FACSIMILE INTERFACE

Linkwitz filters
EPROM programmer
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ELECTRONICS TECHNOLOGY

23 Electronic potentiometers.
31 Secondary breakdown in power transistors.
36 Linkwitz filters.
44 Where electronic messages have the edge.
48 RIMS: counting atoms.
56 Local area networking.
57 Schools equipment for tomorrow's scientists.

PROJECTS

20 Feedback in loudspeakers: acoustic feedback is rarely used, but R Connell suggests some ways of experimenting with it in a low-frequency loudspeaker.
26 Valve preamplifier—2: part 2 completes this interesting design with a multi-voltage supply and a relay control board.
34 Preset extension a simple-to-build 10-frequency preset unit for the Elektor Electronics Function Generator as designed by M Kistinger.
39 Facsimile interface: a multi-standard facsimile converter that can be used with any good-quality short-wave receiver, a BBC or C64 computer, and an Epson compatible printer.
52 MSX extensions—5: this second part of the EPROM programmer looks at the way it is controlled from the MSX computer and details the supporting software.

INFORMATION

46 New literature; 58 New Products; 68 Readers' Services; 70 Terms of business; 77-78 Infocards.

GUIDE LINES

71 Switchboard; 74 Buyers guide; 76 Classified ads; 76 Index of advertisers.

In next month's issue:
- Spot sine wave generator
- How does the human computer work?
- Decoding satellite TV signals
- Bursting the bubble myth
- MIDI signal redistribution

This month's front cover shows a laser being used in industrial processing of heavy sheet metal. A laser (acronym of light amplification by stimulated emission of radiation) is a source of intense monochromatic coherent radiation in the visible, ultraviolet, and infra-red regions of the spectrum. A more detailed look at lasers will be published in a forthcoming issue.
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T.J.A. DEVELOPMENTS

Dept. EK, 53 Hartington Road, London E17 8AS.

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P8000... £ 4.95
P12000... £ 6.95

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Inmos's IMS T414 transputer has brought nearer the dream of a computer not bigger than a suitcase, yet powerful enough to model a nuclear explosion, or to plot a space vehicle's path to distant planets.

Where even powerful present-day computers may take hours to process certain graphic images, the transputer can produce highly complex graphics as quickly as the operator can think. When used in supercomputers, the transputer allows the simulation of experiments hitherto possible only in laboratories. This of course makes these processes cheaper than the real thing.

The key to the transputer is parallel processing. Conventional computers process data serially—one task at a time. The transputer processes several different parts of an operation simultaneously, often millions at a time, by linking a number of processing elements together. This speeds up the process, but creates complex design and programming difficulties. To simplify the programming of parallel processors, a new programming language, Occam, was developed in 1983.

So far, so good. A story of yet another great British invention. Why, then, is most of British industry so slow in accepting the transputer which could become the world's standard chip for supercomputers?

It cannot be because the transputer is not what Inmos has claimed it to be. A small number of British companies, such as Floating Point Systems, Meiko Ltd, and Smith Associates, among others, have designed hardware and software based on the transputer, the performance of which completely confirms Inmos's claims.

There is, of course, the problem of software compatibility, but this is often exaggerated, and is also likely to arise when performance improvements in conventional systems are required. A number of computing experts questioned on this score felt that much existing software can be converted to Occam.

Nor can it be claimed that either the transputer or Occam is difficult to use: according to transputer expert and co-author of The Inmos Saga, Mick Lean, the essence of both is their simplicity.

The worrying aspect about British industry's apathy is that the world at large is not going to be so backward. The transputer is such an important step forward in computer technology that if it is not exploited to the full in Britain some foreign competitors will grasp the chance offered them on a plate with both hands—and we will have failed to reap the benefits of yet another great British invention.
World semiconductor market in 1986

A report by Dataquest, a company of The Dun & Bradstreet Corporation, and a world leader in industrial and high technology market research, says that the top ten suppliers, measured in US dollars, are Japanese companies. NEC retained its number one position, but Hitachi and Toshiba replaced Motorola and Texas Instruments in 2nd and 3rd place respectively. The top ten suppliers, with revenues given in millions of dollars, are shown in the table.

Exchange rate fluctuations had a significant impact on this listing. Expressed in US dollars, the world semiconductor market grew by 26.1% in 1986 compared with 1985. By this measure, Japanese producers chalked up a growth in world-wide factory shipments of almost 40%. European producers had the next best record, with a 15% increase in factory shipments, and the North American region fared worst with only a 6.4% growth.

A different situation emerges when factory shipments from the three regions are expressed in local currencies. Then, the three regions are expressed when factory shipments from the three regions are expressed in local currencies. Then, the three regions are expressed in local currencies. The North American region fared worst with only a 6.4% growth.

Scope probe from Lefax

The Lefax SCOPE-PROBE has been developed to meet the need for an integrated oscilloscope and logic probe. The instrument has the obvious advantage that the operator has the display always in his line of vision. The instrument is powered from an internal alkaline battery which has an average life of about 12 hours in continuous use.

The probe tip can be detached if required, so that the instrument can be used hand-held or as a bench unit. It can accept standard oscilloscope leads if needed. The probe tip has a frequency coverage of 0.1 Hz to 20 kHz in five ranges; most waveforms can be displayed over the entire range. It also includes a direct-reading d.c. voltmeter with 0-10 V and 0-20 V scales.

The price of the instrument is £89.95 excl. VAT and p&p. The instrument should be of interest to repair and maintenance engineers; laboratory staff; schools and technical colleges; and government retraining centres.

Communications engineering backup from DACCOM

Founded on the conviction that engineering quality is more important than corporate strategy, Fleet-based DACCOM can provide a wide range of services to the communications industry at home and abroad. Services offered include consultancy, project management, feasibility studies; radio surveys; training; design; and fact file. Moreover, the company has available qualified, experienced personnel on an as-required basis to enable producers to smooth out any peaks in activity.

DACCOM
122 Tavistock Road
Fleet GU13 6EE
Telephone: (0252) 623315

New function generator from ITT

The new Type GX239 Function Generator from ITT Instruments is a universal instrument providing a choice of sine wave, square wave, and triangular wave signals, in addition to DC and pulse outputs.

The generator has an output frequency range of 0.2 Hz to 2 MHz, selectable over seven decade increments by front panel push-buttons. As a result, it is equally applicable to low-frequency and high-frequency use, and typical applications are likely to be found in vibration testing, general audio circuit testing, AM radio testing, ultra-sonics, and servo-systems tests.

ITT Instruments
346 Edinburgh Avenue
Slough SL1 4TU
Advanced universal digital filter

A real-time universal digital filter, developed by Fern Developments for use in speech processing, audio, bio, psychoacoustics, electrophysiology, and geophysics, offers linear filtering capabilities which are said to be superior to those that can be achieved with conventional analogue techniques. The benchtop EF8, based on a design conceived by the Medical Research Council, is a 512-coefficient finite-impulse-response, non-recursive filter that offers an unlimited number of totally different filtering actions, the anti-alias (pre-process) and post-process sections use high-precision programmable low-pass filters. The filter unit has an operating bandwidth of 0.0-50 kHz, attenuation rates of typically 4000 dB per octave, and up to 512 weighting coefficients for symmetrical responses.

Fern Developments Ltd
7 Springburn Place
College Milton North
Glasgow G74 5NU

Surface Mount Devices market to treble by 1991

According to Surface-mounted Devices in Europe, a 201-page report just published by Frost & Sullivan, the European demand for SMDs will treble to almost $2 billion by 1991. Surface-mount technology—SMT—was pioneered in Japan for cameras, calculators, and other consumer electronics. The current Japanese market for SMDs is some six times the size of Europe's. At present, SMDs account for less than a tenth of all electronic component sales, but will climb to nearly a fifth by 1991. Penetration will be highest then in capacitors (well over a quarter of all capacitors will be SMDs), and integrated circuits (more than a fifth of all ICs will be SMDs).

The report deals with ten categories of SMDs, though these are broken down into their constituent product types. Estimated market shares of suppliers show AVX Corporation to lead in capacitors; Convar and Philips head up the field in resistors; and Texas Instruments is well in front in front of other ICs.

Grundig do it with robots

Helping Grundig on the road to success is a new robotic VCR production line which, the company says, is in advance of any other in the world today. Making VS400 machines, which will retail in the UK at around £2000, the production line has been an-the of PCBs

The WS500 combination workstation from Surface Mounted Production Systems Ltd is intended for the surface-mounted assembly (SMA) of printed circuit boards (PCBs). It incorporates a precision dispenser, vacuum pickup, infra-red soldering unit, and a soldering iron. PCBs up to 1 x 4 inches can be accommodated.

Grundig's approach to video production.

Grundig do it with robots

Surface Mounted Production Systems Ltd
Unit 5
Sandbank Industrial Estate
Dunoon PA23 8PB

More power from Vidor batteries

Increases of up to 20% in the capacity of lithium thionyl chloride—TCL—batteries size T04/5 (1/8 AA) and size T06/8 (AA), now rated at 0.85 Ah and 2.0 Ah respectively, have been announced by Crompton Vidor, a Hawker Siddley company. The maximum current drain figures of these batteries have also been improved. With a capacity loss of only 2% per year for the first 10 years' shelf life, Vidor TCL batteries are recommended for use in low-temperature applications in electronic equipment. These include CMOS memory back-up in civil and military telecommunications equipment, data processing systems, industrial process control, and a variety of electronic medical and laboratory equipment. All batteries in the range are recognized under Underwriters Laboratories-UL-component programme.

Crompton Parkinson Ltd
Woodlands House
The Avenue
Northampton NN1 5BS

Ultra-low-profile modem transformer

Electronic Techniques have developed an ultra-low-profile line-matching transformer for use in modems. Measuring only 15 x 20 x 11 mm, the PI165 offers high standards of match, isolation, frequency response, balance and distortion. It is said to satisfy the stringent isolation and safety requirements of Britain's telecommunications authorities.

Electronic Techniques
(England) Ltd
Viking Works
Kirton
Ipswich IP10 0NX
Cirkit in Saudi Arabia

Cirkit electronic construction kits are used extensively by hundreds of students at the Dharhan Technical Training Institute as part of their 2-year practical training programme. Cirkit, a specialist distributor of electronic components kits, and modules to industry and the hobbyist, established an Educational Division last year to service the growing technological needs of schools, colleges, and universities.

With vested interests in the future of the British electronics industry, Cirkit places a strong emphasis on supporting practical education as part of its corporate policy. This led to the company’s origination of the Young Electronics Designer Awards Scheme—YEDA.

Seen in the left-hand photograph is student Imad Ibrahim Al-Mohammed demonstrating his project, a Cirkit tracer robot, to some high ranking officials. In the top right-hand photograph Saleh Hashbooll Al-Ghamdi is seen receiving his Cirkit certificate from Sheikh Nasser Asset, President of Civil Aviation. Pictured at the left is Saleem S Al-Qarni, Director of the Institute. In the lower right-hand picture: Prince Turki Bin Abdul-Aziz, Colonel Commander of the King Abdul-Aziz Air Base in Dharhan, Sheikh Nasser Assar, President of Civil Aviation, and Saeed Al-Farhan Al-Ghamdi, Director-General of Airways Facilities during a recent graduation ceremony of TDDI.

Cirkit Holdings PLC
Park Lane
Broxbourne EN10 7NQ

Triple SDI success for EASAMS

EASAMS, the GEC systems house, has started the year with a run of successes with three SDI—Strategic Defence Initiative—contracts in one week: two from the MoD and the third from Hughes Aircraft Corporation.

In the UK, EASAMS will lead an industrial consortium of several British companies in the largest SDI study yet to date through the MoD. The work is for the Battle Management and Command, Control and Communications (BM/C3) in the European Theatre of Defence. In addition, as part of a second successful bid by the same consortium with Ferranti as prime contractor, EASAMS will receive a share of a study for an Allied Test Bed.

The export order from the USA is particularly interesting. Hughes were in competition with twelve major international consortia. The Hughes team, consisting of EASAMS, Matra (France), Selenia Spazio (Italy), and Krupp-Atlas (Federal Germany) have won phase I of a £6 million contract from the US Army Strategic Defence Command to study Theatre Defence Architectures.

EASAMS Limited
Lyon Way
Frimley Road
Camberley GU16 5EX

New kits for audiophiles

AUDIOKITS is introducing new high-quality audio amplifier kits, new high-grade audio components, and better support services for hi-fi enthusiasts who enjoy building or modifying equipment for better sound quality. AUDIOKITS is the first supplier to introduce bulk foil resistors to audio constructors. These components are manufactured to the highest standards of accuracy with low internal capacitance and inductance, as well as a very low temperature coefficient (better than 5 ppm/°C over the temperature range 0-60 °C).

Foil polystyrene capacitors, intended for exciting telecommunications filter circuits, are now available in values up to 250 nF. Specially manufactured low-noise versions of all transformers used in their kits can also be supplied by the company.

AUDIOKITS Precision Components
6 Mill Close
Borrowash DE7 3GU
Telephone: (0332) 674929

Following a recent agreement, Hawke Systems now distributes VME bus products of Electronic Modular Systems. See the photograph are from left to right: Lindsay Hughes, Product Marketing Support, Hawke Systems; Russell Ward, Managing Director, EMS; Hazel Scott, VME Business Manager, Hawke; and Graham Fage, Sales Manager, EMS. Further information from EMS 6 Mill Close

Cordwallis Industrial Estate
Maidenhead SL6 7DE or Hawke Systems 6 Mill Close

45 Hanworth Road  Sunbury-on-Thames.
New Vortex Flowmeter

Kent Industrial Measurements' new Vortex Flowmeter GLS is the result of years of research and development by the company to produce a flowmeter offering low cost, high accuracy and long-term repeatability.

The principle of the device is straightforward: a bluff body at the sensor upstream end sheds vortices onto a cylindrical downstream bluff body, which vibrates at the vortex shedding frequency. A piezo-electric transducer outside the pipeline section, but connected direct to the bluff body, detects this frequency and the transmitter converts it to either a frequency or an analogue ±20 mA current output.

Kent Industrial Measurements Ltd
Oldends Lane
Stonehouse GL10 3TA

Strong hybrid circuits market in Europe

The world's fastest computer for civilian market

The world's fastest real-time computer, designed for use with military over-the-horizon radars, will be available on the civilian market from Microsystem Services Ltd (MSS)

under an agreement signed with Marconi Radar Systems Ltd. Both MSS and Marconi Radar feel that the ultra-fast XN-10 digital signal processing unit has applications in such fields as speech and image processing, seismic research, sonar, automatic testing, telecommunications, and others.

In its basic form, XN-10 is capable of carrying out 10 million decimal calculations per second. When a number of these units are connected together, thousands of millions of calculations per second can be achieved.

* See Elektor Electronics, September 1986, p.20

Marconi Radar Systems Ltd
Writtle Road Works
Chelmsford CM1 3BN

New divisional structure at Dowty

According to The Hybrid Circuits Market in Europe (E905) a new report from Frost & Sullivan, the hybrid circuits market in Europe will grow at an average annual rate of 27.8% from $1 billion in 1985 to $4.8 billion in 1991 (in constant dollars, 1986 exchange rate). Europe's space industry, which received a boost after the American shuttle disaster, is an ideal application field for hybrid circuits because of the need for high complexity electronics in very small quantities.

