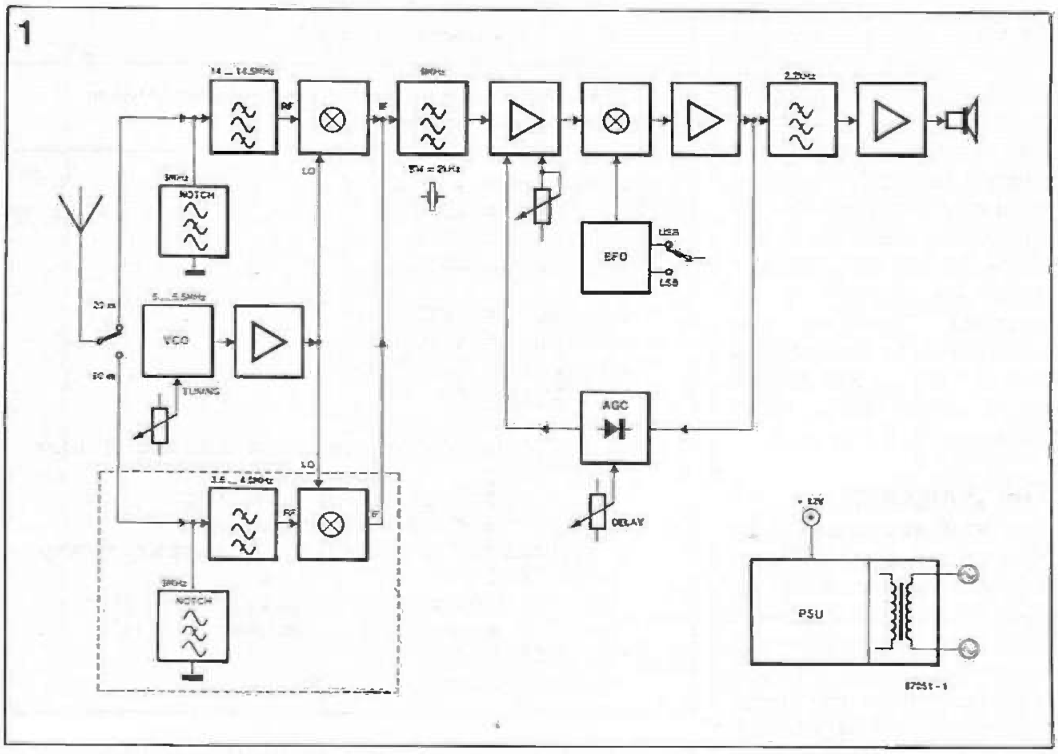


Fig. 1 Block diagram of the SSB receiver for 20 and 80 metres.

ceiver. The output of a voltage-controlled oscillator (VCO) with a tuning range of 5 to 5.5 MHz is buffered, and fed to the local oscillator (LO) inputs of the active mixers that follow the 20 m and 80 m input sections. The IF signal is fed to a 9 MHz quartz crystal filter which ensures a bandwidth of about 2 kHz. After the IF amplifier stage comes the product detector for demodulating the SSB signals. The beat frequency oscillator (BFO) enables detection of the upper or lower sideband (USB/LSB). The output signal of the detector is filtered and fed to the AF power amplifier, but it is also used for driving an AGC (automatic gain control) circuit with adjustable delay. The AGC controls the gain of the IF amplifier.

Circuit description

The circuit diagram of the receiver is shown in Fig. 2. It is seen that a single DPDT switch, S_1, selects reception in the 20 m or 80 m band. The 9 MHz, series resonant, notches are formed by L_4-C_6-C_7 (80 m) and L_1-C_2-C_1 (20 m). The aerial signal is applied to a bandpass composed of a T-filter, L_5-L_6-C_8, and a damped, parallel resonant, circuit L_7-C_{10}-R_5. It is seen that gates g_2 of DG MOSFETs T_1 and T_2 are connected in parallel to enable optimum, DC coupled, driving by the VCO buffer, T_6. The drains of T_1 and T_2 are also joined for feeding the mixers via the damped primary of IF transformer L_8. Switch section S_{1b} takes the source of the relevant mixer to ground. The non-used MOSFET has its source taken to +12 V via a 100 kΩ resistor, and forms a high impedance at the drain. Trimmer C_{13} is used for peaking L_8 at 9 MHz. The bandpass filter for 20 metres is a series-parallel combination with 2 trimmers for setting the correct frequency response.

The VCO is formed by oscillator T_7 and DC coupled buffer T_6. Its output frequency range of 5 to 5.5 MHz is set by C_{24}, while tuning is effected with the aid of the direct voltage from P_1 applied to double varactor D_2. The high impedance at g_1 of MOSFET T_7 guarantees minimum loading of the parallel tuned circuit that determines the frequency of oscillation. Positive feedback is created in

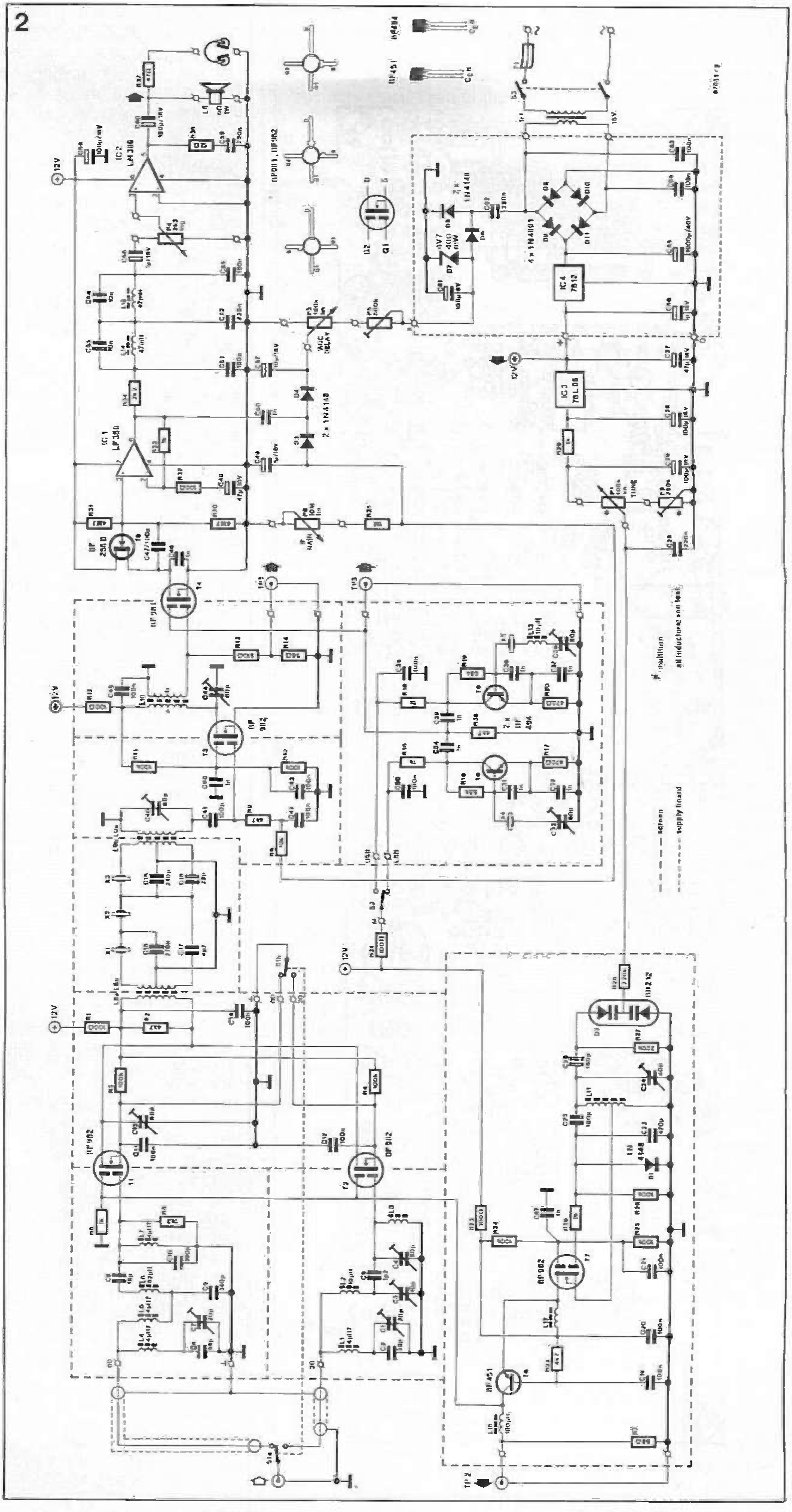


Fig. 2 Circuit diagram of the SSB receiver. The dashed lines represent metal screens on the board.

3

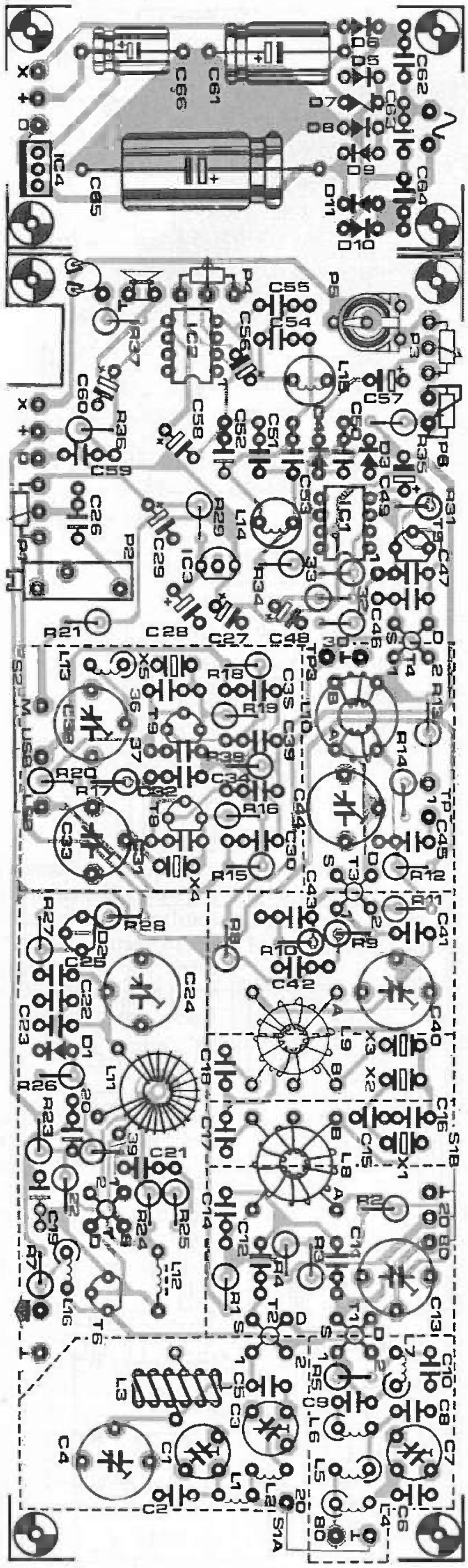


Fig. 3 Component mounting plan of the SSB receiver.

Parts list

Resistors (±5%):

R1;R12;R21;R23;R32 = 100R
R2;R9;R22;R38 = 4K7
R3;R4;R10;R11;
R24;R25;R26 = 100K
R5 = 1K2
R6;R15;R18;R29;R33;R39 = 1K0
R7 = 68R
R8 = 10K
R13 = 560R
R14 = 56R
R16;R19 = 68K
R17;R20 = 470R
R27;R28 = 220K
R30;R31 = 4M7
R34 = 2K2
R35 = 1M0
R36 = 12R
R37 = 47R
P1 = 100K multiturn potentiometer
P2 = 250K multiturn preset
P3 = 100K linear potentiometer
P4 = 2K2 logaritmic potentiometer
P5 = 500K
P6 = 10M linear potentiometer

Capacitors:

C1;C7 = 20p foil trimmer (green)
C2 = 39p
C3 = 10p foil trimmer (yellow)
C4;C13;C33;C38;C40;C44 = 80p foil trimmer (purple)
C5 = 1p2
C6 = 56p
C8;C10 = 390p
C9 = 18p
C11;C12;C14;C19;C20;C21;C30;C35;C42;C43;C45;C47;C63;C64 = 100n
C15;C16 = 270p
C17 = 4p7
C18 = 22p
C22 = 470p
C23;C41 = 100p
C24 = 40p foil trimmer (red)
C25 = 180p
C26;C52;C59;C62 = 220n
C27 = 47µ; 16 V
C28;C29;C60 = 100µ; 16 V
C31;C32;C34;C36;C37;C39;C46;C50 = 1n0
C48 = 47µ; 10 V
C49;C56;C66 = 1µ0; 16 V
C51;C55 = 180n
C53;C54 = 10n
C57 = 10µ; 16 V
C61 = 100µ; 6 V
C65 = 1000µ; 40 V
C67;C68 = 1n0 SMA capacitor

Semiconductors:

D1;D3...D6 incl. = 1N4148
D2 = BB212
D7 = zener diode 4V7; 400 mW
D8...D11 incl. = 1N4001
T1;T2;T3;T7 = BF982
T4 = BF981
T5 = BF256B
T6 = BF451
T8;T9 = BF494
IC1 = LF356
IC2 = LM386
IC3 = 78L08
IC4 = 7812

Inductors:

L1;L4;L5;L7 = 4µH7
L2;L13 = 10 µH
L3 = 24 turns Ø0.3 mm (SWG30) enamelled copper wire on core Type T25-6.
L6 = 82µH
L8A;L9A;L10A = 25 turns Ø0.3 mm (SWG30) enamelled copper wire on core Type T50-6.
L8B;L9B = 5+5 turns turns Ø0.3 mm (SWG30) enamelled copper wire.
L10B = 8 turns Ø0.3 mm (SWG30) enamelled copper wire.
L11 = 42 turns Ø0.2 mm (SWG36) enamelled copper wire on core Type T50-6. Tap at 4 turns from ground.
L12 = 10 turns Ø0.2 mm (SWG36) enamelled copper wire through a ferrite bead.
L14;L15 = 47mH
L16 = 100µH

Miscellaneous:

S1 = miniature DPDT switch.
S2 = miniature SPDT switch.
S3 = DPDT mains switch.
F1 = 100 mA fuse plus holder.
X1...X5 incl. = quartz crystal 27.005 MHz (third overtone).
Tr1 = 15 V; 250 mA mains transformer.
LS = 8 Ω; 1 W loudspeaker.
PCB Type 87051 (available through the Readers services).

the oscillator by taking the source of T_7 to ground via a tap on inductor L_{11}. Test point TP2 at the output of the buffer stage is useful for connecting a frequency meter that can so take the function of a digital frequency readout.