At the same time, the increasing use of microprocessors in domestic appliances opens the way for more use of hybrid circuits. The automotive field looks especially favourable.

Because hybrid circuits are involved with so many different uses of electronics, this 276-page report is really a survey of electronic applications in general.

Frost & Sullivan Ltd
Sullivan House
4 Grosvenor Gardens
London SW1W 0DH
or
106 Fulton Street
New York NY 10038

Avel-Lindberg
for fire fighting services

Various fire brigade headquarters have recently been equipped with tactical computers which, when a 999 call is received, are fed with the location of the fire. The computer then gives the best route to the fire, displays the nearest hydrant to the fire, selects the most suitable appliance and the name of the crew, and indicates where the appliance should be parked in the most advantageous position in relation to the fire and the hydrant. It also displays any potential fire hazards in the area and shows which appliances should be moved to provide cover for those attending the fire.

The power supply for these systems is obviously very important, and to ensure continuity Avel-Lindberg have supplied uninterruptable power supplies at each location. In addition, the company also supplies Home Office approved converters that enable radio-telephones and other electronic equipment fitted to fire appliances to be powered from the appliance's batteries.

Avel-Lindberg Ltd
South Ockendon
Essex RM15 5TD
A Q A P - 1 approval for frequency control products

A range of cold-weld crystals, crystal filters, and crystal oscillators with NATO AQAP-1 approval, manufactured by the C R Snelgrove division of Leigh Instruments, are now available in the UK from Piezo Products. Quartz crystals are available for the frequency range 14 MHz to 200 MHz.

Piezo Products Ltd
Millstream Trading Estate
Christchurch Road
Ringwood BH21 3SD

People

Dr Marc Faktor, who spent more than two decades researching the optical and electrical properties of materials, and in doing so helped to put Britain in the world forefront of optoelectronic technology, was last January awarded British Telecom's Martlesham Medal for outstanding contributions to science and technology.

The council of the Institution of Electrical Engineers has announced the following elections to Honorary Fellowship of the IEE.

Professor W E J Farvis CBE BSc(Eng) FRSE for his outstanding contribution to the profession, particularly through his activities in the field of electrical engineering education.

Sir Robert Telford CBE DL MA FEng for his outstanding contribution to the development of the UK Defence Electronics Industry, particularly in connection with his service as Managing Director and latterly Life President of the Marconi Company.

The Council has also announced that the 55th award of the Faraday Medal has been made to Professor D E N Davies CBE DSc FEng FRs for his outstanding contributions to the development of radar systems, notable to techniques of electronic scanning and to novel radar arrays, and also for his pioneering researches on optical fibres sensors and the use of optical fibres for signal processing.

Mr Andrew Glasgow OBE has been appointed Managing Director of Marconi Communication Systems Limited at Chelmsford. He was formerly Managing Director of Marconi Space Systems at Portsmouth.

Mr John Powell has been appointed Financial Director of Marconi Communication Systems Ltd of Chelmsford. He was previously Financial Director of Marconi Space Systems Ltd at Portsmouth (see photograph).

Mr Angus Cairns has been appointed Managing Director of EASAMS, a GEC company, which was probably the first UK System and Software Company. The company was formed in 1962 and operates in both the defence and the civil sector.

Mr Kevin Thomas has been appointed UK Sales Manager of Advance Bryans Instruments Ltd, the Mitcham-based manufacturer of digital plotters and recording systems.

Mr Tom Smith has retired from his position as Divisional Director of Design after a career spanning 46 years with A F Bulgin & Co PLC. He will, however, continue his association with the company as a consultant.

Avel-Lindberg on the QE2

An 8 kVA uninterruptible power supply—UPS—from Avel-Lindberg will play a vital role in maintaining power to the QE2's CEM-80 micro-based Uninterruptible Power Supply (UPS) system, which will alert QE2 maintenance staff to the performance of the nine diesel engines, the associated generators, the two largest electrical propulsion motors ever manufactured, and the ship's existing equipment, including pumps, water systems, and so on.

The Avel KD system is based on a ferro-resonant technology, which has been proven in service to give reliable operation, has a mean-time-between-failures—MTBF—of over 50,000 hours, and has a low component count.

Avel have also provided two other important power supply systems which provide power to the engine control and management equipment on a line of four and a line of five diesel/alternators. The photograph shows a couple of uninterruptable power supplies being tested.

For DDD ask BAL

BAL Components Ltd
Bermuda Road
Nuneaton CV10 7QF

Electronic wheelchair controller

Base Ten Systems has won a contract worth £400,000 for the supply of microprocessor-based controllers for electrically powered wheelchairs. The contract, placed by the Disablement Services Branch of the DHSS, involves the development of equipment to meet the requirements laid down by the DHSS and to manufacture the controllers and associated joystick mechanisms at Base Ten's plant at Farnborough.

The system has undergone extensive testing by Salford University's independent test service in addition to failure-mode analysis to ensure that it is fail-safe in operation.

Base Ten Systems Ltd
12 Eelmoor Road
Farnborough GU14 7QN
Harrier GR5 ATE contract for Factron

Factron Schlumberger has been awarded the prime contract for provision of avionic third-line testing for the Royal Air Force fleet of Harrier GR5s. The GR5 is the UK version of the McDonnell-Douglas Harrier AV8B, which is fitted with a mix of US and UK avionics. This multi-million pound contract, won under the MoD's tendering principles against competition from eight other consortia from around the world, is expected to extend over a two-year period. It is for the supply of a total test solution for over 150 modules and PCBs, which will be achieved by enhanced versions of Factron's commercial general-purpose automatic test equipment—ATE—plus associated applications software, fixtures, and support facilities.

Factron Schlumberger
Ferndown Industrial Estate
Winborne BH21 7PP

Silicon chip plant for Antrim

Antrim is the site chosen for Northern Ireland's first silicon chip factory. The development is part of a £4 million expansion plan by Lucas Stability Electronics, a local concern. The plant will employ 200 people. The expansion will allow stability to introduce a new range of silicon-chip-based components for use in the protection of sensitive electronic systems from lightning, nuclear radiation, and static electricity. Two main markets for the new products will be Federal Germany, Italy, and the USA.

Lucas Industries PLC
Brueton House
New Road
Sollull BH1 3TX

BELGIAN AIR FORCE ORDER FOR HAWKER SIDDELEY

The Belgian Air Force has placed an order worth nearly £400,000 with Hawker Siddeley Dynamics Engineering for equipment to update its existing fleet of Sea King helicopters to the latest standard of MKIA control systems for the Rolls Royce Gnome gas turbine. Belgium has now joined the majority of Gnome operators, including the RAF, Royal Navy, Royal Norwegian Air Force, Swedish Air Force and Navy, German Navy, and Australian Navy in taking advantage of the increased in-service reliability provided by the MKIA control system.

Rapid Silicon transputer from Rapid Silicon

Rapid Silicon is handling sales of Inmos's Type IMS 7800 transputer, which is capable of sustaining over 2.25 million floating-point operations per second.
FEEDBACK IN LOUDSPEAKERS
by R Conell

Electrical feedback is the backbone of many an electronic circuit. Acoustic feedback is not nearly so common, but R Conell suggests some ways of experimenting with it in a low-frequency loudspeaker.

Ever since Thiele and Small published their works on loudspeaker theory, it has been possible to calculate fairly accurately what the ideal enclosure is for a certain type of loudspeaker, or conversely how a loudspeaker will behave in a certain enclosure. According to Small, a closed box will behave as a second-order high-pass filter, while Thiele shows that bass reflex and transmission line boxes act as fourth- or sixth-order filters. From this it is clear that a closed box will give better bass reproduction than an open system.

The performance of a filter is determined by its quality factor $Q$ and its resonance frequency $f$. This is also true of a complete loudspeaker system, including the enclosure, when the total $Q$ is designated $Q_c$ and the resonant frequency $f_c$. In an ideal bass system, these quantities should have values as follows:

$$Q_c = 0.5 \text{ to } 0.7, \quad f_c < 30 \text{ Hz}.$$  

Moreover, the volume of the enclosure should preferably not exceed 100 litres, the frequency range should be greater than 300 Hz, and the distortion should not exceed 1%.

It is virtually impossible to meet these requirements with a passive speaker system, particularly as regards $Q_c$ and $f_c$. In an active system, it is far easier to approach the ideal.

Feedback is one way to tackle the problem. Basically, it is better, however, to make use of a controlled system. Unfortunately, such a system is prone to spurious oscillations, which can, however, be obviated by negative feedback.

Basic controlled system
Control is possible by converting some of the acoustic output of the loudspeaker into an electrical signal and returning this to the input of the power amplifier. To this end, a low-mass acceleration pick-up has to be fitted to the cone of the drive unit.

The block schematic of a possible arrangement is shown in Fig. 1. The left-hand box contains the control electronics, followed by the power amplifier, which has a gain of about 30 dB, and the loudspeaker system. The control electronics consist of an adder that combines the left- and right-hand signals, a low-pass filter with a cut-off frequency of 100 Hz, and a difference amplifier where the filtered input signal is reduced by the correction signal from the feedback loop.

The power amplifier can be of any type, but its gain should preferably be about 30 dB. A smaller gain would require some adjustment of the control loop, while a higher gain increases the tendency to oscillations in the loudspeaker system.

The loudspeaker system contains the drive unit, fitted with the acceleration pick-up, $M$, and an impedance converter, $IC$.

Impedance converter
The impedance converter—see Fig. 2—consists of a Type TL071 operational amplifier. Its pin-out is shown in Fig. 3. This stage should be fitted as close as possible to the acceleration pick-up, preferable direct onto the chassis of the drive unit as shown in Fig. 7.

Control circuits
Adder IC2 in Fig. 3 combines the two stereo signals into a monaural signal. Potentiometer $P_1$ sets the input level for low-pass filter IC3-IC4. This Bessel filter has a cut-off frequency of 100 Hz and a roll-off of 24 dB/octave. A similar filter was described in the December 1985 issue of Elektor Electronics.

The control amplifier proper is formed by IC9: the values of $R_9$, $R_8$, and $C_9$ determine the transient response of the overall system. These values will be reverted to under Setting up.

The control signal is deducted from the filtered audio signal in subtractor IC6. The output of this stage is fed to buffer IC7 via two low-pass sections, $R_{16}$-$C_9$ and $R_{18}$-$C_{12}$. These sections further suppress any tendency to oscillation and are absolutely necessary.

Fig. 1. Block schematic of proposed set-up with modified drive unit.

Fig. 2. Circuit diagram of the impedance converter. The pin-out of the TL071 is shown in Fig. 3.
It is possible to omit impedance converter IC3 and buffer IC7, but the values of the low-pass sections between IC6 and IC7 should then be recalculated with due account of the input impedance of the power amplifier.

Modifying the drive unit

The acceleration pick-up is made from a piezo tweeter from which the chassis has been removed as shown in Fig. 4. The connexion wires have been cut at the terminals, not at the crystal end. The remaining cone is then cut to the same size as the piezo disc. The resulting acceleration pick-up may be fitted over or under the dust cap of the woofer. The latter method is preferable, but only possible if the dust cap has been fastened with a thermoplastic glue. The cap may then be removed quite easily with a heated knife as shown in Fig. 5. The epoxy resin may be used at the same time to fix the pick-up in place. In the mean time, the woofer should be kept upside down to prevent dust entering the air gap. After the epoxy resin has hardened, a thin flexible wire should be soldered to each of the two short connexion of the pick-up. These wires should also be glued to the dust cap to prevent them vibrating in unison with the cone later. Next, the dust cap can be fastened onto the cone again, preferably with thermoplastic glue to enable removal at a later stage if necessary. Before gluing it in place, however, pierce a small hole in the cone through which the flexible wires are fed. These wires should also be glued to the cone in the same way as those to the speech coil. Finally, they should be connected to the impedance converter board as shown in Fig. 2 and
Fig. 6. The dustcap should be stiffened on its inside with a thin layer of epoxy reson, which can be used at the same time to fix the acceleration pick-up.

Table 1

<table>
<thead>
<tr>
<th>Harmonic distortion at 96 dB at 1 m distance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency (Hz)</td>
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<tr>
<td>----------------</td>
</tr>
<tr>
<td>Without feedback</td>
</tr>
<tr>
<td>With feedback</td>
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</tbody>
</table>

<table>
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<tr>
<th>Maximum sound pressure at 40 Hz with different enclosure volumes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volume (litre)</td>
</tr>
<tr>
<td>----------------</td>
</tr>
<tr>
<td>Without feedback</td>
</tr>
<tr>
<td>With feedback</td>
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</tbody>
</table>

<table>
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<tr>
<th>System parameters measured in a 70 l enclosure</th>
</tr>
</thead>
<tbody>
<tr>
<td>$Qc$</td>
</tr>
<tr>
<td>------</td>
</tr>
<tr>
<td>Without feedback</td>
</tr>
<tr>
<td>With feedback</td>
</tr>
</tbody>
</table>

Fig. 7. The modified bass drive unit: note how the impedance changer is fixed to its chassis.

Fig. 7. They should preferably be of about the same length as those to the speech coil. The drive unit is then ready for operational use—see Fig. 7.

Setting up

All the constituent parts of the system should now be interconnected as shown in Fig. 1. Short out $R_{11}$ and $C_{6}$ with the aid of a switch to disable the control circuit. When the switch is opened momentarily, one of three things will happen:

- the loudspeaker remains quiet;
- the system oscillates at a low frequency (<100 Hz);
- the system oscillates at a high frequency (>1 kHz).

In the first case, everything is in order and the system can be taken into use.

In the second case, the connections from the pick-up to the impedance converter board must be reversed.

In the third case, the oscillations must be damped by changing the values of a few components. First, increase $C_{6}$ to 1 nF and, if this does not help, $C_{7}$ to 1 μF. If that still does not cure the problem, reduce the value of $R_{6}$ and increase that of $C_{10}$. Resistor $R_{6}$ affects the lower cross-over frequency, while $C_{10}$ alters the $Q_{9}$ of the system. The author has built several of these systems and alleviation problems. Do not forget to remove the switch from across $R_{11}$ and $R_{6}$.

Finally

The frequency characteristics in Fig. 8 show the results of the modification: it is quite evident that the lump between 30 and 100 Hz in the response of the system disappears when the feedback is introduced. The response between 20 and 30 Hz is also much improved.

A number of pertinent measurements are tabulated in Table 1.

The system with feedback was also compared with a number of top quality loudspeaker systems: in all cases, it performed equally well over the bass range, in spite of its cost being only a fraction of that of the competition.
ELECTRONIC POTENTIOMETERS

by T Scherer

An exploratory look at all-electronic replacements for potentiometers in high quality AF applications.

Potentiometers are, arguably, not the best way of controlling the volume and tone settings in an AF amplifier. We all know that they can cause scratching noises when operated, collect dust, and sometimes develop contact problems giving rise to troublesome discontinuities in the operative range. High quality potentiometers for AF applications are not only difficult to obtain, but also notoriously expensive. In the following sections we will briefly examine a number of low-cost alternatives to potentiometers used in various circuit sections of AF equipment.