Mixing is additive for the 80 m band (3.5+5.5=9 MHz), and subtractive for the 20 m band (14−5=9 MHz). From this it can be deduced that the tuning direction is reversed on the 80 m band, i.e., a higher VCO frequency results in tuning to a lower input frequency.

A narrow IF bandfilter is set up with the aid of 3 27.005 MHz, third overtone, quartz crystals. Each of these resonates at a very small offset from its *fundamental* frequency, as determined by the particular capacitive arrangement around it. Each of the crystals forms a series tuned circuit with a very high Q (quality) factor. Together with the capacitance and inductance around them, the crystals form a 9 MHz IF filter with a bandwidth of about 2 kHz. MOSFET T_3 forms the IF amplifier whose gain is AGC controlled, as well as adjustable with P_6. The amplified IF signal is coupled out inductively via L_{10}. Test point TP_1 carries the filtered IF signal, and can be used for alignment purposes. The product detector for demodulating the SSB signal is formed by T_4, which is fed from current source T_5. The sideband (USB/LSB) oscillators are vitually identical. The crystals oscillate at the fundamental frequency with a very small offset from 9 MHz. The output signal of a sideband oscillator forms the reference against which the SSB signal is demodulated. USB/LSB selection is effected with the aid of S_2. Trimmer capacitors C_{33} and C_{38} enable adjusting the output frequency of the respective oscillator. The oscillator frequencies can be checked with a frequency meter conected to TP_3.

The unfiltered AF signal is raised in IC_1. Diodes D_3 and D_4 rectify the AF signal to provide the AGC (automatic gain control) voltage. The negative bias voltage on C_{57} is made adjustable with the AGC DELAY potentiometer, P_3. The bias voltage on C_{57} is derived from a stabilized −4.7 V supply set up around zener diode D_7. The AGC works in conjunction with the IF GAIN control, so that the negative voltage effectively controls the amplification of T_3 by pulling the g_1 potential below that of the source.

The 2.2 kHz AF filter discussed under *Block diagram* is a double π type between the output of buffer IC_1 and AF power amplifier IC_2.

The power supply for the receiver is a conventional type based on the well-known 78 series of integrated regulators. The output of 12 V regulator IC_4 is reduced to 8 V in IC_3 to obtain the required span of the tuning voltage at the wiper of P_1. The minimum tuning voltage can be set with the aid of preset P_2.

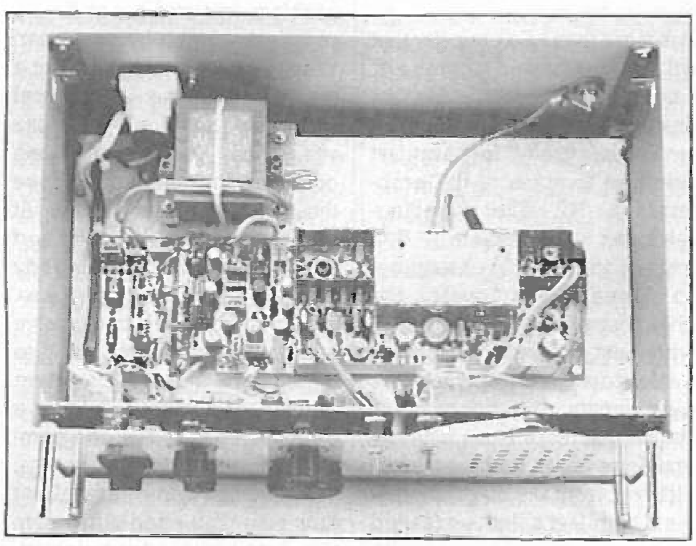
Construction

The printed circuit board for the receiver is a double-sided, but not through-plated, type, whose component mounting plan is given in Fig. 3. The component side of the board functions as a large earth surface. The power supply section on the board may be cut off for mounting as a separate unit in the cabinet.

Commence the construction with winding inductors L_3, L_9, L_{10}, L_{11} and L_{12} as per the indications in the parts list. Secure the wire on the cores using Araldite or wax, then fit the completed inductors on the board as orientation points, observing the right connection of the primary and secondary windings, and the taps. Proceed with fitting the soldering pins, resistors, ready-made inductors, diodes, crystals, and all fixed capacitors except SMA types C_{67} and C_{68}, noting that soldering is sometimes required at the component side also. Pay attention to the polarization of the radial electrolytic capacitors! Then fit the transistors and ICs. Ascertain the pinning of MOSFETs $T_1 \dots T_4$ incl., and T_7, before these are fitted. Push-fit the leads of these transistors securely into the relevant holes before soldering. The source connections on T_3 and T_4 are also soldered at the component side of the board. Now fit SMA capacitors C_{67} & C_{68} direct onto the source and g_2 terminals of the relevant MOSFET. The presets (P_2; P_5) are then mounted, followed by the trimmer capacitors. Care should be taken not to deform the PTFE material in the trimmers when soldering the two ground pins to the copper surface at the component side.

It is absoluty necessary to fit 20 mm high screens at the component side as indicated by the dotted lines on the overlay. Cut these screens from tin plate or brass sheet, and solder them vertically onto the board, taking care not to damage nearby components. Cut a clearance in any screen that runs across an inductor, or a MOSFET with nearby components. The IF section is completely screened with a top plate after setting up the receiver.

The transformer, mains fuse, mains entrance socket, and, if applicable, the supply board, are fitted at suitable (and safe) locations in the metal cabinet. The layout of the front panel is a matter of personal preference; a suggestion is shown in the introductory photograph of this article. Screened wire should be used for connecting the USB/LSB and the 20/80 m switch on the front panel to the respective soldering pins on the PCB. Twist the wires for connecting the IF GAIN, AF GAIN, AGC DELAY, and TUNING potentiometers. Note that the latter is a multiturn type fitted with a suitable knob and dial. The aerial input is an Amphenol SO239 (Type UHF) or BNC socket mounted onto the rear panel of the receiver. The connection to the relevant soldering pins is made in coax. Test point TP2 can be connected to a BNC socket on the rear panel via a length of thin coax, e.g. RG174. Remember that this is a DC coupled, low impedance, output.



Inside view of the prototype receiver.

Setting up

Check the operation of the power supply before connecting it to the receiver.

Set all presets, trimmer capacitors and potentiometers to the centre of their travel. Connect a frequency meter to TP2, and adjust C_{24} and P_2 such that the tuning range of P_1 corresponds to 5.0 to 5.5 MHz. Set the band switch to 80 m, and connect an aerial. Some noise should be audible. Initially, C_{13}, C_{40} and C_{44} are adjusted for maximum noise output. These adjustments are fairly critical. Check that the noise level varies slightly when the IF GAIN control is operated. Use TP3 to measure the output frequency of the sideband oscillators. Select LSB and adjust C_{33} for 8.9985 MHz. Select USB and adjust C_{38} for 9.0015 MHz. Tune across the band to find a relatively strong SSB or RTTY transmission. Optimize the setting of the above trimmers while reducing the IF gain as appropriate. Check the function of the AGC by tuning to a weak signal. The adjustment of P_5 is to the operator's preference regarding the response of the AGC circuit. Redo all the adjustments to optimize reception across the whole of the 80 m band. Switch to 20 m, and peak the input bandfilter for optimum reception. The notch filters are adjusted for highest attenuation at 9 MHz. One of the 9 MHz oscillators can be used temporarily as an RF signal generator. Attenuate the signal at TP3 with a suitable resistance network, and connect it to the

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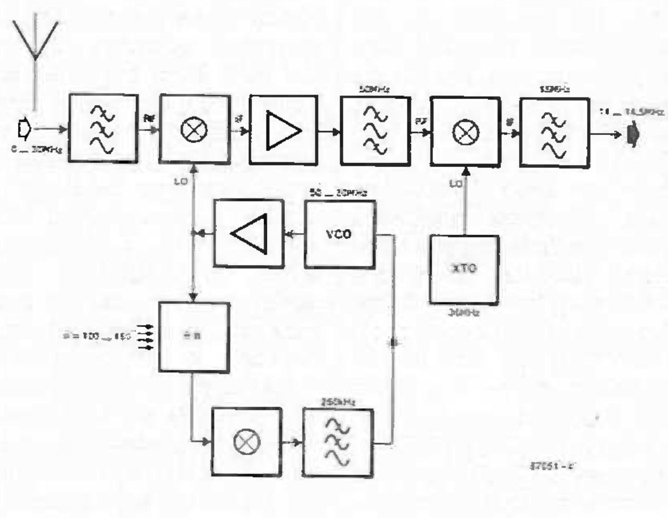


Fig. 4 Suggested block diagram of a 0 – 30 MHz converter.

aerial input. Connect a 10 MΩ, 5 pF scope probe to the RF side of C_4. Peak C_1 for maximum rejection of the 9 MHz signal. Set the band switch to 80 m, place the scope probe on the RF side of L_7, and adjust C_7 similarly.

A general coverage receiver

The unit described can form the tuneable IF section of a 0–30 MHz communication receiver. A suggested block diagram is given in Fig. 4, while the practical circuit of the synthesizer can be found in [1]. The output of the converter is fed to the 20 m input of the present receiver, whose 80 m input can be omitted. Computer control of the receiver so made is relatively simple since all adjustments are effected by direct voltages, which can be generated with the aid of DACs. Also, the computer is likely to be required in any case for decoding slow-scan transmissions, RTTY, morse, or FAX. *B*

Reference:

[1] *Synthesizer for SW receiver.* Elektor Electronics, July/August 1987, Supplement page 61. Designs for a mixer, an RF input amplifier, morse filters, and a computer interface appear in the same issue.

Radio Wave Propagation (HF bands) by F C Judd G2BCX. Heineman Newnes; ISBN 0-434-90926-2.

COMPUTER SCIENCE'S HOLY GRAIL

The art of computing gave birth to its own science, which, since it is abstract and mathematical, is a mystery to most people. This is a pity because computer science explores the limits of tomorrow's computers. The next three pages examine its practitioners' current obsession: "P=NP?"

Suppose you have 10,000 numbers and want to find out quickly whether any group of them adds up to 17. This sounds a straightforward enough job for a computer. Alas, this is not the case. Take the problem to a computer programmer and he will shake his head sadly and say that he does not know any practical way to do it. This is strange, because computers do all sorts of complicated things in a trice. And the 10,000-number problem is, after all, so simple that it can be stated in one short sentence. You have stumbled on a member of a class of problems known as NP. In fact you have hit a problem in this class that is in some ways the most difficult of all (computer scientists call it an NP-complete problem). NP has had computer scientists tied up in knots for the last 15 years. Nobody has found a way of making these problems easy, but nobody has shown that there is no way to do so.

It is more than idle curiosity that drives theoretical computer scientists to search for an answer one way or the other. It would be useful to have fast solutions to some of the problems in NP. The travelling-salesman problem, a mathematicians' old chestnut, is an example. It seeks the cheapest route for a salesman who must visit several cities on a sales trip. No fast way to solve it is known, but nobody has shown that there is no way. NP-problems are in limbo: are they different from the class of problems with fast solutions (called P) or are they one and the same? This question, usually put as "P=NP?" in shorthand, has become the Holy Grail of theoretical computer science.

Remember that our number problem was said not to have a practical solution by computer. What exactly does it mean for a problem to have a practical computer solution? Suppose you work for a telephone company and need to produce the local telephone book. At some point you have to sort through the list of everybody who has a telephone line. Since, for some cities, this can involve millions of names, you need to make sure it can be done quickly. And you not only have to consider how well the computer sorts this year's names, you also have to worry about next year. You need a program that does not take too much additional time as the number of names increases. The best measure of the efficiency of such a program is an indication of how the computation time needed to perform the task rises with the number of names. The relation between the running time and the size of the input (here, the number of names) is called the time complexity of a program.

Computer theorists say a problem has a practical computational solution if there is a program with polynomial time complexity that solves it (or, alternatively, that it can be solved "in polytime"). This means that the time needed to solve it depends directly on the size of the input, or on the size of the input multiplied by itself, or on the size of the input multiplied by itself twice, or thrice, or four times, and so on.

Such problems are said to be in the class P (for polynomial time). Like all theorists, computer theorists tend to be a little unrealistic at times: actually, despite this definition, not all P-problems have genuinely practical solutions. Most programs that run in a time that is any larger than the size of the input cubed (ie, multiplied by itself twice) are probably going to be impractical. This is because the greater the power of the polynomial (the more times you multiply the size of the input by itself) the longer the program will take as the input size increases.

Towards exponential blow-up

NP is the class of problems with solutions that can be checked in polynomial time. For example, in the "subset-sum problem" considered at the beginning of this article: if you want to convince somebody that there is a group of numbers whose sum is 17, all you need do is provide a group that does add up to 17. A computer takes practically no time at all to add up a given group of numbers and check whether or not the result is 17. Note that this implies nothing about how hard it is to find a solution, only that if somebody thinks they have a solution, a computer can easily check it. The trouble with problems such as subset-sum is that however hard computer scientists try, they can come up with little better than a program that inspects every possible group of numbers from the 10,000 provided and checks to see if the sum is 17. With a few tricks, it is possible to get the number of combinations to be inspected down to just over one thousand billion billion billion. Given that the fastest computers operate at a rate of mere millions of instructions per second, solving the problem is a lost cause.

This obstacle is known as exponential blow-up. All the known programs for problems such as subset-sum and the travelling salesmen suffer from the fact that when you add just one more element to the input (such as one more city in the case of the travelling salesman) the amount if computation time required is multiplied by some number. Such a program is said to have exponential time complexity. This quickly makes the computation time extremely large. Imagine a chessboard with a penny on the first square, two on the second square, and so on, with the number of pennies doubling on each square. On the last square, there will be enough pennies to buy around ten billion tons of gold.

When computer scientists defined the class P in 1964, NP was not even a dot on the horizon. But they were turning up problem after problem that exhibited the troublesome features of subset-sum: easy to check a solution if you have one, difficult to find the solution in the first place. Scheduling the operation of different bits of machinery at a factory to get the most efficient production is another such problem, for which no polynomial-time program has yet been found. Current programs use rough and ready rules of thumb to get an answer that is good, but probably not the best.

During the 1960s, scientists noticed that some NP problems could be reduced to other NP problems, which turns out to be a helpful start. For instance, a travelling-salesman problem can be converted into an instance of the subset-sum problem with the help of a conversion program that runs in polynomial time. At the moment, this does not help much because subset-sum problems are just as difficult to solve as travelling-salesman problems. But if you could find a polynomial time solution to subset-sum problems, you could automatically get a polynomial solution to travelling salesman problems by tacking the program to solve the subset-sum problem on to the conversion program. This is because the running time for the two-part program would be the sum of the times for its constituent programs, and adding two polynomials gives you another polynomial. Suddenly, solving many problems became as easy—or as difficult—as solving one of them.

The main breakthough came in 1971 when Dr Stephen Cook, a computer scientist at the University of Toronto, proved a remarkable theorem. He showed that all NP problems could be reduced to a single NP problem in logic called satisfiability (or SAT). If SAT has a fast solution, every NP problem has a fast solution. SAT is therefore said to be an NP-complete problem. It became, in one sense, the most difficult problem in NP. In 1982, Dr Cook got a Turing award—computer science's equivalent of the Nobel prize.

Hard on Dr Cook's heels came Dr Richard Karp from the University of California at Berkeley. Dr Karp reduced SAT to a raft of other NP-problems. At first, this sounds an odd thing to do because Dr Cook had already shown that everything in NP can be reduced to SAT. But the fact that SAT itself can be reduced to subset-sum, and to a handful of other NP-problems, as Dr Karp showed, means that SAT cannot be harder to solve than subset-sum. Dr Cook's reduction of everything in NP to SAT showed, in effect, that nothing in NP was harder than SAT, so—taking Dr Cook's and Dr Karp's results together—it follows that nothing in NP is harder than subset-sum. Subset-sum, like SAT, is NP-complete. Dr Karp, who gave the question "P=NP?" its present form in a paper published in 1972, won the Turing award in 1985.

Dr Leonid Levin, a Russian mathematician now at Boston University (there are quite a few emigré Russian mathematicians working in computer science in America) developed the concept of NP-completeness independently, if a litte later than Dr Cook and Dr Karp. The concept of completeness is crucial to a problem such as "P=NP?". Either you show that P=NP is true or you show that it is false. To show that it is true, you must show that every NP-problem is in P. But there are infinitely many NP-problems. On the other hand, showing that P=NP is false would mean producing an NP-problem that cannot under any circumstances be solved by a polynomial time program. Which problem from NP do you select? You may choose one only to find that it does belong in P, which still leaves you in the dark about all the other (infinitely many) problems in NP.

The concept of NP-complete problems helps you here, because it tells you which problems in NP to look at. The NP-complete problems are the hardest ones in NP. If any NP-complete problem can be shown to be in P, then all of NP is in P. Likewise, if you are working on the assumption that NP is different from P, your best bet is to show that some NP-complete problem is not in P, because if any problem in NP is not in P it will be the hardest one. Cook's theorem allowed computer scientists to confine their attention to the complete problems, and ignore the rest.

Can oracles help?

Even so, and despite their best efforts, computer scientists have got nowhere with the problem in the 15 years since Dr Karp first brought it to their attention. Perhaps surprisingly, there are three possible answers to "P=NP?": yes, no, and indeterminable. Although each has its champions, most computer theorists believe that the answer is no—largely because people have been trying to find polynomial time programs for NP-problems for a long time, and have failed miserably.

Not only have computer scientists failed to prove that P is not equal to NP, they have managed to show (worse luck) that one of the traditional methods for distinguishing classes of problems can work in the case of NP. This emerged from work on some strange computers called oracle machines.

Imagine an ordinary computer that is attached to a black box. In the black box lives an elf, who is an expert on a certain problem—call it A—but doesn't know about anything else. If a programmer asks the elf true-or-false questions about A, the elf answers instantaneously. Now it is possible to define two classes of problems, P^A and NP^A in the same way that P and NP were defined: P^A is all problems that can be solved in polytime by the computer with the aid of the elf, while NP^A is all problems that have solutions that can be checked in polytime. The computer now has the extra power of this elf, or oracle. With this extra power the computer can solve problems in far less time than before. Suppose, for example, that the elf knows all about subset-sum. Then the oracle computer can compute any NP-problem in polynomial time, since it need only convert the NP-problem to subset-sum (which takes polynomial time) and ask the oracle the answer (which it gives instantaneously). Such oracle computers are unrealistic, so what does imagining them prove? Imagining one oracle did not achieve much, but imagining two let computer scientists discover something new. It is possible to work out the details of two different oracles, called A and B, such that $P^A=NP^A$ is true, but $P^B=NP^B$ is false. This is a depressing result for computer scientists. Computer theorists have some tried and tested methods of showing that two classes of problems are different. But all these methods work independently of the presence of an oracle. This means that if the methods were to show that P=NP is false, then $P^A=NP^A$ would be false for every oracle A. But there is a particular oracle B for which $P^B=NP^B$ is true. Thus none of the traditional methods can ever show that P=NP is false.

Another attempt at the problem uses random oracles. In a random oracle the black box contains a little elf with a coin. When asked any true-or-false question the elf simply flips his coin, answering true if he gets heads, and false if he gets tails—unless he is asked a question he has already answered, in which case he gives the same answer as before. For complicated reasons, considering random oracles turns out to be a way of considering all possible oracles at once. Computer scientists found that, for almost all oracle machines, P and NP were not the same. What they wanted to show was that if something was overwhelmingly likely for a random oracle machine, it must be true for machines without oracles. Unfortunately this turned out to be wrong.

Back to the wiring

At the moment, most of the work on the "P=NP?" problem concentrates on circuits, which is ironic. Computer science developed by abstracting computation away from its material basis in electronics and other hardware in order to consider it mathematically. Now computer scientists are turning back to circuits to answer the questions raised by those mathematical abstractions.

The idea is to consider all the digital circuits that can solve a certain problem. The problem is encoded using 0s and 1s and fed into the inputs of the circuit, which yields the answer (1 or 0). A circuit is made up of simple components called gates. The link between circuits and the "P=NP?" question lies in the number of gates required by a circuit to solve a particular problem. If the circuit for a given problem needs more than a polynomial number of gates, that problem cannot be in P. So computer scientists try to show that, for example, SAT cannot be solved by a circuit with only a polynomial number of gates. If it cannot, P=NP must be false.

One of the leading computer scientists now working on circuits is Dr Michael Sipser at the Massachusetts Institute of Technology (MIT). Dr Sipser and his colleagues concentrate on much easier problems than NP-complete ones. Thei have spent a lot of time on the circuit for a problem called parity, which works out whether there is an odd or an even number of 1s in a string of 0s and 1s. The problem of parity is a straightforward one that is definitely in P, but studying satisfiability without looking at simpler problems first would be just too difficult. One technique is to handicap the circuit in some way. For instance, computer scientists might restrict the type of gate used. If they can sort out the simpler restricted cases, they may be able to apply the principles they learn there to the general case.

Plenty of work on circuits has already been done by scientists in the Sovjet Union, as a group of graduate students at the University of California at Berkely accidentally discovered last year. The students had come up with what they and most others thought was a novel result about the minimum number of gates needed to solve the parity problem. To their chagrin, they learned from a paper in an obscure Soviet journal that it had already been done several years earlier. Dr Alexander Razbarov from the Steklov Institute in Moscow seems to be the leading researcher. Dr Sipser collars the occasional Russian graduate student at MIT to translate for him when the latest paper from Dr Razbarov arrives.

Circuit analysis of this sort is not of interest only to theorists. The makers of semiconductors would like to know just how few gates they can get away with using on their chips.

It it were proved that P=NP is false, computer scientists would know for sure that there are no fast ways of solving problems such as the travelling salesman. Some people would be happy to hear it. For a long time, so-called "unbreakable" codes were designed by making up codes, giving them to mathematicians, and letting the mathematicians chew on them for a while. It they could not break them after concentrated effort, then the code was deemed to be usable. The problem with this approach is that a code might turn out to be crackable after just a teeny bit more effort—say one day after it has been passed as uncrackable. If P and NP are not the same, then there are some problems whose solutions are easy to check but difficult to obtain. Much of modern cryptography—at least the part of it that is publicly known—works on this assumption. Some cryptographers would be quite happy to learn that P=NP is false.

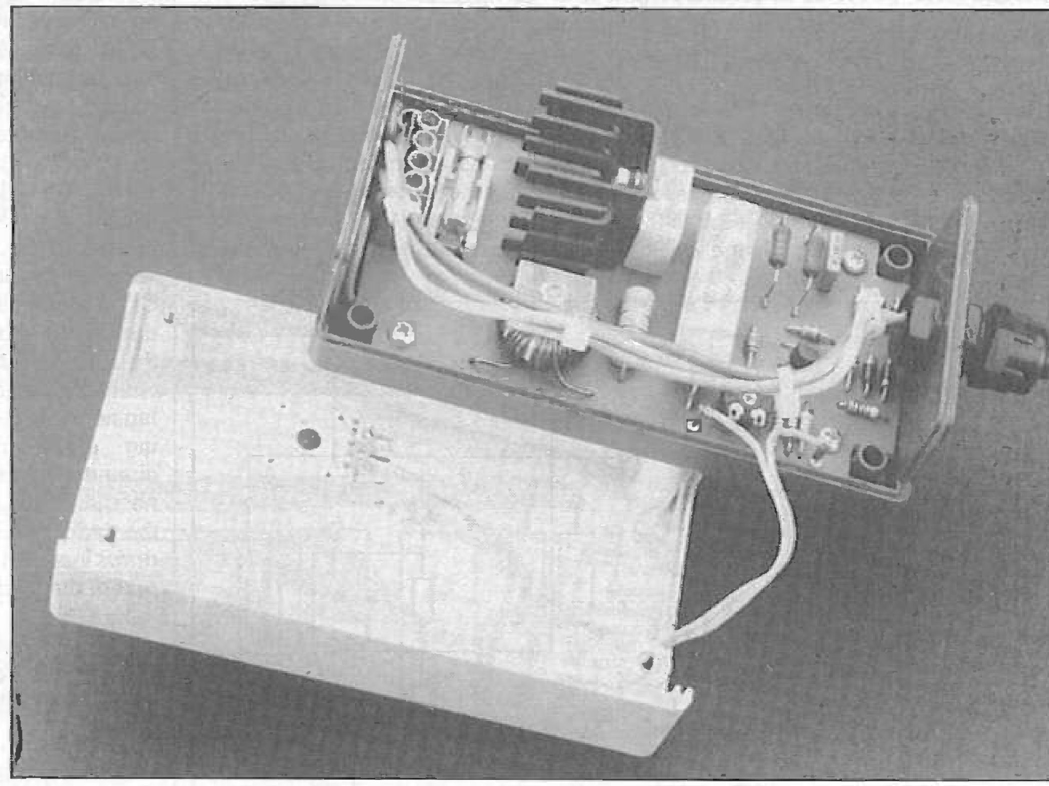
There are still some researchers who believe that P=NP. Many of them are not taken very seriously because they produce endless numbers of flawed papers that purport to show that P=NP. One problem with such papers is their length. Since all the obvious ways of making a fast program from NP-complete problems have been tried, any new attempt is going to be fairly devious. On the other hand, bad proofs purporting to show that NP is different from P are not unknown, either. Dr David Johnson at AT&T's Bell Laboratories in New Jersey has a modest (and almost serious) proposal to stem the tide of bad papers. He proposes that anybody who wants their proof published in a reputable journal should post a $1,000 bond. If the proof turned out to be rubbish, they would forfeit the bond. As an added incentive, forfeited money would go into a pot that would be given to the first verified proof.