The carbon track potentiometer

This most commonly used voltage divider is generally composed of a carbon film deposit on a ceramic base arranged in a three-quarter circular form (270°). The poor contact definition of the wiper on this thin carbon film readily gives rise to scratching noises made audible in the loudspeakers. Furthermore, dust and foreign particles can easily enter the potentiometer enclosure, and block certain sections of the carbon track, so that the amplifier falls still at particular volume settings, making the adjustment very difficult. Stereo potentiometers of the carbon film type are a further source of trouble. With most inexpensive types, the tolerance on synchronicity of the set resistance is often no less than 20%, even with linear law types. The voltages at the wipers of a logarithmic stereo potentiometer can also differ by some 20%, causing a volume difference between the channels of a maximum of 2 dB, which may be noticeable in listening.

Potentiometers are generally mounted on equipment front panels, and are connected to the electronic circuit with the aid of shielded wires that often

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Fig. 1. Experimental stereo volume control circuit based on the use of a LED-LDR optocoupler.
carry very low signal level at relatively high impedance. This makes the amplifier susceptible to noise, hum and strong RF fields, which can still be picked up by the carbon track in the potentiometer (plastic enclosures), and even in the cable shield.

In conclusion, it is reasonable to say that the standard carbon track potentiometer is unsuitable for a great many critical applications.

Stepping switches
Rotary (wafer) switches with fixed resistors at the contacts are, in principle, a good way to effect volume and tone setting in an amplifier. The tracking is adequate, and scratching noises due to spindle movement are effectively ruled out. However many rotary switches of suspect quality do develop contact problems after prologed use. A major difficulty in the designing with stepping switches is the finding of types having the number of positions required to ensure a sufficiently smooth adjustment range.

Wire-wound potentiometers
Long ago in the history of electronics, all potentiometers and resistors were made from resistance wire. For a number of specific applications, the wire-wound potentiometer is still in use. Ganged types with motor drive units can be found in some of the most expensive types of amplifier. This application, however, requires sophisticated mechanical engineering on the one hand, and a fairly complex electronic control circuit on the other, making the whole set-up rather cumbersome and expensive at the same time.

An LDR-based potentiometer
The first attempts at making a fully electronic potentiometer were carried out with combinations of LDRs (light dependent resistor) and a small bulb. Although the results were quite satisfactory for AF equipment on the market in the early 1980s, we would nowadays reject the LDR-and-bulb control for incorporation in Hi-Fi equipment in view of the noise production, rumble sensitivity, and poor tracking characteristic of the stereo versions.

We all know that each and every electronic component remains subject to continuous enhancement by the joint force of manufacturers and their research laboratories. The German firm Heimann, for instance, took up the long forgotten LDR for further research, and used two of these devices together with a LED to make an optocoupler that has adequate features for Hi-Fi applications. The LDRs in their Types LT10xx and LT20xx optocouplers are of excellent quality, and especially the LT20xx should do very well as a stereo potentiometer with adequate tracking properties—see Fig. 1a for the pinning and R-Ia curves, and Fig. 1b for a suggested application circuit.

An OTA-based potentiometer
A fairly simple potentiometer replacement can be realized with the aid of an OTA (operational transconductance amplifier), which is essentially an amplifier with current-controlled gain. The gain range of about 80 dB, the extensive usable frequency range and linearity of the current-gain correlation, make an OTA such as the Type LM13600 eminently suitable for the applications we are concerned with here.

Those who want to experiment with these devices will find the suggested circuit in Fig. 2 of use for further experiments. The only drawback associated with OTAs is their limited dynamic range, which results in a maximum attainable signal-to-noise ratio of about 80 dB.

Analogue multiplexers
The circuit shown in Fig. 3 is a high-quality, all-electronic volume control featuring 16 dB and 2 dB steps as controlled from a 6-bit digital input. The ICs in this circuit are the well-known Type 4051 eight-channel/multiplexer/demultiplexer, which is in essence an electronic version of an 8-way, single pole rotary switch. The contacts are inputs 0-7, the pole is output Z, and the switch position is set with the 3 bits at the A-B-C inputs. Example: applying binary code 010 to the A-B-C inputs of the left-hand multiplexer connects input 2 (pin 15) to output Z. The input signal for Dpamp A? is therefore taken from the -32 dB contact on the resistor ladder. The resistors at the inputs of the second multiplexer connect input 2 (pin 15) to output Z. The input signal for Dpamp A? is therefore taken from the -32 dB contact on the resistor ladder. The resistors at the inputs of the second multiplexer connect input 2 (pin 15) to output Z.
Table 1

<table>
<thead>
<tr>
<th>INPUT STATES</th>
<th>&quot;ON&quot;</th>
</tr>
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<tbody>
<tr>
<td>C B A CHANNELS</td>
<td></td>
</tr>
<tr>
<td>---------------</td>
<td>-----</td>
</tr>
<tr>
<td>CD4051B</td>
<td></td>
</tr>
<tr>
<td>0 0 0 0</td>
<td>0</td>
</tr>
<tr>
<td>0 0 0 1</td>
<td>1</td>
</tr>
<tr>
<td>0 0 1 0</td>
<td>2</td>
</tr>
<tr>
<td>0 0 1 1</td>
<td>3</td>
</tr>
<tr>
<td>0 1 0 0</td>
<td>4</td>
</tr>
<tr>
<td>0 1 0 1</td>
<td>5</td>
</tr>
<tr>
<td>0 1 1 0</td>
<td>6</td>
</tr>
<tr>
<td>0 1 1 1</td>
<td>7</td>
</tr>
<tr>
<td>1 X X X</td>
<td>NONE</td>
</tr>
</tbody>
</table>

Fig. 3. A 6-bit high quality volume control circuit that uses CMOS analogue multiplexers.

Fig. 4. Using electronic switches instead of a potentiometer in a tone control circuit.

sioned to give 2 dB attenuation steps, so that the overall range of this electronic potentiometer is from 0 to -96 dB as set with 6 bits. A balance control can be made with two of these circuits, operated on the basis of software.

The tone control section shown in Fig. 4 uses the same principle as the above volume adjustment. The resistors as part of the R-C filters in the feedback loop of A are selected with 3-bit codes for bass and treble.

Use high-stability resistors and capacitors when constructing these circuits, and provide ample decoupling of the supply lines. The opamps should be low-noise types such as the TL074 indicated in the circuit diagram. The digital adjustment of the volume and tone control circuits is a matter we leave in your hands. You may want to use an up/down counter, a microprocessor port, or a special switch to arrange for the correct bit combinations at the multiplexer control inputs (consult Table 1).
The design is completed with a multi-voltage supply and a relay control board.

The main task of the boards described in this final instalment of the article is to enable the preamplifier to operate at the top of its potential. To accomplish this, one board holds a relatively extensive power supply, the other a combination of logic circuits for driving the various relays in the preamplifier.

The power supply

The present design is no exception to the rule that high-quality AF circuits, whether preamplifiers or power amplifiers, invariably call for the use of no-compromise supplies that are based on the use of conservatively rated components of the best quality available.

The proposed supply is, therefore, a relatively complex circuit, set up to deliver three voltages to the preamplifier board, and two to the relay control circuitry. The high-voltage (HV) rails for the preamplifier are stabilized with a series regulator to ensure optimum operation of the cascaded triodes, and also to effectively keep low-frequency noise out of these highly sensitive sections.

Not all components in the power supply are accommodated on a printed circuit board. With reference to the wiring diagram shown in Fig. 10, a varistor (SIV 510 K250) is fitted across the mains lines to suppress noise and voltage peaks. The contacts of the double-pole mains switch have shunt capacitors which afford protection against inductive transients being superimposed onto the mains when the amplifier is switched off. Without these high-voltage capacitors, the loudspeakers in the audio system would be in real danger of being damaged by powerful clicks—or worse, bangs—originating from the preamplifier. The mains transformer, Tr, supplies four voltages from its five secondary windings. Where a transformer as shown is difficult to obtain or make, two or more may be used to provide for the various alternating voltages.

The circuit diagram of the valve supply appears in Fig. 6. The 6.3 V secondary of Tr only powers the filament of the HT rectifier valve, Vm, a Type EZ80 or EZ81 used in a full-wave rectifier circuit fed from the centre-tapped 360 V windings on Tr. When REC is activated, the cathode voltage of Vm is smoothed with the aid of R127 and C128. Series regulator IC11 is a special high-voltage type, protected against excessive dissipation and reverse voltage with zener diodes D119-D121 and shunt D122. The HV rails for the LINE and MD preamplifiers are adequately decoupled with the aid of R-C filters R125-C130 and R129-C131, respectively. Series resistor Rm also serves to protect IC11 from being damaged by a short-circuit on the +350 V rail.

As an alternative to the regulator circuit, power resistor Rm can be fitted to drop the cathode voltage of Vm to +350 V. Since it denotes the regulation of the supply, this solution should not be adopted, however, if the amplifier is to work optimally. Moreover, the output filter capacitors could then be blown out owing to overvoltage if the valves were removed from their sockets, or if the preamplifier board was not, or not yet, connected to the supply. The TL763 is not very expensive and effectively prevents all this misery from happening.

The filament supply (+U0 is arranged to "Boot" at about +80 V with respect to ground with the aid of voltage divider R126-R127-C134. This ensures that the cathode-to-filament voltage of the upper triodes in the preamplifier stages does not exceed the safe limit. The filament supply based around the Type LM337 regulator is adjustable with Rn, and features a "soft-start" facility (realized with R112-C111-T10) to enable the valves to heat up gradually at power-on, thus extending the useful life of the emissive elements.

The +12 V & +13 V supply for the relay control circuitry is shown in the lower left-hand corner of Fig. 7. Note that the rectifier diodes have shunt capacitors to suppress noise, and that D113 raises the common connection of IC10 of to about 1 V with respect to ground in order to obtain a sufficiently high relay coil voltage from the 7812 regulator.

Relay control

The relays on the source selector board are controlled by the logic circuit shown in Fig. 7. When the power is first switched on, the LINE OUT relay (RE) is energized after a slight delay, but it is deactivated immediately when the preamplifier is switched off. To ensure noise-free switching operation of the preamplifier, the LINE OUT relay is briefly deactivated if either the TAPE MONITOR or the SOURCE SELECT switch is operated.

With reference to Fig. 7, the logic configuration at the contacts of S2 is inverted by gates IC12-A5 and applied to 4-bit comparator IC13. The A-B output of this chip is high whenever the two nibbles at the AB-A inputs are equal. Delay networks R19-C11, R18-C12, R17-C13 and R16-C14 cause the B nibble to differ very briefly from the A one when S2 is turned to select another source input for the preamplifier. The negative pulse at the A-B output of IC13 triggers monostable multivibrators MMV101 and MMV102, which are configured to pro-
The LINE OUT relay can not be activated before \(N_{21}\) is enabled with the aid of the \(Q\) signal from \(FF_{102}\), which forms part of the power-on delay and failure detection circuit. Binary counter \(IC_{112}\) controls two timing sequences. After a delay of about half a minute, output \(Q\) switches on the high voltage with the aid of relay \(G\). After another 30 seconds, output \(Q\) of \(FF_{102}\) enables \(N_{123}\) to activate the LINE OUT relay. The binary counter is clocked by its internal oscillator, whose frequency is determined with \(R_{101}C_{105}\). Schmitt-trigger gate \(N_{126}\) provides a power-up delay for the relay control circuitry, in order to ensure the correct initial logic states of \(IC_{112}, FF_{101}\) and \(FF_{102}\). Gate \(N_{126}\) makes it possible to control the LINE OUT relay by an optional failure detection circuit, which should provide a logic low level at the ERR input in response to a direct voltage component or excessive noise at the (pre-)amplifier output. There are two ways of restoring the LINE OUT connection to the power amplifier: either RSTA is made logic high by, for instance, pressing a push button connected to this input; or RSTB is similarly made logic low. The latter operation causes the previously detailed power-up cycle for the high voltage to be restarted, before RER is re-energized.

**Construction**

Before commencing the fitting of parts onto the supply and relay control board, this may have to be cut to suit a particular arrangement in the pre-amplifier enclosure. The track layout and component mounting plan for each section of the board are shown in Fig. 8 (power supply) and Fig. 9 (relay control circuitry).

The high voltage supply

To allow for adequate heat dissipation, all power resistors on the supply board must be fitted slightly off the circuit board. Filament voltage regulator \(IC_{110}\) is fitted onto two heatsinks clamped back to back. The high voltage regulator, \(IC_{110}\), needs only one heatsink, which must none the less be adequately sized. Should electrolytic capacitor \(C_{107}\) prove hard to obtain in the stated voltage rating, it is possible to replace it with two series connected \(100 \mu F; 250 V\) types, each fitted with a 470k \(1 W\) shunt resistor for equal voltage distribution. The circuit board should allow plenty of space to accommodate these additional parts.

The use of the stabilization circuit with \(IC_{110}\) requires the voltage across \(C_{107}\) to be no more than 450 V, and no less than 400 V. Series resistor \(R_{113}\) may have to be adapted to stay within these limits. If it is dimensioned for an output in the region of 400 to 420 V, it becomes possible to use a 450 V rated capacitor in the \(C_{107}\).
Fig. 8. The printed circuit board for the power supply.

Fig. 9. The printed circuit board for the relay controller.
Fig. 10. Wiring diagram for the valve preamplifier.

Fig. 11. Suggested front panel layout.
The completed supply and relay control boards.

Continued on p. 51
SECONDARY BREAKDOWN IN POWER TRANSISTORS

by Sue Cain & Ray Ashmore

This article examines the different types of secondary breakdown that occur in power transistors, and investigates the phenomena that cause them. It concludes that secondary breakdown is a function of transistor technology, and cannot always be improved without some trade-off in other parameters.

One of the basic failure mechanisms in power transistors is second breakdown. This term includes various physical phenomena which are completely different. They depend on the different use of transistors in the circuits and have in common the electrical and thermal instability inherent in transistors themselves.

The conduction behaviour of an emitter base junction and the current gain of a transistor depend significantly on the temperature and increase as a function of the temperature. Electrical and thermal instabilities may act simultaneously within the device, thereby giving rise to destructive second breakdown mechanisms.

An understanding of this mechanism is of great importance for a safer optimum application of a power transistor.

A distinction should be made between direct second breakdown (Vds) which is distinguished by a normal direction of base current Is (entering into an NPN transistor) and inverse second breakdown (Vds), when Is is in the opposite direction (extracted from an NPN transistor). The limits to which a transistor may be used without entering into Vds are defined by the reverse bias safe operating area (RBsOA).

Direct second breakdown

It is important for the power circuit designer to know the locus of the Ic-Vce points defining the boundary between stable and unstable operation of forward biased transistors. This locus defines the SOA safe operating area, that is, the area of the log Ic-log Vce plane which may be used without any risk in DC current conditions or with different width pulses at a known temperature. A typical SOA is shown in Fig.1. The limits of this area are as follows:

1) The A-B section represents the upper limit of the collector current that may normally be used, generally limited by wire bonds. Operation at higher currents may cause damage to the wires of their bonding.

2) The B-C section is the Ic slope curve section (i.e. the section with constant dissipation) defined by:

\[ V_{ce} = P_{max} = \frac{(T_{max} - T_0)}{R_e} \]  [1]

This section therefore indicates the maximum dissipable power of the device. Tmax is the maximum temperature which the collector-base junction may reach, over which the device reliability may be compromised. In power transistors, Tmax varies between 125 and 200 degrees Celsius and generally depends on the metallurgy and the type of package. Req is the thermal resistance between the collector-base junction and the case, including all the silicon and package system. The increase in the maximum dissipable power when the pulse width decreases (Fig. 1) corresponds to the decrease of \( E_b \) with respect to Req.

3) Section C-D corresponds to the second breakdown phenomenon (or \( A_n \)) and limits the maximum power that the transistor can dissipate. This may occur even at relatively low Vce voltages.

4) Section D-F is the limit due to the transistor's BVCEO. Second breakdown is generated by the electrical and thermal instability of the transistor. The main causes of this instability are:

a) an increase of the junction temperature, giving rise to an increase of Is and hrr, and therefore to an increase of Ic with a following increase of P and, therefore, a further temperature increase.

b) a dissipation to the external environment, controlled by the thermal resistance \( R_g = \frac{d T}{d P} \) which tends to stabilize the device.

The situation evolves towards stability when:

\[ \frac{\Delta I_c}{\Delta I_c} = \frac{A E_b}{A E_c} = \frac{\Delta V_{ce}}{\Delta T} \]  [3]

is smaller than 1, or instability if \( >1 \).

In this way, a stability factor, S, may be defined that will be a function of Vce and Ic:

\[ S = \frac{R_g V_{ce}}{\Delta I_c/\Delta T} \]  [4]

---

**Figure 1.** Safe operating areas which may be used without any risk in DC current conditions or with different width pulses at a known temperature.
When $S>1$, so called "thermal runaway" occurs and the junction temperature increases without any limit, thereby degrading and possibly damaging the transistor. The failure generally occurs when the surface temperature becomes greater than the eutectic temperature between silicon and the contact metal (front aluminum) with a consequent melting of the alloy. A localized temperature increase may also damage the crystal, or the inner temperature of the device may reach values high enough to melt the silicon.

To understand the phenomena which give rise to a reduction of the maximum power that the transistor can dissipate as $V_{CE}$ increases (zone D-E), it is necessary to take into account that device operation is not homogeneous on all the dice area. There are disuniformities in the emitter base current density that may be due to junction disuniformities, crystal defects and, most of all, to the emitter edge concentration phenomenon.

The voltage drop due to the base current flowing through the cross resistance $r_{bb'}$ gives rise to a disuniformity of $V_{CE}$ at the junction, and therefore to the disuniformity of the current density $J_c$ (see Fig. 2). A side drop of 26 mV reduces the injected emitter current by a factor $k/e$, where $e$ is the base of the natural system of logarithms ($= 2.71828...$).

A concentration of the current at the emitter periphery is therefore generated, so the active silicon area is reduced and hot spots occur, leading to an effective increase of the thermal resistance. As a result, the maximum dissipable power is decreased.

When $V_{CE}$ is increased, the effect of the base-collector electric field is to increase the base current concentration.

Different techniques may be adopted to limit the $I/B$ phenomenon. Fundamentally, these consist of minimizing the mechanisms that trigger electrical and thermal instabilities in the transistor. The basic techniques are:

1. minimization of crystal damages, metal impurities, and doping disuniformities;
2. optimization of package and die attach techniques to minimize the thermal resistance on which the stability factor $S$ depends. Disuniformities of silicon die bondings to the case may give rise to adverse variations of $R_b$ as a macroscopic parameter for the dice as a whole, but also to significant variations between different points, giving rise to premature second breakdown;
3. increase of the base thickness to reduce the high current densities (due to emitter crowding) flowing through the collector base junction (where the electric field is localized), so that the density of the dissipated power is decreased. High base thicknesses, however, will result in lower cut off frequencies and slower switching times;
4. optimization of the horizontal geometry;
5. introduction of distributed ballast resistances connected in series with the base, the emitter or both, which tend to give a negative feedback to thermal runaway, therefore stabilizing the device.

The introduction of a ballast resistance in series with the base of the emitter may reduce from $I_B$ to $I_c$ the current density in the hot spot. The emitter ballast resistance is generally obtained by opening emitter contacts thinner than the emitter strip. In this way it is possible to limit the current density at the boundaries of the emitter. These resistances show the drawback of increasing the saturation voltage of the transistor by the amount $V_{CE} = R_E I_B$.

On the other hand, the base ballast resistance is obtained through a "N+ pocket" (in the case of NPN), around the emitter area. This $N^+$ diffusion, being unbiased, cannot be traversed by the base current, so this is forced to flow below the $N^+$ through a small section and, in the case of a diffused base, encounters a higher resistance on the way to the edge of the emitter. In this way it is possible to improve $I/B$ significantly.

It should be noted that the SOA limits are temperature dependent and suitable derating must be applied.

**Reverse second breakdown**

The reverse breakdown phenomenon ($EOB$) is also due to thermal and electrical instability of the transistor. As already mentioned, it is distinguished from $I_{ES}$ by the presence of a reverse $I_E$ (i.e. with a direction opposite to the normal direction of a transistor operating in the active zone) and by high $V_{CE}$ values of the transistor. The device may be in these working conditions during turn-off with an inductive load.

In Figure 3 the common emitter characteristic curves for a transistor are shown. It is easy to understand the reverse behaviour of these curves when the common emitter gain expression is considered:

$$\frac{I_E}{I_R} = \frac{A_r}{(1-A_r)}\quad [5]$$

For high $V_{CE}$ values, $A_r$ is replaced by $M$. For low $V_{CE}$ values, $M$ is an insignificant factor, being very close to 1, it increases when $V_{CE}$ is increased according to the following expression:

$$M = \frac{1}{1-V_{CE}/V_{CO}}\quad [6]$$

From expressions (5) and (6) it is clear that $I_E$ depends on $V_{CE}$, becoming infinite when $M_{ES} = 1/V_{CO}$.

The negative slope section, which is a feature of the curves with $I_E > 0$, is due to the fact that $A_r$ decreases at low values of the emitter current.

During turn-off with an inductive load, the transistor has to operate with negative base current and high value of $I_c$, because of a reverse $V_{CO}$, remaining there all the time required for the inductance to be discharged. Fig. 4 shows the behaviour of $I_E$, $V_{CE}$, $I_R$ and the power dissipated by the transistor during turn-off.

The area of the dissipated power corresponds to the energy stored by the inductance, $\frac{1}{2}L I^2$, which is discharged into the transistor and this is called second breakdown energy ($EOB$).

Like $I_{ES}$, the voltage drop due to the reverse $I_E$ flowing through the side resistance $r_{bb'}$ makes the centre of the emitter strip more biased than its periphery. In this way, a current concentration occurs at the emitter centre.

Let us analyze the case of an NPN transistor with diffused base and epitaxial collector, i.e. with constant concentration ND of donors doping particles. Poisson's equation is:
current is limited to low values. Figure 5. Typical electric field behaviour when the collector

metallic substrate. When the collector current is limited to low values, expression [7] becomes (q being the
electron charge):

\[ \frac{dE}{dx} = q \frac{I_c}{I_x} \]

and the electric field behaviour is similar to that shown in figure 5 for \( J = J_c \). The voltage \( V_{cs} \) (= \( V_{cr} \)) is given by the area of the \( E-X \) graph and is smaller than primary breakdown voltage due to the reaching of critical field \( E_c \). In the presence of significant values of current density \( J_c \), the expression [8] is modified due to the \( n \) concentration of electrons flowing at the speed \( V \) through the depletion layer.

\[ \frac{dE}{dx} = q \frac{N_d}{n} \]

where \( n = J_c / q V \). At constant \( V_{cs} \), the area limited by \( E \) has to remain constant. When \( J_c \) increases, the \( E-X \) slope varies (J3) until its sign is changed (J2) and \( E_c \) is reached (J3). At this point avalanche local multiplication of electrons occurs with an uncontrolled current increase—and so a strip is formed with a very high temperature that gives rise to either crystal damage or silicon melting. Possible crystal defects, metal ions, and junction disuniformities further exaggerate this phenomenon. The avalanche multiplication is very fast and very localized so the device remains externally cold. The \( E \) behaviour is not influenced by the die bonding quality. High \( E \) values can be obtained with a proper geometric design to limit the current crowding and, most of all, by inserting a second epitaxial layer \( N \) of intermediate doping between the collector and the substrate.

The intermediate layer creates the condition shown in Fig. 6. When the current density increases (J2) the electric field at the interface \( N^- \)/\( N^+ \) is increased. Before the critical field \( E_{cr} \) is reached at the interface, the contribution of layer \( N \) becomes significant in sustaining the voltage. A further density increase (J3) reduces the electric field at the interface

N^-/N and the breakdown is not triggered until the critical field is reached at interface N^-/N.

For a good power transistor with \( V_{ceasum} = 450 \text{V} \), the current density \( J_c \) corresponding to \( E_c \) is of the order of 20 \( \text{A/mm}^2 \), i.e., greater by a factor 10 when compared to the average current density given by the ratio between maximum saturation current and emitter area.

The \( E_{br} \) behaviour is also influenced by the conditions outside the transistor, \( R_{bs}, V_{br}, L \). The base conditions are especially important, as they regulate the crowding phenomenon. The system most commonly used by power designers to reduce the \( E_{br} \) effect during turn off with inductive load is a clamping or 'snubber' circuit, that limits the voltage peak between collector and emitter.

The presence of the clamping circuit allows only a minimal amount of the energy stored in the inductance to be absorbed by the transistor, and \( E_{br} \) becomes independent of the value of \( L \) and practical RBSOA limits may be defined.

The presence of high \( V_{ce} \) and negative base current, \( I_n \), may give rise at high current to the previously described \( E_{br} \) phenomenon, even in the presence of a clamp. The reverse bias safe operating area establishes the maximum switchable current with inductive load versus clamping voltage in very harsh base conditions that simulate the real base driving conditions in the circuits.

The temperature is not a major factor in the \( E_{br} \) and so the RBSOA rating can be considered to be independent of temperature.

Conclusion

Second breakdown performance is a function of transistor technology and cannot always be improved without some trade-off in other parameters. The application conditions have a considerable effect on both \( I_n \) and \( E_{br} \) capability.

* Sue Cain is with BA Electronics and Ray Ashmore is with SOS.
The AF Function Generator described in Elektor Electronics, December 1984, has generated a lot of interest, which is mainly due to the instrument being versatile, relatively simple to construct, and sufficiently accurate for a great many applications. The preset extension proposed here is a separately housed, 10-way programmable ancillary intended to drive the generator's VCO input. Frequencies that are often used for test and measurement purposes can be called up at the flick of a switch, and there is also a facility to successively select all ten of them at variable speed, providing a 10-frequency sweep function. Furthermore, the extension provides an output signal to trigger an oscilloscope with any one of the ten available frequencies.

Ease of control is the key word in this design. Once you have set the ten generator output frequencies with the aid of multturn preset potentiometers, you can select manual operation on the extension and press the single-step key until the relevant frequency is enabled, as indicated by the associated LED. If the manual/auto switch is in the auto position, the VCO voltages are successively output at a rate defined with the speed potentiometer and the fast/slow push-button selector. A BCD (thumwheel) switch is used to select the period of one of the 10 available VCO voltages for triggering an oscilloscope.

Standard components are used throughout this extension, which will quickly prove an indispensable add-on unit that can save you quite some time in setting the generator's output frequency.

Circuit description

The circuit diagram of the proposed extension is shown in Fig.1. At the lower left is the power supply, which delivers +5 V for the logic circuits, and +10 V for the sweep oscillator, IC4, and the VCO output drivers, Tr1-Tr3. The latter voltage is provided by a precision regulator Type LM317 (IC12) to ensure the stability of the ten VCO drive levels. The +5 V supply is conventionally based on a Type 7805 regulator which can easily handle the 150 mA current demand of the LSTTL circuits.

With Si set to man., depression of single push-button Si causes Ni and delay network R11-C Ci to provide a trigger pulse to the B input of monostable multivibrator IC1, whose output period is defined with R12-C2. As Si is open, the pulse at output Q of IC1 is passed through gates N12 and N13 and led to the clock input of counter IC3.

If Si is in the auto position, Ni blocks the single-step pulses from IC1, and IC4 is arranged to be clocked from oscillator IC2 via level translator Tr5. Potentiometer P1, and fast/slow push-button S5 allow precise setting of the VCO sweep speed. Note that S5 is actually part of the speed potentiometer, so that turning this fully counter-clockwise automatically enables manual selection of the direct voltage level from the preset extension, and hence of the function generator's output frequency.

Counter IC2 is advanced by pulses from N4, and the BCD code at its Q6-Q0 outputs is applied to the XOR gates in IC3, as well as to BCD-to-decimal decoder IC5. The Type 74LS00 counter is set up to count from 0 to 9, and is reset to state 0 at power-on with the aid of C1-Ri.

The trigger signal for the oscilloscope is obtained from N4-N6 and N9-N14, which function as a 4-bit comparator in conjunction with IC7 and a BCD switch for selection of the relevant trigger pulse. The output of N14 goes high if the logic state of outputs Q6-Q0 on IC7 matches that of the A-D lines on the BCD switch.

Any one of the 10 outputs of decoder IC8 can enable an associated driver stage, whose direct output voltage is defined with a multturn preset. If, for instance, output 9 of IC7 goes low, the output of open-collector inverter N14 goes high. Transistor Tr6 is turned on, LED D1 lights, and a portion of the emitter voltage is fed to the VCO input of the function generator, via the wiper of P1 and summing diode D10. The circuit around Tr6 serves to raise the ground potential of the extension so as to increase the active range of the presets in the analogue output stages. It should be noted that this arrangement makes it impossible to feed the preset extension from the generator's output.
supply. Also, observe that the pulse level at the sync out terminal is 5 Vpp with respect to the extension ground potential, not that of the function generator. LED D11 serves the double purpose of raising the base potential of T11 and functioning as the on/off indicator of the preset extension.

Construction and setting up
The proposed extension circuit is readily built on a piece of Veroboard and housed in an ABS enclosure that can be placed on top of the function generator or the associated sweep generator. Although not shown in the circuit diagram, the supply lines to the logic circuits should be decoupled with 100n capacitors. Keep the wires to the switches and the speed potentiometer as short as possible. The frequency indication LEDs can be fitted in a neat row on the front panel, complete with numbers 1-10 for easy reference.

After building the circuit, it is suggested to adjust the output voltage of IC12. Use a DMM and set P2 for a reading of 10.00 V. Turn P1 to MAN and check whether operation of S4 causes the LEDs to light in succession. Turn P1 to AUTO and check whether the sweep speed can be adjusted with P1 and S1. If necessary, adapt C6 or C8 to define the sweep speed. Turn P1 back to MAN and use a DC-coupled oscilloscope to see whether the VCO voltages are all stable and free from digital noise and ripple.

Finally, connect the extension to the VCO input on the function generator, and adjust the 10 presets for the test frequencies you require.

An analysis by Siegfried Linkwitz in the January 1976 issue of the Journal of the Audio Engineering Society shows that conventional cross-over filters have a negative effect on the radiation pattern of a multi-way loudspeaker system, as regards both directivity and amplitude. On the basis of his research, Linkwitz proposed a new type of network that gives a uniform radiation pattern and constant amplitude. This filter, which is essentially a Butterworth-derived type, was first described by Riley and is, therefore, sometimes referred to as a Linkwitz-Riley network.