If "P=NP?" turned out to have no answer, everybody would lose their money. Before the second world war, a Viennese mathematician, Kurt Gödel, and others proved that some questions in mathematics can never be answered. It is possible that "P=NP?" is one of them. Possible, but inherently unlikely, according to most mathematicians. After all, either there is a program that does subset-sum in polynomial time or there is not. Computer scientists tend to invoke Gödel late at night when they are tired and frustrated.

The smart money is on NP as a separate class, but nobody expects to have an easy time proving it. Dr Cook and Dr Johnson think that the whole field needs an overhaul before the status of NP can be established one way or the other. This is no cause for despair. Computer science is still a young field compared with physics and mathematics. There are ancient unsolved problems in mathematics, such as Fermat's Last Theorem, which get chipped down piece by piece over the years. P=NP has many more implications than Fermat's Last Theorem, an unsolved chestnut about polynomials that has taxed mathematicians for over 300 years. Pure mathematicians are being drawn into the field and computer science problems are being solved by using branches of mathematics, such as geometry, which seemed at first unrelated to computer science.

Everyone concedes that it is difficult to prove even the simplest results in computer science. Even proofs that are easy to understand seem extraordinarily hard to think up, and they may prove unexpected things. This summer Dr Neil Immerman of Yale University settled a question, known as "NL=co-NP?", which is even older though less significant than "P=NP?". A relatively straightforward two-page proof showed that Dr Immerman's answer to the question was yes—the opposite of what most computer scientists expected. Many computer scientists were amazed at how easy the proof was. As one graduate student in computer science put it: "a bunch of complexity theorists are all kicking themselves", which sums up the present atmosphere in a curiously tricky field.

DIMMER FOR INDUCTIVE LOADS



A simple circuit overcomes the well-known difficulty in maintaining the triggered condition of a silicon controlled rectifier when this is used for regulating inductive loads.

The vast majority of dimmer circuits is only suitable for regulating resistive (*non-reactive*) loads, i.e., when there is no phase difference between the mains voltage and the load current. This means that the trigger pulses can be kept relatively short, since the load current is in phase with the mains voltage immediately after triggering has taken place. Normally, the load current is greater than the holding current, so that the triac or thyristor is triggered immediately, and remains on.

When the load is mainly inductive (e.g. a transformer, or a choke for a fluorescent lamp) the load current lags the voltage, and may either not have reached, or exceeded, the holding level. The SCR then conducts briefly, but is switched off at the end of the trigger pulse. This unwanted effect can be kept within limits by means of stretching of the trigger pulse, triggering by pulse trains, or the use of an R-C network. The first approach calls for a control circuit with appropriate drive power. The pulse duration requires exact controlling to prevent pulses occurring after the zero crossing of the mains voltage, causing erroneous triggering. Suitable circuits to accomplish this are, understandably, relatively complex.

A simpler way out is the R-C network, which in essence raises the current to the holding threshold, so that the SCR remains on when the trigger pulse is inactive. Although SCR manufacturers usually provide the relevant design data for this application, it is still fairly difficult to dimension the circuit for optimum and reliable triggering. In most cases, therefore, trial and error adjustments are required, as well as signal analysis with the aid of an oscilloscope.

Triggering by pulse train

The circuit described here is based on gate triggering by a pulse train, yet is composed of discrete components only.

Figure 1 shows 3 ways of controlling a triac.

Figure 1a illustrates a phase angle control circuit for the load Z_L. It is composed of a triac T, a diac D, and a timing network *R-C*, where *R* is (P), connected in parallel with D-A_2, and *C* is connected in parallel with D-A_1. In this circuit, the triggering is load dependent, in other words, synchronization is by the voltage across the triac, and this is a function of the load current. The circuit is, therefore, unsuitable for regulating highly inductive loads requiring a small conduction angle. Also, there exists a strong tendency to asymetrical operation, which can be dangerous in view of saturation of the inductance due to the relatively high direct current.

Figure 1b shows a basic circuit for triggering the triac by the mains voltage. Here, timing resistor (P) is connected to the neutral line instead of parallel to D-A_2. The trigger pulses occur with a fixed phase difference of 180°, irrespective of the load current. Although this circuit offers more accurate control of the load than the previous one, its operation becomes completely asymmetrical if the gate angle is smaller than the angle representing the current lag in the load. Another disadvantage is the requirement for connection to the phase and neutral lines as shown in the diagram.

Figure 1c shows a slightly more complex triac control circuit. Following the trigger pulse, additional pulses are generated up to the next zero crossing of the mains voltage. The operation of the circuit is illustrated in timing diagram Fig. 2. Assuming a phase difference, φ, of 85° between the mains voltage and the load current, and a gate angle, Φ, of 60°, the triac is triggered after the trigger delay has lapsed (A), and remains on up to about 240° (B) thanks to the pulse train. It is blocked at point B, but is immediately retriggered by the next repetitive gate pulse. The operation is slightly asymtrical during the first half periods, but the duration of conduction gradually becomes more balanced, as shown by the dotted curve.

The practical circuit

The circuit diagram of the dimmer for inductive loads is given in Fig. 3. A small, sensitive, auxiliary triac, Tri_2, generates the pulse train necessary for maintaining the gate control signal for Tri_1. Capacitor C_1, compensation resistor R_5 and potentiometer P_2 define the gate angle Φ. Preset P_1 enables setting the minimum conduction angle, so ensuring reliable triggering of Tri_1 even when the load current is fairly low.

Capacitor C_1 is charged from 0 V, and diac Di_1 triggers as soon as its breakover voltage is reached. The set conduction angle is equal for both half periods.

A first pulse is applied to the gate of TRi_1, and the voltage surge on R_8 triggers Tri_2. Once this is on, it bypasses resistance (R_4+P_2 // R_3+P_1), so that the remaining charge cycles of C_1 have a much shorter period $(R_5+R_6)C_1$. After this delay, Tri_2 is triggered, starting a new cycle. A succession of pulses is applied to the gate of the main triac, Tri_1, until the mains voltage reaches the zero crossing. Triac Tri_2 is then blocked, so that the charging of C_1 during the following half period is determined by the time constant set by the resistance (R_4+P_2 // R_3+P_1). Once more consult the timing diagram of Fig. 2 for further details on the operation of the circuit.

Zener diodes $D_5 \ldots D_8$ incl. afford protection against overvoltage, and at the same time ensure a stable supply voltage for the trigger circuit, eliminating instability due to fluctuations on the mains. Diodes $D_1 \ldots D_4$ incl. and resistors R_1 and R_2 ensure that C_1 is completely discharged during the zero crossings, so that the hysteresis remains within acceptable limits. Damping network C_2-R_7 has a stabilizing effect on the control circuitry because it suppresses needle pulses originating from the inductive load when this draws less than the holding current of the main triac.

Construction: safety first

The dimmer is constructed on the printed circuit board shown in Fig. 4. Power resistor R_5 should be fitted slightly off the board to allow for its dissipated heat. Inductor L_1 is a common triac suppressor choke, which is not strictly required for in-

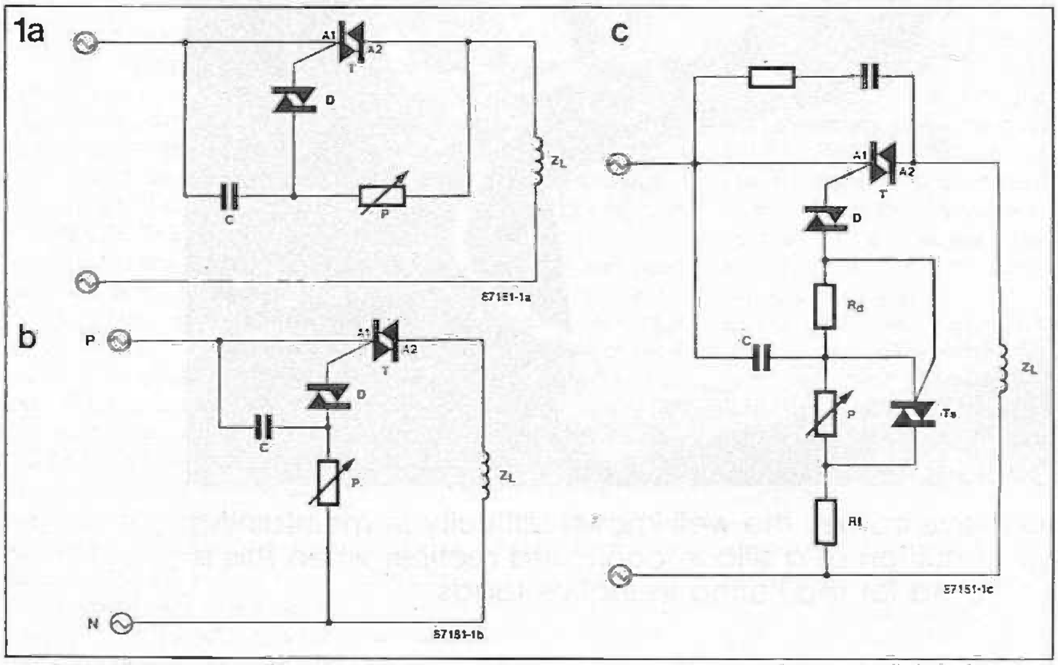


Fig. 1 Three ways of controlling the gate angle in a triac based dimmer.

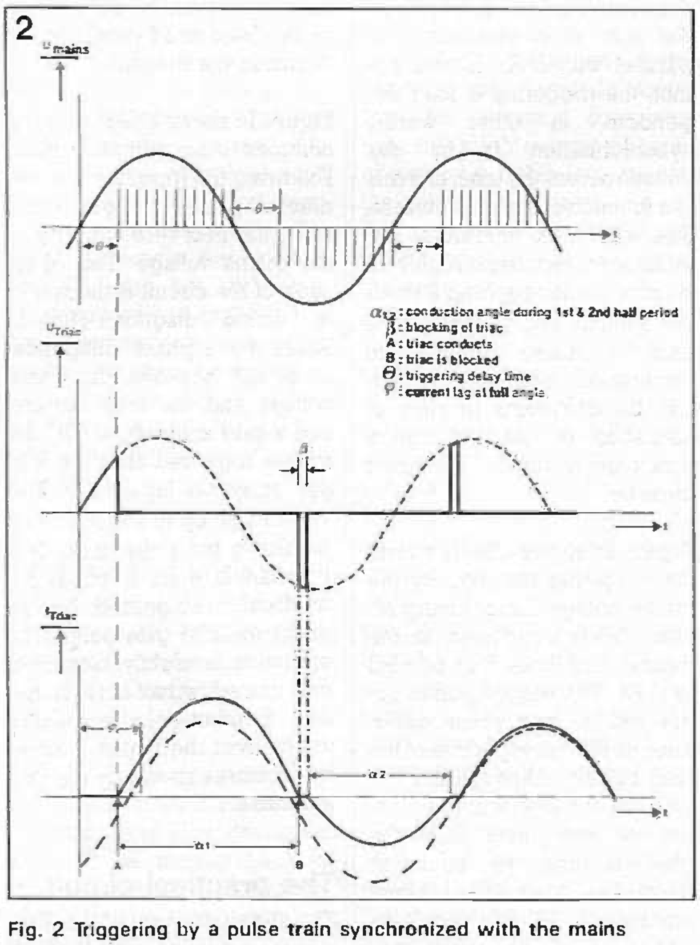


Fig. 2 Triggering by a pulse train synchronized with the mains voltage.