For simplicity's sake, the following discussion is based on a two-way loudspeaker system. For optimum results, Linkwitz suggested that the filter must meet three requirements:

1. There must be no phase shift between the outputs of the loudspeakers at the relevant cross-over frequency to prevent an upward or downward displacement of the radiation pattern.
2. The signal attenuation at each filter output must be 6 dB instead of the usual 3 dB to prevent peaks in the sums of the signals.
3. The phase shift between the output signals must be constant at all frequencies to retain the symmetry of the radiation pattern above and below the cross-over frequency; this condition is conveniently met by the use of symmetrical filters in both the low-pass and the high-pass sections.

Linkwitz found that these requirements can be met by cascading two identical second-order Butterworth filters. Higher-order types may, of course, be used, but in practical applications these are less interesting. It should be noted that in any case the filter must be an even-order type, since each order causes a phase shift of 45° at the cross-over frequency.

Fig. 1 shows the amplitude and phase shift behaviour of a Butterworth filter, and Fig. 2 those of a Linkwitz-Riley network. Note the 3 dB peak of the Butterworth filter. This cannot be avoided by increasing the separation of the cross-over frequencies of the low- and high-pass sections, because this would violate the first requirement of zero phase shift between the outputs. For clarity's sake, the two characteristics are combined in Fig. 3 to highlight the difference between them.

Fig. 1. Butterworth network: amplitude and phase characteristics over the audio frequency range. The fat line represents the sum of the outputs of the filters.

Fig. 2. Linkwitz network: amplitude and phase characteristics over the audio frequency range. The fat line represents the sum of the outputs of the filter sections.

Fig. 3. Butterworth and Linkwitz characteristics combined to highlight their differences. The networks used had a slope of 24 dB per octave.

The Linkwitz curve is rather more rounded in the vicinity of the cross-over frequency, and starts falling off somewhat earlier. The slightly different phase shift of the two filters should also be noted.

The foregoing discussion is true only if the signals are sinusoidal. The pulse (or step) response of the Linkwitz filter causes the same problems as that of a Butterworth filter, assuming that both filters have separate low- and high-pass sections. Even a Linkwitz filter is therefore not perfect.

A practical filter

A Linkwitz filter may be designed as a passive or as an active type. The circuit diagram of an active design is shown in Fig. 4; this may be constructed on the printed-circuit board shown in Fig. 5. Note that this board is identical to that used for the electronic cross-over network published in the September 1984 issue of Elektor Electronics.

The circuit of Fig. 4 is for a three-way loudspeaker system. The network has cross-over frequencies of 500 Hz and 5,000 Hz and roll-offs of 24 dB per octave. Stage A1 serves as a buffer for the input signal, before this is split three-way. The low-pass section is formed by A2 and A5, the middle-frequency section by A3 and A6 (high) and A4 and A7 (low), and the high-pass section by A8 and A9. Each section is provided with a potentiometer for setting the level of the output signal (P1, P2, and P3 respectively), and a stage to buffer the output (A2, A3, and A4 respectively). The power supply lines are stabilized by voltage regulators IC7 and IC8. The cross-over frequencies may be altered with the aid of Table 1 (any frequency) or Table 2 (the 17 most likely frequencies). The values in Table 2 have deliberately not been rounded off to the nearest
The sections may also be given a slope of 12 dB per octave by using $A_5$, $A_6$, $A_7$, and $A_8$ as buffers. Resistors $R_6$, $R_7$, $R_8$, and $R_9$, as well as capacitors $C_{12}$, $C_{13}$, $C_{14}$, and $C_{15}$, are then replaced by wire links, while $R_1$, $R_2$, $R_3$, $R_4$, $C_{16}$, $C_{17}$, $C_{18}$, and $C_{19}$ are omitted.

The circuit may be adapted for use with a two-way system by the omission of the entire middle-frequency section, except for $A_9$ which is housed in the same package as $A_5$. If the slope is changed to 12 dB per octave, the connections to one of the loudspeakers must be reversed, because the phase shift at the cross-over frequency is 180° here. In a three-way system, this should be done at the middle-frequency speaker, in a two-way system at the tweeter.

A passive filter may be constructed as shown in Fig. 6. The values of the actual components used should be as close as possible to the calculated ones, otherwise the filter will become a cross between a Linkwitz and a Butterworth standard E12 or E24 value.
type. If the filters are given a 12 dB per octave slope, the con-
nexions to the middle-frequency loudspeaker (in a three-
way system) or those to the tweeter (in a two-way system) should be reversed.

The loudspeaker impedance must be corrected in a manner that ensures that it is constant and ohmic at the cross-over fre-
quency. The corrected im-

Table 1

<table>
<thead>
<tr>
<th>Low-pass section 12 dB/octave</th>
<th>Low-pass section 24 dB/octave</th>
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</thead>
<tbody>
<tr>
<td>C_A = C_0/2zfr</td>
<td>C_A = C_0/2zfr</td>
</tr>
<tr>
<td>R = 4.7_10 kΩ</td>
<td>R = 4.7_10 kΩ</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>High-pass section 12 dB/octave</th>
<th>High-pass section 24 dB/octave</th>
</tr>
</thead>
<tbody>
<tr>
<td>R_A = R_0 = 1/2zfrC</td>
<td>R_A = R_0 = 1/2zfrC</td>
</tr>
<tr>
<td>C = 4.7_10 nF</td>
<td>C = 4.7_10 nF</td>
</tr>
</tbody>
</table>

Table 2

<table>
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<tr>
<th>Low-pass 12 dB/octave</th>
<th>Low-pass 24 dB/octave</th>
<th>High-pass 12 dB/octave</th>
<th>High-pass 24 dB/octave</th>
</tr>
</thead>
<tbody>
<tr>
<td>R = 5kΩ</td>
<td>R = 5kΩ</td>
<td>C = 4nF</td>
<td>C = 4nF</td>
</tr>
<tr>
<td>f (Hz)</td>
<td>C_A = C_0 [nF]</td>
<td>f (Hz)</td>
<td>C_A = C_0 [nF]</td>
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<td>142</td>
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<td>5.02</td>
</tr>
<tr>
<td>5,000</td>
<td>5.88</td>
<td>5,000</td>
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<tr>
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<td>2.01</td>
</tr>
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A multi-standard fax converter that is easy to build and set up, for reliable use in conjunction with any good quality SW receiver, a BBC or C64 computer, and an Epson compatible printer.

Facsimile—or fax for short—is a communication technique whereby graphic information is converted into electrical signals for transmission to a receiver which, ideally, reproduces a hard copy printout of the original. Facsimile stations can be received on the short-wave bands, and are intended primarily for the transmission of weather charts (meteorological services), press photographs, and handwritten messages.

A facsimile receiver is traditionally a rather complex electromechanical apparatus which does not lend itself to DIY construction. Numerous radio amateurs, however, are the proud owners of Creed, Muirhead, or Siemens facsimile chassis obtained from surplus outlets at a fraction of the original price. These machines are not generally difficult to modify for amateur use, but remain fairly cumbersome to handle devices when compared with the more recently introduced computer-based versions.

The electromechanical facsimile receiver is generally based on the recording of the received image either on electrolytic or on photosensitive paper, secured on the outer surface of a revolving drum. When electrolytic paper is used, intensity-modulated current is fed to a metal stylus which transfers the image onto the paper. The photosensitive method is essentially identical, but uses a combination of a lamp, an aperture, and a lens to illuminate the spots that make up the received picture. The intensity of the light beam, or the current fed to the stylus, determines the density of the individual pixels, giving the necessary picture definition. Facsimile signals are mostly transmitted as a frequency shift keying signal (FSK; denotation F4), similar to cassette-based data storage and retrieval available on many home computers. The centre frequency is usually 1800 Hz, and white and black correspond to a frequency shift of +400 Hz and -400 Hz, respectively. At the receiver side, a sheet of paper is secured onto a drum with a standard diameter of 152 mm and a minimum length of 550 mm. A worm drive and clutch assembly are used in conjunction with a precision electric motor to make the drum revolve at 120 revolutions per minute. Prior to the reception of a new picture, the system is synchronized with the aid of a number of black lines with an initial white period, as will be seen below.

After every complete revolution of the drum, this is arranged to move laterally for the recording of the next vertical track. Apart from 120 rev/min stations, there are also services that operate at other multiples of 60, e.g., 60 rev/min and 240 rev/min. By convention, a fax station is, therefore, often referred to as a 1, 2, or 4 Hz service. The size of the picture elements recorded on paper is usually of the order of 0.1 to 0.2 mm, whence the use of precision-made mechanical parts in fax machines.

The facsimile picture shown in Fig. 1 is purposely printed as it would have been positioned on the scanning drum of a conventional, electromechanical fax machine. The writing of the weather chart proper commences on completion of a number of drum revolutions during which the black lines with initial white portions are written—see the black bar with the white block in the top left-hand corner of the picture. The correct horizontal aspect of the picture as it is written onto the paper is ensured only when the transmitter and the receiver operate at the same, or very nearly the same, clock frequency. If the receiver clock operates at a fixed offset with respect to that used in the transmitter, vertical lines will appear to slant, causing the picture to become confused and distorted.

The interface proposed in this article is based on the use of a computer and a graphics-compatible printer to produce facsimile pictures. Pixel data is read and loaded into a RAM buffer on reception of a “drum advance” pulse (or rather line feed in the electronic version), which is derived from the interface clock. Eight fax lines are loaded to form a string of data that can be printed horizontally by a printer set to operate in the dot image mode.
The circuit is versatile—it can handle signals from 1, 2 and 4 Hz stations—as well as simple to construct from commonly available parts.

**Circuit description**

Figure 2 shows the circuit diagram of the interface, which translates the fax signal from an SSB receiver into pulses that can be processed in a computer system.

**Timebase.**

The central clock signal is obtained with crystal-controlled oscillator/divider IC1 and the modulo-10 dividers in IC2. Switch section S1 selects the signal from IC1 output Qs (102,400 Hz), Q4 (204,800 Hz), or Q4 (409,600 Hz) for proper synchronization with 1 Hz, 2 Hz, or 4 Hz stations, respectively. The signal at the pole is divided by 100 in IC2, and made suitable for recording as a sync track on a tape or cassette recorder with

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Fig. 1. Example of a weather chart taken from the drum of a facsimile receiver.

Fig. 2. Circuit diagram of the facsimile interface.
the aid of network Rz-Cza. Whether the system sync pulses originate from the internal clock, or from the cassette REPLAY interface set up around Tz, they can be "speeded up" or "slowed down" by pressing S0 or S1, respectively. When S1 is closed, N3 receives an additional clock signal from the oscillator based around N2-N1. As N3 is an XOR gate, its output frequency is then higher than that of the system clock, and hence IC3 is clocked at a higher rate, causing the LINE SYNC pulse to come sooner than normal. Therefore, the pressing of S1 forces the picture to shift to the left; this is useful when tuning in to a picture whose sync bar has already been transmitted. The amount of correction can be set with P2. When S0 is closed, T3 temporarily connects the inputs of XOR gate N3, so that clock pulses from N3 can not advance counter IC3. Hence, the LINE SYNC pulse from MMV is delayed, causing the picture to shift to the right. Preset P2 controls the amount of rightward correction.

Depending on the position of S0, either the sync pulses from the REPLAY interface, or those from the internal clock section, trigger monostable multivibrator MMV, which outputs the PIXEL SYNC pulses that have a period determined with R31-C24. The PIXEL SYNC signal is used to flag the presence of valid pixel data for the com-

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**Parts list**

Resistors (±5%):

- R1 = 100k
- R2 = 1k
- R3, R10 = 2.2k
- R1, R30 = 47k
- R11 = 5k
- R12 = 680k
- R13 = 1M
- R14 = 2.2k
- R15 = 10M

Capacitors:

- C1 = 10n ceramic
- C2 = 68n
- C3, C10 = 100n
- C4 = 10µ
- C6 = 100p ceramic
- C7 = 68p trimmer
- C8 = 22n

Inductors:

- L1 = SM10-603 (4615) 68 mH variable inductor

Semiconductors:

- D0, D1, D2 = 1N4148
- IC1, IC2 = 4060
- IC3 = 4538
- IC4 = 4047
- IC5 = 4013
- IC6 = TL084
- IC7 = TL084
- IC8 = 4026
- IC9 = 4074

Miscellaneous:

- S1 = 2-pole 3-way rotary switch
- S2 = miniature DPDT switch
- K0 = 1.5mm socket for jack plug
- K1 = 4-way DIN socket

Note: the stated sockets are suggested types.

Suitable metal enclosure.

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Fig. 3. Track layout and component mounting plan for the FAX interface.
puter to read from the PBO line. This ensures the correct compilation of pixel data for the printing of one 8-bit wide line on the printer.

**Automatic synchronization circuit.**

The RESET input of counter IC3 is driven with a signal obtained from an automatic sync generator composed of IC14, N4, FF, & FF1, IC1, and N-W. Depression of S forces resetting of IC1 to generate a LINE SYNC pulse when the transmission of the picture commences; after some practising, you will be able to hear when this happens by carefully listening to the receiver’s AF signal. When S is open, the circuit detects the prolonged absence of pixel data during the writing of the black vertical lines to the left of every picture. The white interruption at the beginning of every black track, however, is recognized as the absence of pixel data during 32 clock pulses. For the auto-sync circuit to produce a LF pulse, it must detect 32 successive white pixels. i.e., noise and spurious pulses can not cause erroneous synchronization.

**Tone decoder.**

The fax signal from the SSB (single side band) receiver, or the cassette recorder, is applied to quadrature FM demodulator ICs, the well-known Type TBA1206. This demodulator is tuned to a centre frequency of 1900 Hz with C1 and variable inductor L1. The raw fax signal from the demodulator is cleaned and shaped with the aid of a 47 n capacitor, C12, and active low-pass filter A2, set up as a second-order Butterworth section. Besides faithfully removing noise and spurious signals from the facsimile information, the active filter has an additional advantage in that it produces a certain amount of overshoot that is useful for raising the contrast level of the needle-shaped pulses. Opamp A3 is a simple amplifier with presettable gain, and A4 is the pulse shaper that decides between the black and white signal levels. The pixelfax data for the computer port line is output by level translator T1. A power supply is not included in this design, but we are confident that the omission will not present insurmountable problems. A suitable supply can be a very conventional circuit set up to deliver 12 V and 5 V at output currents of the order of several tens of milli-amperes, a Type 7812 and 7805 voltage regulator fed from a common mains transformer will do adequately in this case, while you may also consider taking the +5 V and +12 V from the computer’s built-in supply, as suggested in the circuit diagram.

**Construction and setting up**

The use of ready-made circuit board Type 87058 makes the construction of this fax interface largely a matter of routine; simply fit all the parts as shown in Fig. 3. There are no special precautions for the completion of the interface board, as this holds standard components only. However do not forget to install all eight wire links on the board, as these are easily overlooked due to the white overlay lines that indicate the position. Fit the interface board in a metal enclosure and use whatever sockets and明晰 plugs you think suitable for the connections to the receiver and the computer. For the setting up of the interface you need a good quality SSB receiver tuned to a strong facsimile station. Alternatively, you may find the use of recorded data available from cassette more convenient; drive the interface from the cassette recorder’s external loudspeaker or earphone output by connecting this to K1. Later on, you will be able to use K1 for recording and playing back of the data and sync, recorded separately on the left and right track of the tape. Set P1 and P2 to the centre of their travel, and P3 for minimum amplification (wiper turned fully towards P4). Presets P1 and P2 are adjusted to personal preference, and can be set to mid-travel initially. Trimmer capacitor C11 is adjusted until the vertical lines on the hard copy page run straight; a slanting line indicates that the clock frequency needs further adjustment. For a precise setting of the demodulator centre frequency, apply a 1800 Hz sinewave to the interface, and measure the direct voltage at the output of A1. Turn the core in L1 to find the adjustments that give a maximum and a minimum value on the voltmeter, then carefully turn the core back to obtain a reading that lies exactly in between the previously noted extremes. Now adjust P1 and P2 to set the extremes to 4 and 8 V, and redo the adjustment of L1.

**At the computer side**

Machine language routines have been developed to enable the use of the fax interface with either a BBC or C64 computer. The programs essentially accumulate data in a buffer and redirect this to the printer. The connection to the BBC computer is extremely straightforward by making use of the built-in user port. The Com-
Table 2. Facsimile decoding program for the C64 computer (not suitable for 4 Hz stations).

```
10 PRINT "This program cannot be interrupted with":
20 PRINT "the ADF of the C64 keyboard.",
30 PRINT "If print mode is not selected the program will halt after one line.",
40 PRINT "Press ADF to return control to BASIC.",
50 PRINT "If print mode is active the printer is offline.",
60 PRINT "If print mode is not selected the program will halt after one line.",
70 PRINT "Press ADF to return control to BASIC.",
80 PRINT "If print mode is active the printer is offline.",
90 PRINT "If print mode is not selected the program will halt after one line.",
100 PRINT "Press ADF to return control to BASIC.",
110 PRINT "If print mode is active the printer is offline.",
120 PRINT "If print mode is not selected the program will halt after one line.",
130 PRINT "Press ADF to return control to BASIC.",
140 PRINT "If print mode is active the printer is offline.",
150 PRINT "If print mode is not selected the program will halt after one line.",
160 PRINT "Press ADF to return control to BASIC.",
170 PRINT "If print mode is active the printer is offline.",
180 PRINT "If print mode is not selected the program will halt after one line.",
190 PRINT "Press ADF to return control to BASIC.",
200 PRINT "If print mode is active the printer is offline.",
210 PRINT "If print mode is not selected the program will halt after one line.",
220 PRINT "Press ADF to return control to BASIC.",
230 PRINT "If print mode is active the printer is offline.",
240 PRINT "If print mode is not selected the program will halt after one line.",
250 PRINT "Press ADF to return control to BASIC.",
260 PRINT "If print mode is active the printer is offline.",
270 PRINT "If print mode is not selected the program will halt after one line.",
280 PRINT "Press ADF to return control to BASIC.",
290 PRINT "If print mode is active the printer is offline.",
300 PRINT "If print mode is not selected the program will halt after one line.",
310 PRINT "Press ADF to return control to BASIC.",
320 PRINT "If print mode is active the printer is offline.",
330 PRINT "If print mode is not selected the program will halt after one line.",
340 PRINT "Press ADF to return control to BASIC.",
350 PRINT "If print mode is active the printer is offline.",
360 PRINT "If print mode is not selected the program will halt after one line.",
370 PRINT "Press ADF to return control to BASIC.",
380 PRINT "If print mode is active the printer is offline.",
390 PRINT "If print mode is not selected the program will halt after one line.",
400 PRINT "Press ADF to return control to BASIC.",
410 PRINT "If print mode is active the printer is offline.",
420 PRINT "If print mode is not selected the program will halt after one line.",
430 PRINT "Press ADF to return control to BASIC.",
440 PRINT "If print mode is active the printer is offline.",
450 PRINT "If print mode is not selected the program will halt after one line.",
460 PRINT "Press ADF to return control to BASIC.",
470 PRINT "If print mode is active the printer is offline.",
480 PRINT "If print mode is not selected the program will halt after one line.",
490 PRINT "Press ADF to return control to BASIC.",
500 PRINT "If print mode is active the printer is offline.",
510 PRINT "If print mode is not selected the program will halt after one line.",
520 PRINT "Press ADF to return control to BASIC.",
530 PRINT "If print mode is active the printer is offline.",
540 PRINT "If print mode is not selected the program will halt after one line.",
550 PRINT "Press ADF to return control to BASIC.",
560 PRINT "If print mode is active the printer is offline.",
570 PRINT "If print mode is not selected the program will halt after one line.",
580 PRINT "Press ADF to return control to BASIC.",
590 PRINT "If print mode is active the printer is offline.",
600 PRINT "If print mode is not selected the program will halt after one line.",
610 PRINT "Press ADF to return control to BASIC.",
620 PRINT "If print mode is active the printer is offline.",
630 PRINT "If print mode is not selected the program will halt after one line.",
640 PRINT "Press ADF to return control to BASIC.",
650 PRINT "If print mode is active the printer is offline.",
660 PRINT "If print mode is not selected the program will halt after one line.",
670 PRINT "Press ADF to return control to BASIC.",
680 PRINT "If print mode is active the printer is offline.",
690 PRINT "If print mode is not selected the program will halt after one line.",
700 PRINT "Press ADF to return control to BASIC.",
710 PRINT "If print mode is active the printer is offline.",
720 PRINT "If print mode is not selected the program will halt after one line.",
730 PRINT "Press ADF to return control to BASIC.",
740 PRINT "If print mode is active the printer is offline.",
750 PRINT "If print mode is not selected the program will halt after one line.",
760 PRINT "Press ADF to return control to BASIC.",
770 PRINT "If print mode is active the printer is offline.",
780 PRINT "If print mode is not selected the program will halt after one line.",
790 PRINT "Press ADF to return control to BASIC.",
800 PRINT "If print mode is active the printer is offline.",
810 PRINT "If print mode is not selected the program will halt after one line.",
820 PRINT "Press ADF to return control to BASIC.",
830 PRINT "If print mode is active the printer is offline.",
840 PRINT "If print mode is not selected the program will halt after one line.",
850 PRINT "Press ADF to return control to BASIC.",
860 PRINT "If print mode is active the printer is offline.",
870 PRINT "If print mode is not selected the program will halt after one line.",
880 PRINT "Press ADF to return control to BASIC.",
890 PRINT "If print mode is active the printer is offline.",
900 PRINT "If print mode is not selected the program will halt after one line.",
910 PRINT "Press ADF to return control to BASIC.",
920 PRINT "If print mode is active the printer is offline.",
930 PRINT "If print mode is not selected the program will halt after one line.",
940 PRINT "Press ADF to return control to BASIC.",
950 PRINT "If print mode is active the printer is offline.",
960 PRINT "If print mode is not selected the program will halt after one line.",
970 PRINT "Press ADF to return control to BASIC.",
980 PRINT "If print mode is active the printer is offline.",
990 PRINT "If print mode is not selected the program will halt after one line.",
1000 PRINT "Press ADF to return control to BASIC.",
```

modore C64, however, requires an extension port interface as shown in Fig. 4. This circuit is so simple that it is readily constructed on a piece of prototyping board, connected to the computer by a short length of flat ribbon cable terminated with an expansion port connector.

The software for the BBC BASIC is an assembler-in-BASIC program listed in Table 1, while that for the C64 appears in Table 2 and makes use of machine language POKE’d into the memory and called up with a SYS command. Both programs can only be halted with a general system reset; on the BBC the program is automatically restarted with an OLD command, on the C64 it is erased from the memory, and must be reloaded from tape or disk. Reception of 4 Hz stations is not possible when the C64 computer is used.
Table 3. These are only a few of the dozens of FAX stations operating in the European part of Region 1.

Table 3

<table>
<thead>
<tr>
<th>Frequency (kHz)</th>
<th>Callsign</th>
<th>Operating hours (GMT)</th>
<th>Mode</th>
<th>Note(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2818.5</td>
<td>GFE 25</td>
<td>21.00</td>
<td>WX</td>
<td></td>
</tr>
<tr>
<td>3289.5</td>
<td>GFA 21</td>
<td>00.00-24.00</td>
<td>WX</td>
<td>APT 09.00-12.00</td>
</tr>
<tr>
<td>4510.0</td>
<td>GFE 21</td>
<td>18.00</td>
<td>WX</td>
<td>GFA 21 slave</td>
</tr>
<tr>
<td>4782.0</td>
<td>GFE 21</td>
<td>00.00-24.00</td>
<td>WX</td>
<td>APT 09.00-12.00</td>
</tr>
<tr>
<td>117.4</td>
<td>DCF 37</td>
<td>00.00-24.00</td>
<td>WX</td>
<td>WX</td>
</tr>
<tr>
<td>134.2</td>
<td>DCF 54</td>
<td>00.00-24.00</td>
<td>WX/MET</td>
<td>WX</td>
</tr>
<tr>
<td>8185.0</td>
<td>FZE 82</td>
<td>00.00-24.00</td>
<td>WX</td>
<td>FZE 82 slave</td>
</tr>
<tr>
<td>12305.0</td>
<td>DCF 39</td>
<td>10.00-22.00</td>
<td>WX</td>
<td>PIX</td>
</tr>
<tr>
<td>5350.0</td>
<td>RND 77,</td>
<td>18.00-24.00</td>
<td>WX</td>
<td>WX</td>
</tr>
<tr>
<td>7760.0</td>
<td>RAW 78</td>
<td>16.00-23.00</td>
<td>WX</td>
<td>WX</td>
</tr>
<tr>
<td>15980.0</td>
<td>RBI 77</td>
<td>10.00-21.00</td>
<td>WX</td>
<td>WX</td>
</tr>
<tr>
<td>139.0</td>
<td>DCF 39</td>
<td>10.00-22.00</td>
<td>WX</td>
<td>PIX</td>
</tr>
<tr>
<td>WX = weather chart transmissions</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MET = METEOSAT occlusion charts</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PIX = photofax service</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>APT = automatic picture transmission</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Getting started with fax

When you have completed the interface, aligned it, and have keyed in the software, it is time to see what the whole set-up is capable of doing. As already stated, you need a SSB receiver to pick up the signals from amateur and professional fax stations. This receiver should have a reliable BFO (beat frequency oscillator) to enable precise tuning to the often weak signals. After a while, you will be able to unhesitatingly select the typical buzz-saw-like fax signals from the loud hubbub that generally exists on the overcrowded short-wave bands.

Table 3 lists a number of facsimile services that can be received throughout Europe. There are many more stations in operation, but these are generally run at relatively low output power and intended for very specific use only.

The use of the BFO in conjunction with the proposed interface requires some practising to develop a feeling for obtaining the best definition of the received pictures, and this also goes for the operating of correction controls $S_3$ and $S_5$. The best way to gain experience in fax reception is to make recordings of both weak and clear transmissions, and play these back into the interface, so that a signal is constantly available without the need to re-tune the receiver if a service signs off just when you intend to make the final adjustment...
WHERE ELECTRONIC MESSAGES HAVE THE EDGE

by Barry Fox

The new age of information technology is founded on one simple truth. It is quicker, easier, and cheaper to send pulses of electricity down a telephone wire or over a satellite link than it is to transport people or packages by road, sea or air. The Telex service has until now been the standard means of sending text. Telex is a reliable warhorse but has its own snags. The equipment has been reliable and expensive, but many skilled operators are needed to send messages, and the service relies on dedicated lines — that is to say, special circuits designed to carry telex pulses rather than speech.

It is still not widely recognized that almost every personal computer, either desktop or portable, can be used for electronic mail through one of the available services. It is the modern alternative to sending correspondence by telex. Text is sent from one computer to another along a conventional telephone line via a central message-handling computer. Already script writers, translators, bankers, journalists, and lawyers are using electronic mail to send text from home to office. Sales teams use it to keep in touch with their headquarters while moving round the country. Musicians use it while on tour. Electronic mail terminals can work equally well from an office desk or a hotel room far away.

Digital pulses

In its simplest form, a home computer sends messages either to the screen or to a printer. If it is programmed with additional communications software, it can send similar messages from its output — usually on RS-232 — socket. This output is in the form of a stream of digital pulses, similar to telex, but much faster. They can be sent down a short wire cable to a matching computer system. This is how several computers are networked in an office. The pulses will not travel reliably down a conventional telephone line so they must first be converted into audible tones which the telephone network handles like speech.

A special device called a modem — short for modulator/demodulator — is needed to convert the computer pulses into sound tones. It is connected between the computer output and the telephone line socket, while a computer at the other end of the telephone line has a matching modem.

This converts incoming tones back into digital pulses which are then displayed on the computer screen or printed on to paper.

Four services

Electronic mail provides a mail-box system into which messages can be dropped by one user to be picked up later by another. A host computer handles the messages with a system of passwords to ensure that messages can only be picked up by the people to whom they are addressed.

In Britain there are four electronic mail services. The most successful so far is Telecom Gold which is run by British Telecom and has around 30,000 subscribers. Rival services are offered by Easylink—a subsidiary of Cable and Wireless; Comet from Istel—a subsidiary of British Leyland; and One-to-One—a private company now owned by United States Telecom's company Telesis. Each of these services offers a message drop facility.

When someone working from home or a hotel room wants to contact an office, he or she calls the relevant electronic mail telephone number and sends a message which is held in a message service computer. Later, the person at the office calls the same electronic mail number and reads the message off the computer. The text can be viewed on screen, stored on magnetic disk for subsequent word processing, or printed direct on to paper as a telex.

Any office wanting to use electronic mail should first find out what services are on offer. The Telecom Gold service in Britain is derived from the ITT Dialcom system developed in the United States of America. It is now used in over a dozen countries around the world, and is proving increasingly popular.