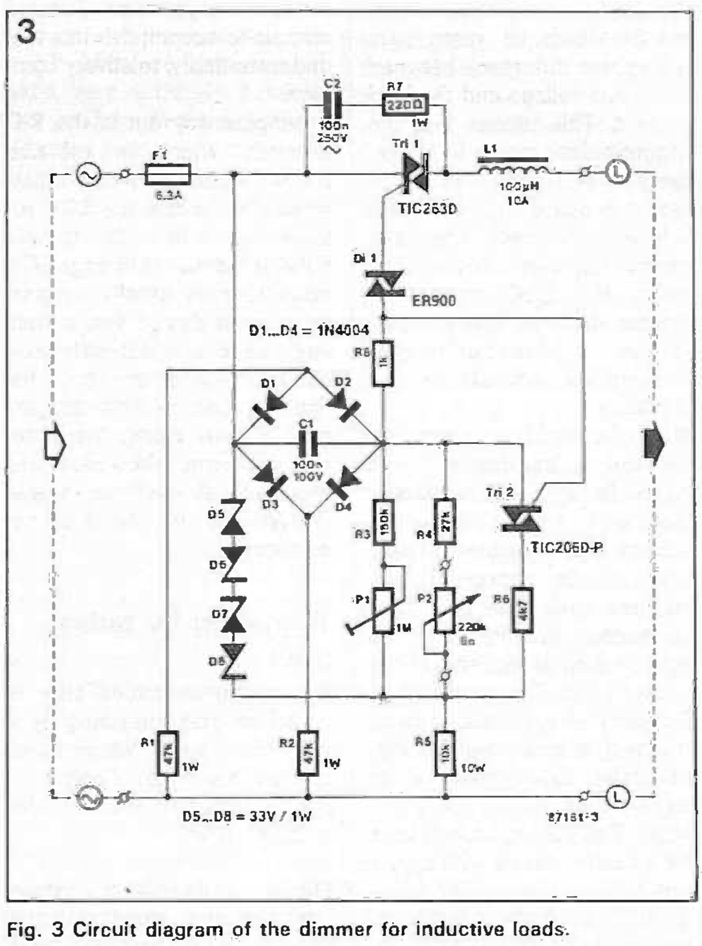


Fig. 3 Circuit diagram of the dimmer for inductive loads.

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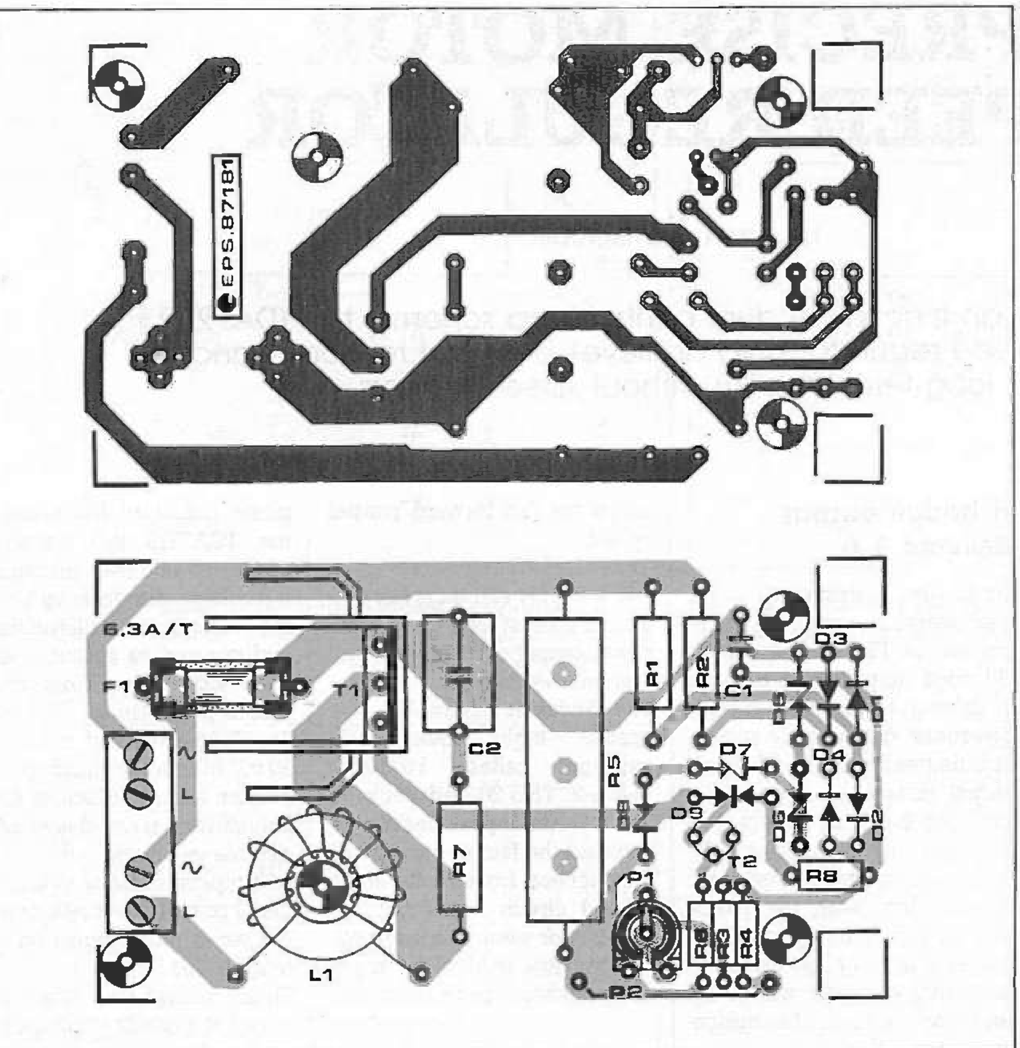

Fig. 4 Track layout and component mounting plan for the dimmer PCB.

ductive loads. For resistive loads, however, it should not be omitted because it limits the switch current surges. The inductance and current rating of L_1 are as required by the load; the indicated values of 100 μH and 10 A are only required when the dimmer is used for regulating loads of the order of 750 W and more. The size of the heat-sink for Tri_1 is mainly determined by the available space in the ABS enclosure. A few holes should be drilled in the lid to ensure sufficient cooling of R_5 and Tri_1. Make sure that the whole unit is rugged and properly insulated. If used, the input and output cable should be fed through a grommet, and secured by a suitable strain relief. Be sure to use a potentiometer with a plastic shaft.

VARIOUS PARTS IN THE DIMMER CARRY THE MAINS VOLTAGE AND ARE, THEREFORE, DANGEROUS TO TOUCH WHEN THE UNIT IS OPERATIONAL.

Finally, the circuit described offers good accuracy of control without the need for an additional supply. It enables virtualy complete variation of power on inductive loads rated up to approximately 1,000 W. *Sv*

Source:

Triac Applications, Thomson Semiconductors.

Parts list

Resistors (± 5%):
R_1;R_2 = 47K; 1 W
R_3 = 150K
R_4 = 27K
R_5 = 10K; 10 W
R_6 = 4K7
R_7 = 220R; 1 W
R_8 = 1K0
P_1 = 1M0
P_2 = 220K or 250K linear potentiometer with insulated shaft.

Capacitors:
C_1 = 100n; 100 VAC
C_2 = 100n; 250 VAC

Inductor:
L_1 = dimmer suppression choke e.g. 47 μH; 10 A *

Semiconductors:
D_1 . . . D_4 incl. = 1N4004
D_5 . . . D_8 incl. = 33 V; 1 W zener diode
Di_1 = general purpose 32 V diac, e.g. ER900, ST2, D132AC, or BR100-03*.
Tri_1 = TIC263D*
Tri_2 = TIC206D-P

Miscellaneous:
F_1 = 6.3 A fuse with PCB mount holder.
Suitable ABS enclosure.
Grommet and strain relief for mains wire.
5-way screw terminal block for PCB edge mounting.
TO220-style heat-sink for Tri_1.
PCB Type 87181 (available through the Readers Services).

* Available from Omni Electronics • 174 Dalkeith Road • Edinburgh EH16 5DX. Telephone: (031 667) 2611.

CORRECTIONS

Stream encryption

September 1987; p. 28 ff.

Equations [24], [26] and [27] should be amended as follows:

$$K'_j = (K_j + 4K_{j+1} + \overline{K}_{j+3}K_{j+2} + K_j) \bmod 2 \qquad [24]$$

$$X_j = (AX_{j-1} + B) \bmod M \qquad [26]$$

$$K_j = X_j \bmod 2 \qquad [27]$$

The number sequence and the binary sequence in the section **X^2 mod *PQ*** generator should be modified to read

$X_j = X^2_{j-1} \bmod N$ and

$K_j = X_j \bmod 2$ respectively.

Active phase-linear cross-over network

September 1987; p. 64.

The parts list should be modified to read:

T_1;T_2 = BD139.

Digital sine-wave generator

February 1987; p. 24 ff.

When the unit is fed from a supply voltage lower than ±10 V, as suggested in the article, it is recommended to change R_{10} from 2K2 to 3K9, and R_{11} from 3K9 to 8K2.

PRECISE MOTOR SPEED REGULATOR

by Arturo Wolfsgruber *

By virtue of an innovative dual control loop scheme, the TDA7272 motor speed regulator chip achieves both fast response and long-term stability without speed sensors.

The speed of small DC motors is usually controlled either by regulating the current or with a velocity feedback loop using a tacho generator or speed sensor. But both of these systems have disadvantages. Current control offers a fast response to transients but poor long term stability, while velocity feedback schemes need a costly tacho generator and only provide an adequate transient response if a high-frequency AC tacho is used.

A new motor speed regulator chip, the SGS TDA7272 (Fig. 1), combines the best features of the two techniques, having a current control loop to guarantee fast transient response, plus a velocity feedback loop to guarantee long term stability. Unlike conventional velocity feedback controllers, the TDA7272 needs no tacho generator or speed sensor; it determines the motor rotation speed exactly by sensing the motor's commutation spikes.

H-bridge output delivers 1 A

Originally designed for autoreverse cassette tape players, the TDA7272 includes a H-bridge output stage capable of driving a DC motor in both directions with a single supply and delivering up to 1 A peak output current.

Two logic inputs select the direction of rotation—clockwise or counterclockwise—and fast braking (with the motor short-circuited by the device's output stage), or the standby/free-running mode where all four transistors in the bridge are turned off.

By means of external resistors or control signals the rotation speed may be set independently for each direction. In a typical μC-controlled autoreverse car cassette player the two speed control inputs are commoned and connected to ground via a resistor which sets the play speed and is shorted by an open-collector output to select the fast forward/rewind speed.

The TDA7272 operates on a 5-18 V supply and includes protection against load dump transients, output short circuits and thermal overload.

The device is assembled in a special high power DIP package called Powerdip 16+2+2. This 20-lead package has a thick copper leadframe and uses the four center pins to conduct heat from the die to the printed circuit board copper. Suitable for automatic insertion, this package is ideal for applications where space is limited.

Senses motor commutation spikes

One of the most interesting features of the TDA7272 is its ability to determine the true motor rotation speed by sensing the commutation spikes across the motor terminals.

Figure 2a shows the current waveform in a typical three-phase miniature DC motor. In the TDA7272 this waveform, converted into the corresponding voltage waveform by a sensing resistor, is differentiated and clipped to obtain a feedback signal consisting of six pulses per rotation (Figs. 2b & 2c). A hysteresis of 10 mV and 20 mV bias in the clipping comparator assure sufficient noise immunity to make this scheme reliable in practice.

In a typical cassette player the motor runs at about 2000 rpm so the tacho pulse signal will be roughly 200 Hz.

These pulses are then integrated to provide a voltage proportional to the motor speed. This voltage is compared with a reference voltage—derived from the speed-setting inputs—in the error amplifier.

However, the integration capacitor must be large to minimize ripple, which explains why pure tacho feedback schemes suffer from a poor transient response.

This is where the TDA7272's

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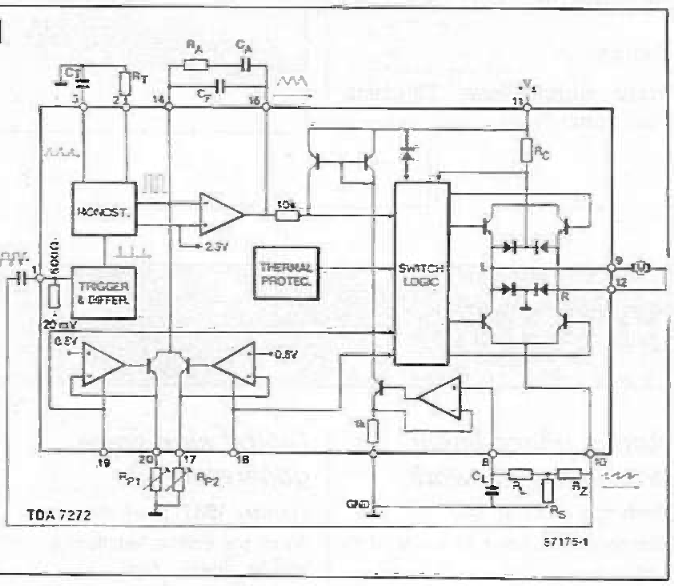

Fig. 1. Internal diagram of the TDA7272 motor speed regulator chip.

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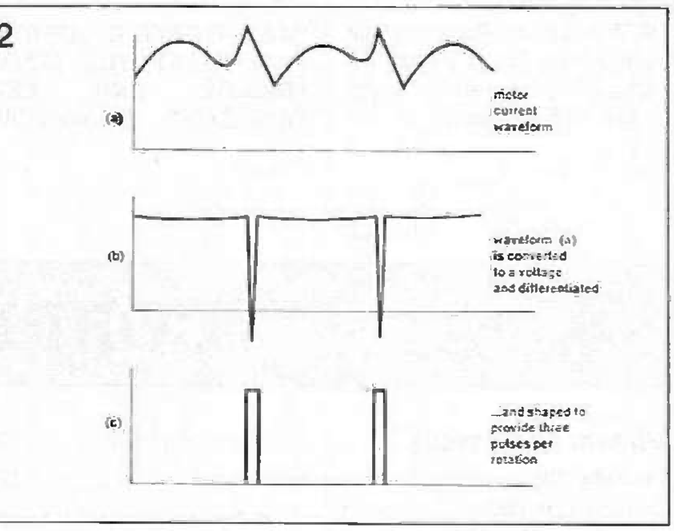

Fig. 2. To obtain a tacho signal without a tacho, the TDA7272 amplifies the commutation spike waveform across the motor terminals, differentiates it, and clips it to provide six pulses per rotation (from a typical three phase motor).

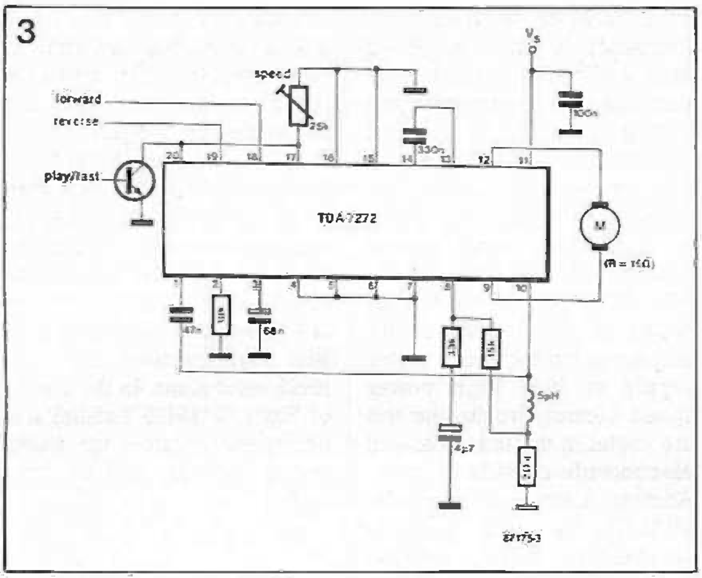

Fig. 3. In a typical autoreverse car-cassette application, the TDA7272 speed controller drives a bidirectional motor and both feedback loops are active. Rewind speed is selected by shorting the resistor on pins 17 & 20.

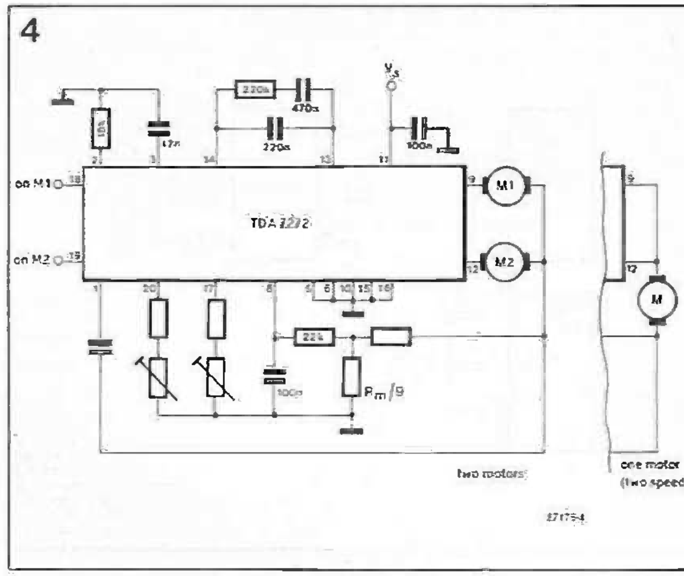

Fig. 4. The TDA7272 may also be used to drive two one-way-only motors running at different speeds, or one motor running at two speeds.

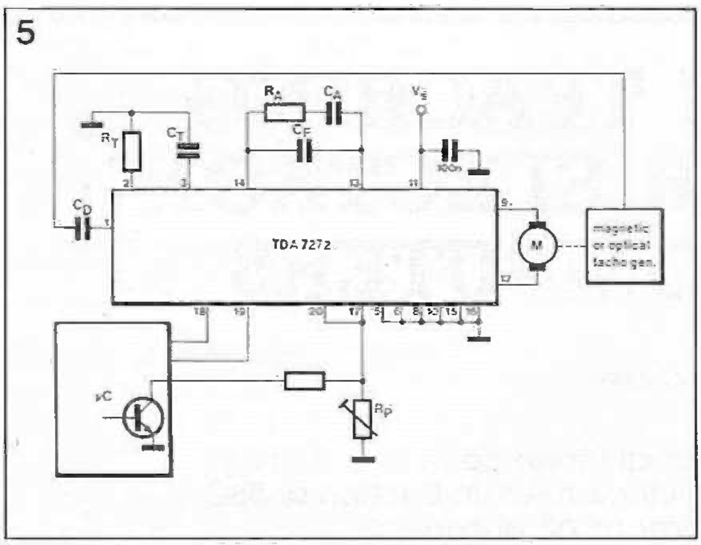

Fig. 5. A tacho generator can be added where greater noise immunity is needed. If the tacho frequency is above 2 kHz the current loop is unnecessary, allowing a saving in external components.

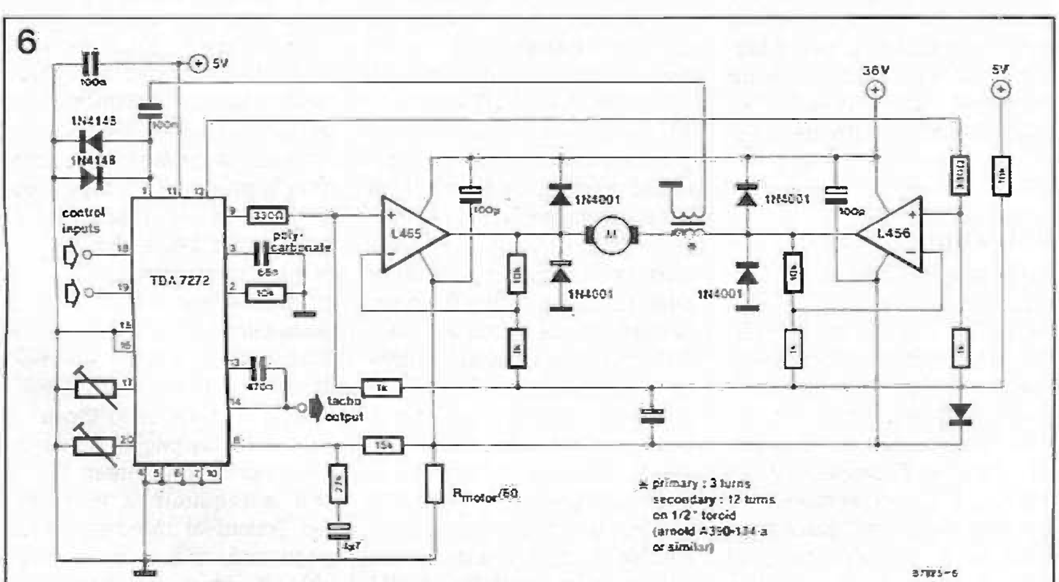

Fig. 6. Where the TDA7272's 1 A output capability is insufficient, power opamp boosters can be added as shown here.

second control loop comes in. Current feedback from the motor is summed with the output of the error amplifier. Consequently, large transient speed changes are compensated immediately by the current loop, leaving only a small error for the velocity loop to correct in order to maintain a precisely controlled speed.

An external resistor sets the amount of V/I 'preregulation' superimposed on the tacho control loop. This resistor is chosen to provide the optimal balance between transient response and speed precision for each application. The current control loop can even be inhibited completely to save components in applications where both the motor's load and supply voltage are sufficiently constant to obviate the need for fast transient response.

Useful in many applications

The TDA7272 motor speed controller is useful in many applications where precise ($\pm 1/1000$) speed control of small DC motors is required.

Figure 3 illustrates how the device is used in an autoreverse car-cassette player or tape recorder, driving a single bidirectional motor. In this application both control loops are used. The effective speed control provided by the TDA7272 is important in tape players since it affects directly the audio quality, minimizing wow, flutter and pitch errors.

Note how an open-collector output of the μC chip selects either play or rewind speed by shorting the speed setting resistor.

The TDA7272 can be used equally well in applications where the motor never reverses. Alternatively, a single device can drive two motors operating at different speeds, or a single two-speed motor as shown in Fig. 4.

Though the device was designed for use without tacho generators, it can easily be used with one, or with a digital-type speed sensor. This can be useful when, for example, greater noise immunity is required, or where a motor/tacho combination is already

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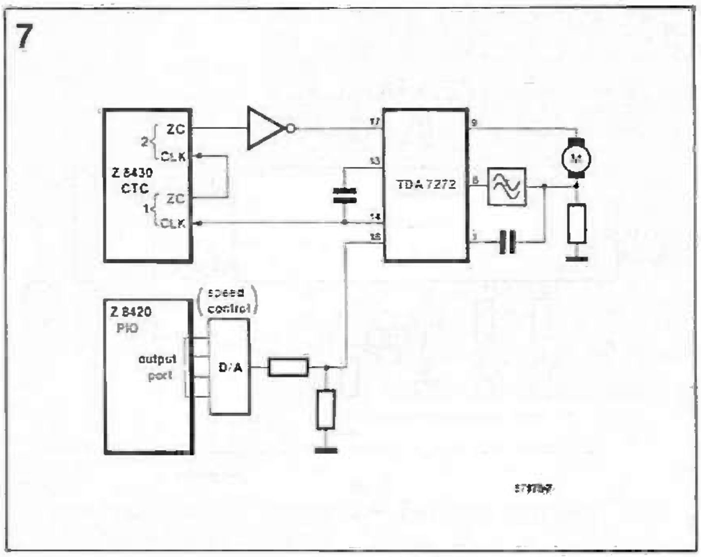


Fig. 7. The tacho signal derived by the TDA7272 from the motor commutation spikes can be useful to count the number of revolutions. Two 8-bit counters cascaded in the Z8430 CTC count up to 10923 revolutions.

available. Moreover, if the tacho frequency is high enough—at least 2 kHz—the current feedback loop is not necessary, permitting a saving in external components, as shown in Fig. 5. For applications where the TDA7272's 1 A output capability is insufficient, high power opamp boosters such as the SGS L465 may be added as shown in Fig. 6. This circuit delivers up to 4 A with a motor supply of 40 V. High power speed control circuits like this are useful in the industrial and electromedical fields.
Another useful feature of the TDA7272 is that a TTL-compatible tacho signal—derived from the commutation pulses—is available on pin 14; there are 6 pulses per rotation. This output can be used, for example, to count the revolutions for applications such as measuring the flow rate of a pump, or the travel of a servomechanism. The pin 14 tacho output may be connected to a presettable up/down counter, or to a counter/timer peripheral such as the Z8430 (Fig. 7). Using an 8-bit counter in the Z8430 it is possible to count up to 42.5 revolutions; 2 cascaded 8-bit counters can count up to 10923 revolutions. In the circuit of Fig. 7, a Z8420 parallel I/O peripheral controls the motor speed through a D/A converter.

* Arturo Wolfsgruber is with SGS Microelettronica SpA.

MORSE CODE TEACHING PROGRAM FOR ELECTRON AND BBC COMPUTERS

by A B Bradshaw

Learning to decipher the international morse code in a step-by-step course, guided by a patient tutor: an Acorn Electron or BBC computer with a printer as an option.

A few minutes spent tuning a good quality short wave receiver will show that there is plenty of morse traffic available to listen to in addition to that on the amateur bands. In spite of the increasing use of voice and purely digital communication, the international morse code is still very much alive. This is mainly because morse allows long distances to be covered using simple, efficiently operating, transmitters. In a CW (continuous wave) transmitter, modulation is effected by the station operator switching the carrier on and off with the aid of a morse key. The international morse code is an agreed set of combinations of dashes (long periods) and dots (short periods) that represent letters, numbers, and signs. At the receiver side, a BFO (beat frequency oscillator) is used for detecting the CW signal, which can be contained in a very narrow bandwidth to ensure good selectivity and freedom of noise on adjacent frequencies.