How to buy

Most businesses that decide to install an electronic mail system will find it cheaper in the long run to buy the hardware and software through a dealer whose purchase price includes the cost of installing the equipment, getting it up and running, and teaching the staff how to use it. Once a system has been installed, staff may very soon wonder how they ever lived without it.
Radio Wave Propagation (HF bands)
by F C Judd G2BCX
Soft cover
146 pages — 215 x 137 mm
Price: £8.95
This new book will be appreciated by short wave listeners and radio amateurs for its detailed discussion of the numerous aspects of an ever fascinating subject, radio wave propagation.
The author, F C Judd, is well known among the radio amateur fraternity for his publications covering the design and construction of aerials.
The book starts with an historic account of the discoveries made in the field of experimental propagation research, with special attention to the work of E V Appleton. Then follows a general discussion of the physical aspects of ionisation, refraction, the conditions of the weather and the ionosphere, diffraction, and echo times. On this is based the definition of the various layers that are now known to constitute the ionosphere, each with its particular behaviour for radio waves. This section of the book, like the ones to follow, is copiously illustrated with graphs, charts, and oscillograms to aid in making the discussed subject as lucid as possible.
The chapters on the eleven-year solar cycle and ionospheric anomalies present a well-founded argument in favour of the need for observation and subsequent interpretation of the effects these phenomena have on worldwide radio contacts.
In the chapter on ionospheric radar systems the author tackles as subject that is still full of mystery to many. There are good introductions into the workings of OTHR (over the horizon radar), both as employed by the American and Russian military authorities. Especially the section on the notorious Woodpecker, the powerful, Ukraine-based wide-band radar, unravels some of the system's technical properties by means of a close analysis of the pulse structure.
The chapter on the function of the transmitting aerial provides sound advice for radio amateurs on how to dimension a particular aerial system for optimum directivity, which, in the context of short-wave propagation, is quite different from the methods that apply to VHF and UHF aerial design. With the aid of a number of well-detailed graphs, the author shows beyond doubt that the aerial radiation pattern can be tailored to obtain an illumination area in a specific ionospheric layer, with an aim to use this for its propagation characteristics.
All the theory presented in the book is put to use in the last chapter on Fregun propagation data. There are tables, graphs, and questions and answers to demonstrate how radio amateurs can utilise this ionospheric region for best DX. In conclusion, the book is an indispensable aid in understanding the mechanisms of radio wave propagation, and deserves a place on any radio amateur's bookshelf.
William Heinemann Limited
10 Upper Grosvenor Street
London W1X 9PA

The Slow Scan Companion
by C G Dixon GC6GK, J Wood GS3YC and M Wooding G6IQM
100 pages
Price £3.50 (Soft cover)
Slow scan television (SSTV) is essentially a method to transmit pictures at a bandwidth that is greatly reduced with respect to the normal television broadcast service. Throughout the years, radio amateurs have worked on improving a technique that would enable them to send and receive pictures world-wide, i.e., farther than would be possible when working with wide-band television on 70 centi-metres and up. There are now numerous radio amateurs all over the world who delight in receiving and transmitting SSTV images, and this new book will be hailed by them as a comprehensive study of general aspects as well as up to date practical designs of SSTV equipment.
The writers have included a section on commercially available SSTV equipment, and SSTV based on the use of various types of home computer, but have not forgotten those many enthusiasts who would like to build their own SSTV transceiver. These converters are state-of-the-art designs whose operation is put out in clearly written circuit descriptions, followed by constructional details and a suggested calibration procedure.
It is fair to say that the book covers all aspects of constructing SSTV equipment, from the complexity of the digital memory to the straightforward use of, say, an EHT power supply. Therefore readers of any level of proficiency in building electronic circuits will have no difficulty in finding suitable designs for the various building blocks that make up an SSTV receiver or a transmitter.

BATIC Publications
14 Lilac Avenue
Leicester LE5 1PN

Computer Engineer's Pocket Book
by Michael Tooley
ISBN 0 434 91967 5
Price: £8.95 (hard cover)
203 pages — 196 x 95 mm
This third in the series of recently published Newnes pocket books is a most welcome reference compendium of facts, figures, circuits, and data for designers, students, service engineers, and all those interested in computer and microprocessor systems.
To be able fully to exploit the potential of microprocessors and microcomputers, it is becoming increasingly necessary to abandon the old, and somewhat rigid, boundaries between hardware and software. Within industry, there is already a growing demand for software engineers. These crusaders of the information technology movement are not primarily programmers, nor are they exclusively electronic engineers. Their talents lie with the integration of software and hardware into functional and optimised systems.
The skills required of these individuals are difficult to define, but they centre on an awareness of, and familiarity with, electronic and microelectronic circuitry, coupled with a detailed knowledge of programming in either assembly language, or an appropriate high-level language. In addition, some knowledge of computer interfacing and communications is highly desirable.
Newnes Computer Engineer's Pocket Book aims to provide the sort of information such individuals require daily, but it is also of value to software and hardware specialists. A pocket compendium can never replace standard works or detailed specifications, but the present book covers a vast range of subjects at a practical level with some explanatory text in appropriate places. Once purchased, it will, no doubt, soon become as much a part of the student's or practising engineer's toolkit as his pocket calculator.
William Heinemann Ltd
10 Upper Grosvenor Street
London W1X 9PA
New catalogues

Catalogues listed here may not be free of charge, although many of them are. Furthermore, some businesses whose catalogue is included may deal with trade or professional customers only; where this is known, it will be indicated by "TRADE ONLY".

Electrovalue catalogue
With more pages (sixty), more items, more illustrations, Electrovalue's latest catalogue is their best yet. This catalogue (Spring issue) with its attractive green and black cover is now even easier to refer to, particularly when it comes to finding the transistors you want out of the hundreds listed. The same is true of the seemingly endless numbers of other items sought by anyone interested in electronics today. Items range from spacers to computers, software, and optoelectronics; many are by Siemens whose components are world renowned for their quality and variety. Consistent with Electrovalue policy, this latest catalogue is free to whosoever would like to have one. Prices are quoted throughout and remain constant at least to publication of the next issue in about four months. You do not even need to stamp your envelope when writing for a free copy of this latest catalogue. Simply address your request to Electrovalue Ltd., FREEPOST, 28 St. Judes Road, Englefield Green, Egham, Surrey, TW20 8BR or phone Egham (0784) 3603 and it is sent you by return.

Greenweld catalogue
The 1987 Greenweld catalogue is a single source for an extensive range of electronic kits catering for all abilities: from the novice to the professional. It contains amplifiers, transmitters, receivers, power supplies, panel meters, timers, door bells, running lights, sound-to-light units, dimmers, and many more, together with an extensive range of computer interfaces that enable the most popular computers to be linked with the outside world.

Stetomike headsets
A new full-colour information pack on the British Approvals Board for Telecommunications approved Stetomike telephone headsets is available free on request from GN Danavox (Gt Britain) Ltd 1 Cheyune Walk Northampton NNI SPT Telephone: (0604) 36531

A 28-page booklet detailing the procedures a user needs to follow to use a BBC microcomputer via the GPIB interface so as to communicate with, and control, Solatron's 1250 Frequency Response Analyser, FRA, is available from Solartron Instruments Victoria Road Farnborough GU14 7PW Telephone: (0252) 544433

Imhof has just published a full colour catalogue covering its latest major product introduction, the Image case range. The Image case range consists of two product types, 19" Cases and Cased Cardframes, which have been designed to be aesthetically pleasing, versatile and functional. The 8-page catalogue gives full details of sizes and depths available, panel options, accessories, with complete technical specifications for the entire range, and is organised to make choice and ordering as easy as possible.

Imhof-Bedco
Ashley Works
Ashley Road
Uxbridge UB8 2SQ
Telephone: (0895) 37123

Verospeed's comprehensive new product catalogue has been expanded with over 800 additions to the existing 13,000 lines covering all product areas from electronics and computers to tools, cables and production equipment. Copies of the catalogue can be obtained free of charge from

Verospeed
Stansted Road
Boyat Wood Industrial Estate
Eastleigh SO5 4ZY
Telephone: (0703) 641111

National Semiconductor's line of surface mounting ICs is detailed in the 34-page brochure Surface Mount Product Availability Guide, which lists the most important data on each product. It includes analogue ICs, gate arrays, interface circuits, logic components, memory chips, microprocessors, and discrete transistors in SOT-23 and SO-8 packages.

National Semiconductor (UK) Ltd
301 Harpur Centre
Home Lane
Bedford MK40 1TR
Telephone: (0234) 47147
Resonant Ionisation Mass Spectroscopy (RIMS) is a unique, ultra-sensitive analytic technique which can detect down to the level of a few atoms. It is applicable to any sample, whether solid, liquid or gas and can be used to assay every element in the periodic table apart from helium and neon, as well as any stable or radioactive isotope. It is likely to find important applications in fundamental and applied physics, and to become a valuable tool in the semiconductor industry and in diagnostic medicine.

The need to develop new analytic ways to measure ultra-trace quantities of elements in various substances is becoming urgent in many branches of science, engineering and medicine. There are already many sensitive analytic techniques, including neutron or photon activation analysis, inductively coupled plasma spectroscopy, atomic absorption and various kinds of mass spectroscopy, particularly secondary-ion mass spectroscopy (SIMS). The sensitivity of these techniques for trace analysis is usually limited to the order of parts in $10^3$ or $10^4$.

In the last few years problems have arisen that require ultra-trace analysis at the previously unheard-of sensitivities of parts in $10^9$ to $10^{12}$ or even further. Already three areas which require such analysis have been identified and as techniques are developed many more applications are likely to become apparent.

Firstly, it is essential to reduce the minimum detection limit of impurities in silicon if improvement, especially in miniaturisation, of the semiconductor manufacturing process is to be maintained. Secondly, Professor M. Baxter of the Scottish Universities Research and Reactor Centre, near Glasgow, has speculated whether there is a health risk from the presence of very low-activity $\beta$ emitters in the environment. They are very difficult to monitor because they are likely to be below the sensitivity range of conventional nuclear counter techniques. Finally, the presence of trace amounts of certain elements in human body fluids and tissues is considered to be essential to health. This is a poorly understood branch of biochemistry and widely divergent figures for trace metal concentrations in apparently healthy people have been published. But there is growing evidence that many of the studies are flawed by gross analytic inaccuracies and that new, reliable techniques are necessary at sensitivity levels of parts in $10^9$.

During the middle and late 1970s the possibility of applying laser techniques of single-atom detection to ultra-trace analysis attracted interest. The technology had been pioneered largely by Professor V. S. Letokhov of the Academy of Sciences in Moscow and Professor G. S. Hurst of Oak Ridge National Laboratory, USA. Resonant Ionisation Spectroscopy, RIS as it has come to be known, can detect one atom of a specific type in a background of $10^{12}$ others in gaseous phase. The implications of this degree of sensitivity for many disparate fields of research are likely to be enormous.

Resonant Ionisation Spectroscopy
With the development of intense, tunable, pulsed lasers the simultaneous absorption of several photons by a single atom or molecule to produce a free electron and a positive ion became experimentally feasible. In the simplest RIS process, a pulsed laser is tuned precisely to the wavelength required to excite the atom or molecule from its ground state of energy to an excited state that is unique to the element under study. A second photon, of the same wavelength and from the same laser pulse, interacts with the atom in its excited state and causes an electron to be released from it, thereby creating a positive ion. This process can be made more selective by adding further resonant steps in the excitation process, using a second laser tuned to another frequency. Five different laser schemes, represented in the first illustration, can ionise all the elements in the periodic table, except helium and neon. From left to right in the diagram they are:

(a) $A(\omega_1e^{-})^+$. This reaction means that two photons of the same wavelength (that is, with angular velocity $\omega_1$) create the ion pair.

(b) $A(\omega_2e^{-})^+$. The laser wavelength is frequency doubled into the ultra-violet and then mixed with the fundamental to create the ion pair.

(c) $A(\omega_3e^{-})^+$. In this process three photons are absorbed with two colours being involved, indicated by $\omega_1$ and $\omega_2$.

(d) $A(\omega_1e^{-})^+$. One colour is frequency doubled ($2\omega_1$) and another photon of a second colour is absorbed as well as one of the original photons.

(e) $A(\omega_1, \omega_2)$. In this case usually three photons of the same colour are absorbed to create the ion pair.

The second diagram is the periodic table of elements with one of the five schemes being assigned to each, after Professor Hurst. In the early days of the technology, the electrons created in the resonance process were detected by ionisation or proportional counters. Soon, however, it became obvious the ultra-trace isotopic selectivity was needed, too, so mass spectrometers were introduced to detect the positive ions. Although both magnetic sector and quadrupole mass spectrometers have been used by different research groups, the arrangement preferred now includes a time-of-flight mass spectrometer.

Resonant Ionisation Mass Spectroscopy
When laser techniques are used to detect ultra-trace amounts of elements or isotopes in a substance or matrix, three separate steps are involved: a typical laser time-of-flight mass spectrometer is shown in the third illustration, indicating the steps. Firstly, a pulsed, charged, argon beam or a neutral argon beam, ablates or creates neutral atoms from the surface of the solid sample to be assayed. Ideally, the atom created should be accurately representative of the solid under analysis and to date argon ablation has been shown to be largely matrix-free. This technique is now considered to be superior to the laser ablation technique, which is a high-temperature method known to cause matrix problems because it favours the easily
Two of the severe limitations of lasers (30 sec) is a limitation.

For this purpose the desirable, technique. so a short analysis time is needed. It is

focusing of a 3-mm beam. It is

commercial lasers require modest facilities. Typical lasers of this kind operate with pulse lengths of several nanoseconds at repetition rates of some tens per second. The transverse spatial dimensions of the beam are typically a few millimetres. One of the strengths of RIS is that the photo-ionisation process can be made almost 100 per cent efficient, that is, it reaches saturation. By saturation of the RIS process, we mean that every atom of a quantum selected species which was in its ground state before being subjected to the photon field of a pulsed laser is converted to a positive ion and a free electron during the short duration of the laser pulse. Because saturation occurs when laser fluences, by which we mean energy per unit area, are typically about 100 mJ cm−2, conventional commercial lasers require modest focusing of a 3-mm beam. It is hoped that RIMS will become a routine ultra-precise analytic technique, so a short analysis time is desirable, of the order of minutes. For this purpose the low repetition rate of Nd:YAG lasers (30 sec−1) is a limitation.

Two of the severe limitations of conventional mass spectrometry can be eliminated when tuned lasers are used to produce the ions for mass analysis. In a conventional mass spectrometer the ions to be analysed are normally electron-impact ionised, so molecular interferences and isobaric effects cannot be avoided. A mass spectrometer cannot easily distinguish between CO and N2, for example. This is a phenomenon known as molecular interference. Nor can it distinguish between 46Ca, 39K and 40Ar because they are isotopes that have similar masses. These ambiguities are avoided when RIMS is used.

The final step of the RIMS tech-
niique is to count and measure the mass of the laser-induced ions, using a time-of-flight (TOF) mass spectrometer. A TOF instrument is a non-magnetic system in which the ions first accelerate through a series of closely spaced electrodes and then pass through a field-free region (D) of considerable dimensions, of the order of one metre, to be detected by an ion detector such as a channeltron. In its simplest form, the transit time (t) of the ion in the field-free region is proportional to the length of the field-free region and to the square root of the ion mass (m). For an accelerating voltage of 1000 V, with D equal to 1 m, t is about 20 μs for a singly ionised mass of 100 atomic mass units.

There are several advantages to be gained by using a TOF mass spectrometer: firstly, entire mass spectra can be accumulated in a very short time and an entire spectrum can be recorded for each laser pulse; secondly, TOF systems measure isotopic ratios very accurately, because they measure them under identical conditions; finally, the accuracy of a TOF spectrometer depends on electronic circuitry instead of extremely accurate mechanical alignment, so it is simpler to make. The time-honoured disadvantage of TOF instruments is low resolution due to the poorly defined spatial and temporal character of conventional ion formation. But that scarcely applies when the ions are formed by lasers, because the laser spot has a tight focus and the laser pulse is so short, between 5 and 10 ns.

In the last few years, a number of groups in the USA, the Soviet Union and Europe have been set up to exploit the sensitivity of RIMS. Already it is claimed that the technique is capable of detecting impurities at the level of 1 part in 10^16 in a routine analysis time of 5 minutes.

Future Development

The design of the RIMS instrument so far described is by no means optimised. A number of promising lines of research have yet to be investigated, which may lead to better sensitivity. Each of the three steps in the RIMS process will be considered, to see whether improvements are possible.