A training session

In the program described, " * " represents a dot, and " — " a dash. The asterisk was preferred over the full stop because it remains in line with the dash, and so prevents visual distraction. Essentially, the program strips the morse character into a serial form, and actuates the computer's internal bleeper in accordance with the length of the " * " and the " — ". The bleeper is programmed to produce a tone of approximately 850 Hz while timing routines ensure the correct duration of the dots and dashes, as well as the spacing between them.
The training speed is user definable in a range from 1 to 10. An option is built into the program to output all available morse characters slowly, in a consecutive fashion, i.e., A, B, C, D. . . . . .X, Y, Z, 0, 1, 2, 3. . . etc, plus the 10 signs. This is done at speed 2, representing the point at which the beginner will start. The trainee can select practising letters, letters and numbers, or letters, numbers and signs. Groups of five pseudo-random morse characters with a 2 character space are generated by the computer, and made audible for taking down by the trainee, who, naturally, should not look at the screen where the characters are arranged in lines to form a page. The page number is displayed in the top right hand corner of the screen. At the end of a page, the word "PAUSE" is flagged up, and the code groups remain on the screen for about 20 seconds. This pause enables an external printer making hard copy of the assignment. As most printers make some noise, this method is preferred to continuous actuation, which would have a distracting effect. The proficiency level can be evaluated later by comparing the trainee's written characters to those on the hard copy page. The author does not own a printer, but all that is required is to enable the printer at the start of the page end, and delay and disable it when the page end delay has lapsed. A REM statement shows the relevant area in the program.

```
10 REM **** MORSE CODE TEACHING PROGRAM ****
20 MODE 6
30 REPEAT
40 PRINT TAB(6,4)"****MORSE TEACHING PROGRAM****"
50 PRINT TAB(6,8)"CHARACTER RANGE:"
70 PRINT TAB(6,10)"1 = LETTERS"
80 PRINT TAB(6,12)"2 = LETTERS & NUMBERS"
90 PRINT TAB(6,14)"3 = LETTERS & NUMBERS & SIGNS"
100 PRINT TAB(4,18)"TO HOLD, USE CTRL & SHIFT KEYS."
110 PRINT TAB(10,20)"20 SEC PAUSE FOR PRINTER."
120 PRINT TAB(12,22)"PRESS SPACEBAR TO CONTINUE."
130 KEY=GET
140 UNTIL KEY=32
150 CLS
160 PRINT:PRINT:PRINT:PRINT:INPUT"DO YOU KNOW THE CHARACTERS---YES/NO",W$
170 IF W$="YES" THEN 210:ELSE IF W$="NO" THEN 190
180 IF W$<>"YES" OR W$<>"NO" THEN 570
190 T=2:A=3
200 IF W$="NO" THEN 270
210 INPUT"INPUT SPEED No. 1 TO 10",T
220 IF T>10 THEN 570:ELSE IF T<1 THEN 570
230 PRINT
240 INPUT"INPUT CHARACTER RANGE No. 1 TO 3",A
250 IF A>3 THEN 570:ELSE IF A<1 THEN 570
260 V=0
270 CLS:V=V+1:PRINT TAB(29,1)"PAGE ";V
280 IF W$="NO" THEN PRINT TAB(34,1)"0"
290 PRINT TAB(5,2)"CURRENT",TAB(20,2);"MORSE"
300 PRINT TAB(5,3)"CHARACTER",TAB(20,3)"CHARACTER"
310 PRINT TAB(5,7)"---------",TAB(20,7);"---------"
320 FOR B=4 TO 6
330 PRINT TAB(5,B);":",TAB(13,B);":";TAB(20,B);":",TAB(29,B);":"
340 NEXT B:FOR L=8 TO 23:FOR O=0 TO 4:FOR K=1 TO 5
350 R=26+(A-1)*10
360 IF W$="YES" THEN 370:ELSE IF W$="NO" THEN 380
370 C=RND(R):GOTO 390
380 FOR C=1 TO R
390 N=4000/T
400 FOR Z=1 TO N:NEXT Z:FOR J=1 TO R:READ S$
410 IF C=J THEN 430
420 NEXT J
430 IF W$="YES" THEN 440:ELSE IF W$="NO" THEN 450
440 PRINT TAB((K+7*O),L)S$:PRINT TAB(9,5)S$:GOTO 620
450 PRINT TAB((K-7*O),L)"    ":PRINT TAB(9,5)S$:GOTO 620
460 RESTORE
470 IF W$="YES" THEN 490
480 NEXT C
490 IF K=5 THEN 510
500 NEXT K
510 NEXT O:IF O=4 THEN 520
520 NEXT L:IF L=24 THEN 530:ELSE 550
530 PRINT TAB(31,2)"PAUSE":REM PRINTER CONTROL HERE
540 FOR Z=1 TO 30000:NEXT Z:PRINT TAB(31,2)"     "
550 GOTO 270
560 DATA A,B,C,D,E,F,G,H,I,J,K,L,M,N,O,P,Q,R,S,T,U,V,W,X,Y,Z,1,2,3,4,
5,6,7,8,9,0,.,:,',",?,+,-,*,/,=
570 PRINT
580 PRINT
590 PRINT
600 PRINT
610 PRINT "INCORRECT ENTRY --- PLEASE RERUN PROGRAM":END
620 FOR D=1 TO (R+(46-R)):READ P$:IF D=46 THEN 640
630 NEXT D
640 PRINT TAB(22,5)"      ":PRINT TAB(22,5)P$
650 FOR Z=1 TO LEN (P$):X$=MID$(P$,Z,1)
660 IF X$="*" THEN 670:ELSE IF X$="-" THEN 680
670 W=30/(3*T):GOTO 690
680 W=30/T
690 SOUND 1,-15,150,W:SOUND 1,0,0,30/(3*T)
700 NEXT Z:SOUND 1,0,0,30/T
710 GOTO 460
720 DATA *-
730 DATA -***
740 DATA -*-*
750 DATA -**
760 DATA *
770 DATA **-*
780 DATA --*
790 DATA ****
800 DATA **
810 DATA *---
820 DATA -*-
830 DATA *-**
840 DATA --
850 DATA -*
860 DATA ---
870 DATA *--*
880 DATA --*-
890 DATA *-*
900 DATA ***
910 DATA -
920 DATA **-
930 DATA ***-
940 DATA *--
950 DATA -**-
960 DATA -*--
970 DATA --**
980 DATA *----
990 DATA **---
1000 DATA ***--
1010 DATA ****-
1020 DATA *****
1030 DATA -****
1040 DATA --***
1050 DATA ---**
1060 DATA ----*
1070 DATA -----
1080 DATA *-*-*-
1090 DATA ---***
1100 DATA *----*
1110 DATA *-**-*
1120 DATA **--**
1130 DATA *-*-*
1140 DATA -****-
1150 DATA -**-
1160 DATA -**-*
1170 DATA -***-

Notes:
On line 450 there are 4 spaces between quotes.
On line 540 there are 5 spaces between quotes.
On line 640 there are 6 spaces between quotes.
```

Program description

The following is a brief description of the function of a number of routines in the BASIC program.

Lines 10 to 150 are the first page instruction to the user. Operating the space bar moves you onto the next page. As usual, the carriage return key is pressed after taking the selections.

Lines 160 to 330 are used for inputting the variables and drawing the boxes. They also detect and advise on false entries, to which the reply is at line 570. Statement END is used so that the machine does not produce any additional information.

Lines 340 to 410 are mainly for loop and control variables effecting character and line control. Note that at line 370 a random number is returned but will be dependent on parameter "R". At line 350 is shown the expression R=26+(A−1)*10, which sets the upper limit of the random numbers, while "A" is a "Character Range" input variable. From this it is seen that
if "A"=1, "R" can have random numbers up to 26;
if "A"=2, "R" can have random numbers up to 36;
if "A"=3, "R" can have random numbers up to 46.

At line 380 it can be seen that "C" is a control variable with an upper bound of "R". A limited random is returned in "C", and this is used by the DATA/READ pointer "J". Hence when J=C the pointer points into the data at line 560. It is the matching of J and C that provides the random selection of data. At line 450, previous characters are erased by printing nulls over them.

Lines 620 to 710 are used for reading the data lines 720 up to and including 1170. The data is in the form of " * " and " — " patterns, pointed at by "D" and loaded into the string variable P$. Whilst the current character has just been generated by a given random number ("C" at line 370), and matched by the data pointer ("J" at line 410), the alphanumerical selection in the first data array (line 560) is related with the morse pattern in the second array (lines 720...1170). This is done at line 620, which is left in primitive form to show that it is used for counting the complement (remainder) of the first data array and then up to the corresponding place in the morse pattern array. For example, if "L" is selected, the equivalent morse pattern is " *—** ". Both the letter and the pattern are placed into their respective box on the screen.

Line 650 first measures the length of the morse pattern. Evidently, this varies from a single dot to, say, a combination up to 6 symbols long. Instruction LEN(P$) is used as an "end stop" in the parallel/serial decoding and splitting routine, i.e., for the FOR/NEXT loop at lines 650/700. This loop enables string variable X$ to be loaded serially by the string operator MID$(P$,Z,1). Remember that P$ contains the morse pattern as a string, displayed in the right hand box. The contents of X$ are "interrogated" at line 660 for controlling the duration of the sound in the SOUND statement at lines 670 & 680. The input speed parameter "T" relates the length of the signals. Lines 670 and 680 are the dot and dash period control, respectively, while the second statements at line 690 and 700 ensure the correct "dot" and "dash" silence (inter character space). All these statements are related to the speed parameter, "T", and so ensure correct morse timing.

Bu

EVENTS

IEE wiring regulation courses

The IEE is running a new series of two-day short courses on the IEE Wiring Regulations. These courses take full account of the June 1987 Amendments to the Wiring Regulations.

There are three types of course:

(1) **Introduction to Design**, which is aimed at professional engineers, senior managers, and others, who have a responsibility for design or specification;

(2) **Installation and Maintenance**, which is suitable for those involved in new installation work and/or the maintenance of existing installations;

(3) **Refresher Workshop**, which is intended for professional engineers, designers, and others, who already have a sound working knowledge of the regulations. The courses are run at Savoy Place, London, and at Manchester, Edinburgh, Glasgow, Bristol, Coventry, Southampton, and Brighton during the autumn and winter months.

Further details from the **Career Development Section • Institution of Electrical Engineers • Station House • Nightingale Road • HITCHIN SG5 1RJ • Telephone (0462) 53331 Ext. 281.**

IEE Meetings this month

2 Open Systems Management
2 The World Administrative Radio Conference for Mobile Services 1987
3 Measurement, Instrumentation and Design
6 Shaped-beam Satellite Antennas
9 Engineering Aspects of UK DSB
10 The Future of the Personal/Home Computer
11 Potential Impact of new Superconducting Materials on Electrical Machines
11 Memories of the Future
20 Machine Learning
20 Optical Techniques for Signal and Image Processing
23 Radio Determination Satellite Systems Geostar and Locstar
26 Radio-based Communication Systems for the Control and Management of Wide-ranging Fast-moving Vehicles
26 The Life and Loves of Sebastian Z de Ferranti
27 Man-Machine interfaces for Intelligent Knowledge-based Systems
30 What is Happening to the UK Broadcast Manufacturing Industry?

Full details from **The Institution of Electrical Engineers • Savoy Place • LONDON WC2R 0BL • Telephone 01-240 1871.**

Electric Indonesia

The third bi-annual International Electrical and Electronic Engineering, Power Generation and Supply Exhibition will take place at the Fairgrounds, Jakarta, from 10 to 14 November. British industry is making a strong presence at this exhibition.

Wescon '87

The Californian Electronics Show and Convention takes place in San Francisco from 17 to 19 November.

Full details of these two events may be obtained from the **Federation of British Electrotechnical and Allied Manufacturers' Associations • 8 Leicester Street • LONDON WC2H 7BN • Telephone 01-437 0678.**

COMEX 1987 will be held at the Sandown Exhibition Centre, Esher, Surrey from 3 to 5 November. Full details are available from **Bush Steadman & Partners Ltd • Crown Chambers • 36 High Street • SAFFRON WALDEN CB10 1EP • Telephone (0799) 26699.**

The **7th International Conference on Custom and Semicustom ICs** will be held at the Heathrow Penta Conference Centre, London, from 3 to 5 November. Full details from **Prodex Ltd • 9 Emson Close • SAFFRON WALDEN CB10 1HL • Telephone (0799) 26699.**

Technology Appraisals is holding two seminars this month: **Office Document Architecture** (ISO ODA Standard) from 23 to 24 November, and **Understanding SNA** from 25 to 27 November. Details from **Technical Appraisals Ltd • Leo House • Portsmouth Road • THAMES Ditton KT7 0XF • Telephone 01-398 9386.**

AMK Berlin seminars this month:

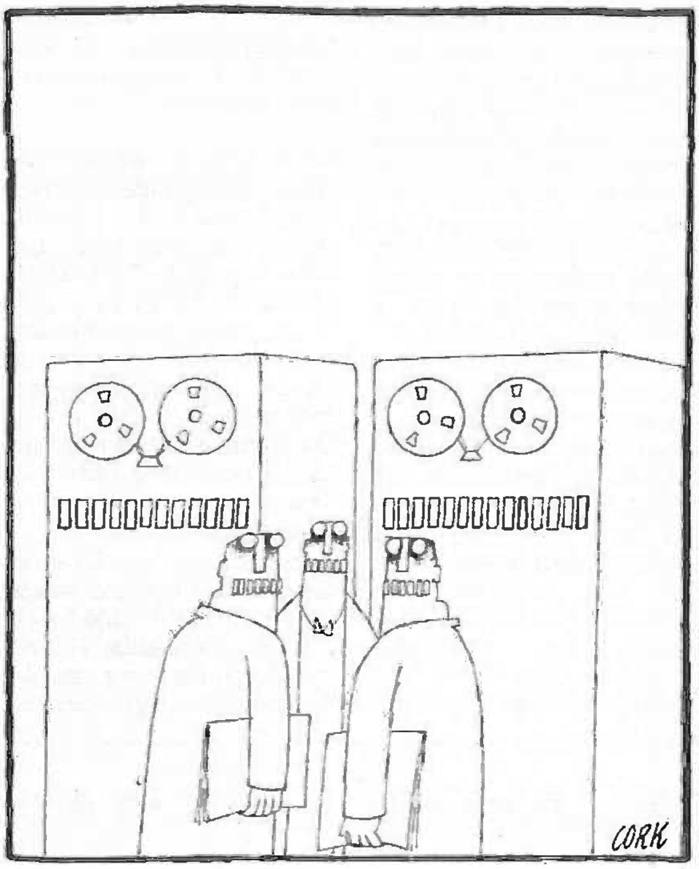
2-4 Implementing Fifth Generation Computer Technology
2-5 Optimized Basic Chip Design
5-6 Fourth and Fifth Generation Languages and Their Implementation
23-26 Communicating and Computing in Real Time
23-27 Software Engineering for Engineers
23-27 Data Network Software Design

Full information from **AMK Berlin • Messedamm 22 • D-1000 BERLIN 19 • Telephone +49 30 3038.**

ICS Courses this month:

Data Communications & Networks
3-6 Stockholm (in Swedish); 17-20 Paris (in French)
Advanced Microprocessor System Design
3-6 London
Common LISP and LISP Environments
3-6 London
Computer Network Design & Protocols
3-6 Stockholm (in Swedish); 10-13 London
High Performance Computer Architectures
10-13 Stockholm (in Swedish)
UNIX Hands-on Workshop
10-13 Stockholm (in Swedish); 24-27 Paris (in French)
Hands-on Microprocessor Troubleshooting
17-20 Stockholm (in Swedish)
Integrated Voice/Data Communications & ISDN
24-27 London
Fibre Optic Communications
24-27 Paris (in French)
Implementing Local Area Networks
24-27 Paris (in French)

Details from **ICS Publishing Company Ltd • 3 Swan Court • Leatherhead KT22 8AD • Telephone Free Linkline Number 0800 282 353 or (0372) 379211**



EW PRODUCTS • NEW PRODUCTS • NEW

Low-cost PCB prototyping workstation

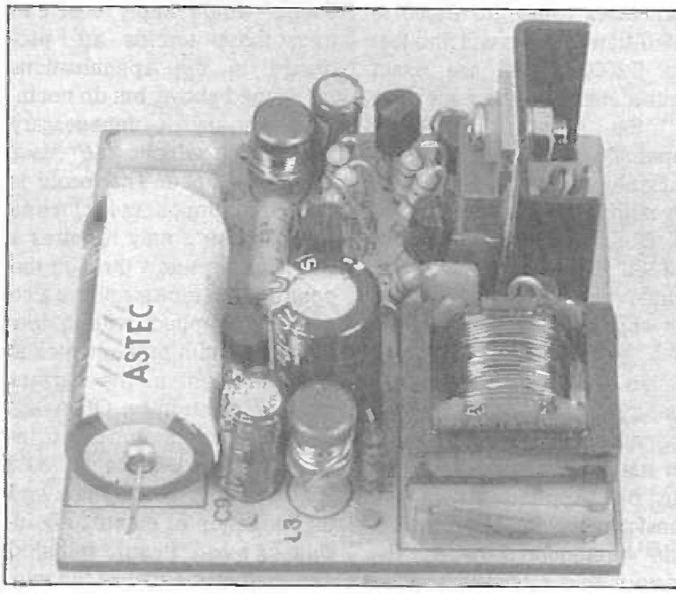
Mega Electronics announce the introduction of a comprehensive but low-cost system for the prototyping of printer circuit boards.

This new system, which is introduced as the SENO Workstation, represents a totally new and unique concept: it is the ultimate in simplicity, yet embodies all of the components required for the design and production of high-quality printed circuit boards. Moreover, it utilises chemicals which are completely safe, and which may be disposed of by conventional means.

Priced at only £45, the SENO Workstation contains every essential element for PCB prototyping. It includes artwork materials, for PCB design and circuit layout; PCB laminate materials; cleaning block; spraywash facilities, which obviate the need for mains water; an environmentally-safe board etching system; and chemicals which are contained in unique, simple to use disposable applicators. Moreover, the chemicals are themselves nonhazardous and non-toxic, and do not require special disposal procedures or precautions. The applicators have been especially developed to simplify the use of these chemicals and to remove problems associated with their disposal.

Mega Electronics Ltd.
9 Radwinter Road
Saffron Walden
Essex CB11 3HU.
Telephone: (0799) 21918, 26626
Telex: 81653 G (3662:12)

Low-cost SMPSU module from Astec



This neat PCB, just 50 mm square, will accept up to 24 V DC input and give a stable 5 V DC out at up to 2 Amps. The six transistor circuit provides current overload protection, thermal cut-out and excellent filtering.

Offered at the remarkably low price of just £5.00 including VAT and postage, this module represents excellent value for money.

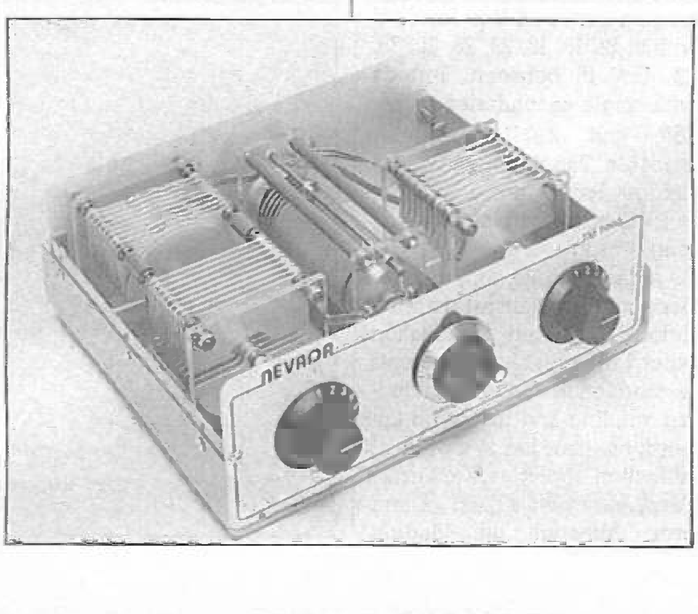
Greenweld Electronic Components
443 Millbrook Road
Southampton SO1 0HX.
Telephone:
(0703) 772501/783740 (3662:17:F)

All band aerial tuning unit

New from Telecomms is the Nevada 1 kW All Band A.T.U., model TM1000. The unit is a natural extension of the Nevada Professional Series of discrete A.T.U. components, i.e., the Roller Coaster, Turns Counter and Variable Capacitors released over the last nine months.

The A.T.U. is continuously variable from 1.8 to 30 MHz and uses a transmatch circuit that allows for maximum flexibility. The unit can handle a wide range of antenna impedances. Stringent efforts have been made in the course of manufacture to offer the best possible value for money at a price the Radio Amateur can afford. Selling at just £125 (inc VAT), the TM1000 is priced well below its competitors.

For those who still wish to construct the A.T.U., we are offering the unit in kit form which includes: — the empty case, predrilled, 2 capacitors, 1 Roller Coaster and 1 Turns Counter at a cost of £100 (inc VAT).



Telecomms have already received many enquiries from around the world for this unit and indeed one sample has already been sent to the Flying Doctor service in Australia, where it will be used for emergency communications.

Telecomms
189 London Road
North End
Portsmouth PO2 9AE.
Telephone: (0705) 662145
(3662:14:F)

SMA 1 Megabit DRAM

STC MULTIcomponent has introduced the latest addition to Toshiba's large capacity memory family—the new TC11000J10 1 MB DRAM—which has been designed for surface mounting.

Applications include personal computers, mini and mainframe computers, terminals, factory automation equipment and large memory systems.

Organised as 1,048,576 words by 1 bit and based on a proven silicon gate CMOS technology, the device is packaged in a 26-pin plastic SOJ. Its size provides high system bit densities and offers compatibility with most standard automated assembly and test equipment.

Features include a fast 8 ms time for 512 refresh cycles, direct interfacing with Schottky TTL, an high-speed 55 ns page mode cycle time and a single power supply of 5 V ±10%. Maximum operational power consumption is a low 570 mW which falls to just 5.5 mW in the standby mode.

STC MULTIcomponent
Edinburgh Way
Harlow
Essex CM20 2DF.
Telephone: (0279) 442971.
(3662:2)

EW PRODUCTS • NEW PRODUCTS • NEW

Low cost solar cells from Hero

Available from Hero Electronics, is a new range of Solar Cells intended for experimental and commercial applications. The Cells are low cost and available in various voltage/size Modules.

The amorphous silicon cells are extremely efficient, even at low light levels, and furthermore, offer an essentially linear response from 50 LUX to 10^5 LUX.

Applications for these Cells include School/College/Hobby Experimental/Commercial, and encompass also Clocks, Portable Instruments Calculators, Memory Saving, Light Detectors, Luxmeters, Telephone Memory, Moving Advertisements, Electrical Fencing and various Remote Control applications.

Hero Electronics Limited
Dunstable Street
Ampthill
Bedfordshire MK452JS.
Telephone: (0525) 405015
Telex: 825906 (3662:6)

Double Insulated Budget Range Toroids

New production methods and materials have enabled Cotswold Electronics to supply their well known 'Budget Range' of toroidal transformers with an alternative double insulation which meets B.S.5850 requirements and B.S.415 Class 2 for insulation in accordance with insulation thickness and creepage distance where two layers of insulation out of the three specified must meet a flash test of 4.2 kV peak. When a thermal cut out is fitted the transformers in the 'Budget Range' would meet all the other aspects of B.S.415. These toroids would also comply witih IEC 65 and IEC 380.

Customers using the D1000 to D1067 transformers will find that the D2000 series are exact equivalents with the exception of the double insulation capability which is now available at no extra cost. The VA ratings remain the same at 30, 60, 100, 160, 230, 330 and 530 VA. The standard stock primary voltage is 120+120 V but single primary 240 V and 110 V and 220 V are also available. The working frequency is 50 to 60 Hz and the operating range is 47 to 400 Hz. An interwinding metal screen can be supplied where the transformer is intended to provide protection against the primary voltage being applied to the secondary in the case of an insultion fault.

The secondary windings are generally dual voltage types ranging from 6+6 V to 50+50 V with 9, 12, 15, 18, 22, 25, 30, 35, 40, 45 V in between. Toroids with single secondaries of 110, 220, and 240 V are also available. The double insulated 'Budget Range' are terminated in P.V.C. insulated leads 150 mm long.

As a general rule, toroids have been more expensive than traditional stacked lamination types but recent improvements in production methods, including winding and insulation application, have led to a gradual reduction in unit cost to virtual parity in any type of 30 VA and over. Although the 'Budget Range' would imply cost cutting, these toroids are produced to the specifications mentioned above, but do not include any unnecessary "features" which the user would not need. The toroid is the ideal component for mounting because it only requires a single fixing screw through the centre of the transformer. It also can be supplied with a low height to width profile which is a requirement in the current slimline electronics. Other advantages claimed for toroids include: approximately 50% lower volume, 50% lighter, and 8:1 reduction in electrically induced noise (hum), reduced audible noise because the windings completely envelope the core and reduce magnetostrictive effects. The toroids are also very efficient which means the circuit designer can afford to be conservative in rating the transformers without incurring size penalties. The 'Budget Range' can be operated where the temperature rise plus ambient does not exceed 105 °C, although protracted tests have shown that transformers can be constructed which will operate at 120 °C without deterioration.

Cotswold Electronics Ltd.
Unit T.1.
Kingsville Road
Kingsditch Trading Estate
Cheltenham GL51 9NX.
Telephone: (0242) 41413
(3662:13:F)

New prototyping board

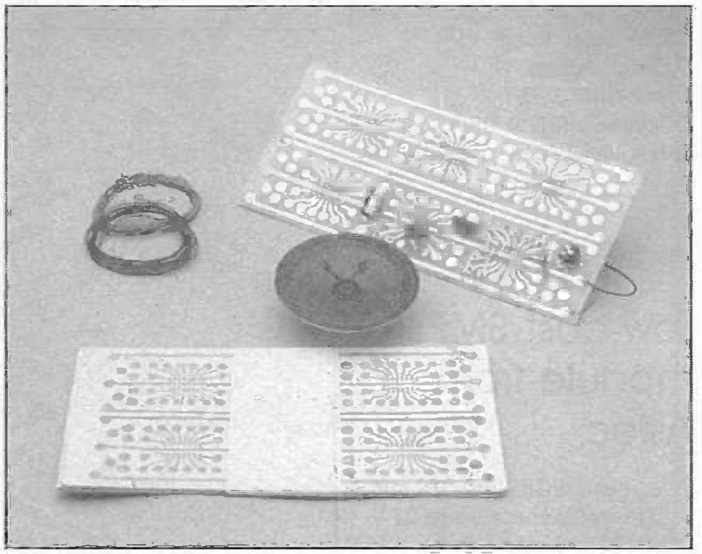
E&H Electronics have recently introduced Protocard, a professionally designed British product for the easy construction of prototypes of new circuits.

Six 16-way DIL sockets have their pins brought out to large area solder pads allowing components to be easily "tacked" onto the PCB. Each IC is marked with a pin location and supply tracks, signal tracks etc. run the full length of the board. Protocard can be used as many times as required: simply remove all components from the PCB, and Protocard is ready for use again.

A pack of Protocard Plancards is supplied for planning the component layout. Solder and instrument wire is also supplied with each Protocard.

Easy to use by either the professional or amateur, Protocard will give years of reliable use. Components do not fall off the board, and there are no bad contracts, often found in push-in type prototyping boards.

E&H Electronics
33 North Street
Keighley
West Yorkshire BD20 3SL.
Telephone: (0535) 44103
(3662:16:F)

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