During the past few years, a great deal of attention has been paid to photon, electron and ion ablation of solids. At present, argon ablation of the sample is the most popular technique, though recent developments in metal ion beams such as those of gallium and caesium might increase the ion-sputtered yield per unit incident current. What is not in question is that these metal-ion beams can be focused to far smaller spots than an argon beam, down to submicron focal dimensions, so they are likely to be of great importance in future for precision scanning of sample surfaces. Over the next few years, it is improvement in the RIS step that is likely to contribute most to greater sensitivity. While an Nd:YAG pumped dye laser system has a repetition rate of 30 pulses s^-1, copper vapour lasers have recently been developed, in particular by Oxford Lasers (UK) which have a repetition rate of 6500 pulses s^-1, capable of pumping dye lasers to provide saturation intensities. This is likely to increase the efficiency of RIMS considerably, especially in detecting minute quantities of the actinides, recently demonstrated by Professor Kluge and Professor Trautmann of the University of Mainz. At present, however, there are electronic difficulties in handling data at such a large rate. The problems arise not having enough storage capacity and from the transfer rates of available high-speed transient recorders.

One possible improvement in sensitivity may be understood by considering the stepped photo-ionisation process in the final diagram. In (a) an electron in its ground state absorbs a photon and is promoted to an excited state with a cross-section above the ionisation level but to 10^-12 cm^-2. Another photon is absorbed and the excited atom is ionised. The photo-ionisation step is characterised by a small cross-section on a of 10^-11 to 10^-12 cm^-2 and therefore by a large laser fluence being needed to achieve saturation. The fluence is achieved by focusing, so that the volume of interaction with the ablation cloud is small. If, however, procedures (b) and (c) are adopted the probability of ionisation is greater by two or three orders of magnitude. In process (b) the atom is excited to close to the continuum (a Rydberg state) and then finaly ionised with high efficiency using a pulsed electric field.

Another possibility of improvement is shown in (c) where the ionisation step is to a so-called auto-ionisation state, above the ionisation level but having a large cross-section. Considerable research is necessary to identify the auto-ionisation states in a number of elements before this powerful procedure can be adopted. If processes (b) and (c) can be used then the saturation fluences of the laser are greatly reduced, so that the beam need not be focused. The volume of interaction is then bigger.

Future Applications

One exciting aspect of this technology is that there are likely to be important applications in both fundamental and applied physics. In connection with fundamental physics, applications of RIMS to solar neutrino experiments, double...
beta decay, baryon conservation and magnetic monopole searches as well as detection of quark atoms and superheavy atoms are being actively pursued. In particular, a detector based on the $^8\text{Br}$ ($\gamma$, e) $^\alpha\text{Kr}$ to measure the $^9\text{Be}$ neutrino source in the Sun has been shown to be feasible because the long-lived (2 x $10^5$ year) $^\alpha\text{Kr}$ can now be counted with RIMS. In applied and commercial science, the applications of RIMS are likely to be very far reaching. In the semiconductor and electronic industries RIMS can identify impurities that restrict performance of high-speed, high-density integrated circuits. The technique can extend downwards the present minimum detection limits for contaminants by perhaps three orders of magnitude or greater. In the medical field, early diagnosis of certain diseases by using trace-element concentrations in body tissues and fluids is a very attractive possibility but must be carried out in a non-invasive way by using as small quantities of material as possible. Finally, RIMS can assist in selecting sites for storing hazardous nuclear wastes by using ground-water dating techniques as well as allaying public concern by ensuring that environmental monitoring be made as sensitive as possible.

Continued from p. 30

VALVE PREAMPLIFIER — 2

Wiring the preamplifier
All the usual rules apply to the wiring of this preamplifier; make the mains and supply connections in relatively strong wire, and protect the ends with insulating sleeving to ensure optimum safety. The signal connections can be made in normal screened wire, or, if this is preferred, in RG58 coax. The noise suppression capacitors, as well as the 2M2 resistor and the varistor, are fitted direct onto the contacts of the double-pole mains switch. As shown in the wiring diagram, the lamp inside the mains switch is powered by the filament supply: this is so arranged to provide a visual indication of the power-up delay. The mains socket at the rear of the preamplifier enclosure is preferably a type with a built-in fuseholder. The amplifier is housed in a standard 19 inch enclosure with a height of 3 units (133 mm). A suitable type is the NME19105 from T.J.A Developments • Dept. EK • 53 Hartington Road • London E17 8AS. Finally, a suggested front panel layout is shown in Fig. 11, while the Type 86111-F foil can be used for the busboard fitted into a rectangular clearance in the rear panel of the enclosure.
The supporting software for the programmer is an EPROM-resident block of Z80 machine code that provides a deluxe menu, help pages, a built-in test routine, and, of course, EPROM status information plus error reports.

After last month’s discussion of the programmer hardware, we will now study the way it is actually controlled from the MSX computer. To begin with, however, we will briefly detail the workings of intelligent programming, already hinted at last month.

The intelligent programming algorithm
As the holding capacity of their EPROMs increases, it is logical for manufacturers to devise programming methods that enable loading these devices within an acceptable time. Should the "old" 50 ms per address programming method apply, say, to Type 27256 EPROM (32 K x 8), roughly half an hour would be needed for the device to be completely loaded. Intel, Fujitsu, National Semiconductor, and other leading EPROM manufacturers have, therefore, come up with various versions of an intelligent programming algorithm to speed up the loading process. As its name implies, this method relies on the use of a microprocessor, ruling out the possibility to use timers with a fixed output period for the generation of the programming pulses. The flowchart shown in Table 4 shows that the essence of the intelligent algorithm lies in the raising of Vcc from +5 V to +6 V, and the variable length of the programming cycle. This method-and-verify loop can only be left with the byte either correctly programmed, or still incorrect after a 25-pulse cycle. Therefore, with relatively few programming pulses required for a byte to verify correctly, the value of variable \( x \) is relatively low, and less time is needed for the address to be loaded.

Figure 8 illustrates that a programming cycle thus takes \((9 \times 1) + (3 \times 9) = 36 \text{ ms}\)

As could be expected, the number of programming pulses required to successfully load a byte into an EPROM address is affected by the pulse multiplication factor. National’s algorithm, however, is based on the use of 0.5 ms pulses, a maximum iteration of 20, no multiplier, and a Vpp level of 13 V instead of the more usual 12.5 V. This MSX EPROM programmer does not support National’s algorithm, but nonetheless gives good results with their chips.

Program description
An MSX compatible micro can have up to 4 primary slots, numbered 0, 1, 2, 3, each with a memory capacity of 64 Kbytes and subdivided in 4 pages of 16 Kbytes. It is also possible for a slot to be expanded, which means that it comprises four sub-slots X0, X1, X2 and X3. In theory, therefore, there can be a maximum of 16 slots identified as 00 up to and including 33.

Since the Type Z80(A) CPU is an 8-bit microprocessor, its addressable memory area is 64 Kbytes, that is, four pages, but these can be part of any (expanded) slot. It is, for instance, possible for the system to operate with page 0 from slot 0, page 1 from slot 2, and pages 2 and 3 from slot 3. The absolute address ranges are thus: page 0 = 0000-3FFF; page 1 = 4000-7FFF; page 2 = 8000-BFFF; page 3 = C000-FFFF.

Pages can be swapped and
Interactive EPROM programming

Table 4. Intelligent programming of EPROMs essentially entails applying no more pulses than strictly necessary for correct loading.

Fig. 8. This oscillogram shows that addresses may differ in respect of the number of programming pulses required for loading a byte. Upper channel: address line A₈; lower channel: (4×1) = 24 ms for the first byte; (1×1) = 3 for the second and third.

Fig. 9. Screendump of the command input screen (settings are examples).
it inserts itself between the stack and string & scratch blocks. After all this has been done, control is returned to the computer's normal start-up procedure, which means in most cases that BASIC will be started.

The EPROM software can now be run by typing CALL EPROMx, where x is the cartridge address area, 0, 1, 2, or 3. The program, when called, automatically selects the appropriate slot(s) for the RAM buffer, and then switches back to where it came from with the aid of routines on page 3. All switching between RAM and EPROM resident subroutines in the programmer is invisible to the user, and makes it possible for the proposed software to run on any MSX computer equipped with at least 64 Kbytes of RAM. Extensive use is made of vector-addressing, and all keyboard and screen input/output is routed via the BIOS on page 0.

To make sure that data for or from the EPROM is not overwritten in the system stack, or possibly the RAM-resident portion of the control program itself, it is a good idea to check whether there is enough room for your data by typing PRINT HEX(S/F(RE(0)+%H8000).

The address returned should be higher than the top location you need, observing that part of the available memory is used for the string and stack blocks, which extend downwards. Those MSX users in possession of a computer with a disc drive may have to limit the DISK-BASIC workspace somewhat by holding down the CONTROL key during power-up. The means of telling the system there is but one virtual disc drive available. Similarly, holding down the SHIFT key disables the disc unit altogether.

**Command summary**

Although the proposed program is extremely simple to use, it is none the less recommended to study this brief summary of the available functions, commands and options. After typing CALL EPROMx, you should see the welcome screen. Press on to the help pages with EPROM data and program information by pressing any key. You can leaf through the help pages by pressing the appropriate cursor movement keys. The command input screen can be called up at any time by pressing the space bar.

The following keys are used during the command input mode:
- Control-1 selects that line you wish to show on the command input screen.
- Control-2 selects that line you wish to execute on the command input screen.
- Control-3 selects the item you wish to work on.
- Control-4 returns you to the help pages.
- Control-5 causes the screen contents to be dumped to a printer (make sure that this is properly connected, else you will get a NO PRINTER error).
- Control-6 runs a test program that causes all functions on the programmer to be successively enabled with aid of CTC interrupts, indicated by the flashing ROM LED. Make sure that jumper J1 is not installed, and never run the test with an EPROM inserted in the ZIF socket.

The various options for the command items (toggle functions), Key-9 causes the program to start executing your set of commands. Always make sure that the command screen shows what you want before pressing S.

Key I enables the storing of BASIC programs in EPROM. The software automatically arranges for the correct initialization of the memory begin & end, and EPROM begin & end addresses. Link addresses are automatically adapted to enable the BASIC program to be run from EPROM.

With reference to Fig. 9, these are the various parameters you need to define before the programmer does what you want it to do:

- **EPROM TYPE** and **PROGRAMMING VOLTAGE**: consult Table 1 or the relevant help page and use the space bar to select the appropriate EPROM type, notice that EPROM BEGIN & END change in accordance with the holding capacity of the relevant EPROM type. It is possible to program part of an EPROM by keying in the relevant hexadecimal address range. The program accepts entries in hexadecimal only, and produces an error message if you try to define an impossible address range, or if the EPROM BEGIN & END entry is not in accordance with the MEMORY BEGIN & END entry. Example: you want to program the first half of a Type 2764 (8 Kbyte): EPROM BEGIN = 0000; EPROM END = 0FFF; MEMORY BEGIN = 4000; MEMORY END = 4FFF. BLANK CHECK should be a fairly well-known facility; it checks, with the aid of EPROM BEGIN & END whether the specified address range contains only bytes FF, indicating that data can be loaded there. PROGRAM speaks for itself.

- This function uses both EPROM BEGIN & END and MEMORY BEGIN & END. VERIFY checks whether the EPROM contents and the RAM buffer contents are the same, and evidently uses EPROM BEGIN & END and MEMORY BEGIN & END to determine what address ranges are to be compared.

**READ AND RUN CHECKSUM** loads the data from the EPROM into the buffer and adds the values of all bytes to produce a 16-bit checksum. DISPLAY MEMORY offers the user the possibility to load the EPROM contents into the computer for examination on the screen (hexadecimal and ASCII format, 8 bytes per line, preceding address). You can, however, display the contents of the EPROM into the buffer and adds the values of all bytes to produce a 16-bit checksum. DISPLAY MEMORY offers the user the possibility to load the EPROM contents into the computer for examination on the screen (hexadecimal and ASCII format, 8 bytes per line, preceding address). You can, however, display the contents of the EPROM into the buffer and adds the values of all bytes to produce a 16-bit checksum. DISPLAY MEMORY offers the user the possibility to load the EPROM contents into the computer for examination on the screen (hexadecimal and ASCII format, 8 bytes per line, preceding address). You can, however, display the contents of the EPROM into the buffer and adds the values of all bytes to produce a 16-bit checksum. DISPLAY MEMORY offers the user the possibility to load the EPROM contents into the computer for examination on the screen (hexadecimal and ASCII format, 8 bytes per line, preceding address). You can, however, display the contents of the EPROM into the buffer and adds the values of all bytes to produce a 16-bit checksum. DISPLAY MEMORY offers the user the possibility to load the EPROM contents into the computer for examination on the screen (hexadecimal and ASCII format, 8 bytes per line, preceding address). You can, however, display the contents of the EPROM into the buffer and adds the values of all bytes to produce a 16-bit checksum. DISPLAY MEMORY offers the user the possibility to load the EPROM contents into the computer for examination on the screen (hexadecimal and ASCII format, 8 bytes per line, preceding address). You can, however, display the contents of the EPROM into the buffer and adds the values of all bytes to produce a 16-bit checksum. DISPLAY MEMORY offers the user the possibility to load the EPROM contents into the computer for examination on the screen (hexadecimal and ASCII format, 8 bytes per line, preceding address). You can, however, display the contents of the EPROM into the buffer and adds the values of all bytes to produce a 16-bit checksum. DISPLAY MEMORY offers the user the possibility to load the EPROM contents into the computer for examination on the screen (hexadecimal and ASCII format, 8 bytes per line, preceding address). You can, however, display the contents of the EPROM into the buffer and adds the values of all bytes to produce a 16-bit checksum. DISPLAY MEMORY offers the user the possibility to load the EPROM contents into the computer for examination on the screen (hexadecimal and ASCII format, 8 bytes per line, preceding address). You can, however, display the contents of the EPROM into the buffer and adds the values of all bytes to produce a 16-bit checksum. DISPLAY MEMORY offers the user the possibility to load the EPROM contents into the computer for examination on the screen (hexadecimal and ASCII format, 8 bytes per line, preceding address). You can, however, display the contents of the EPROM into the buffer and adds the values of all bytes to produce a 16-bit checksum. DISPLAY MEMORY offers the user the possibility to load the EPROM contents into the computer for examination on the screen (hexadecimal and ASCII format, 8 bytes per line, preceding address). You can, however, display the contents of the EPROM into the buffer and adds the values of all bytes to produce a 16-bit checksum. DISPLAY MEMORY offers the user the possibility to load the EPROM contents into the computer for examination on the screen (hexadecimal and ASCII format, 8 bytes per line, preceding address). You can, however, display the contents of the EPROM into the buffer and adds the values of all bytes to produce a 16-bit checksum. DISPLAY MEMORY offers the user the possibility to load the EPROM contents into the computer for examination on the screen (hexadecimal and ASCII format, 8 bytes per line, preceding address). You can, however, display the contents of the EPROM into the buffer and adds the values of all bytes to produce a 16-bit checksum.

**NOT BLANK** reports that one or more bytes in the specified EPROM area do not read FF. The address counter displays the first incorrect address encountered, and the program is halted.

**NOT PROGRAMMABLE** indicates that a verify error was found, but the relevant byte is reprogrammable, i.e., as long as its bits read logic 1 when it should be logic 0. Low levels in EPROMs can only be changed into logic high by exposing the chip to a dosage of ultra-violet light.

**ADDITIONAL OVERVIEW**

The RESULT line at the bottom of the screen can be used to display the following messages (if returns to the help pages):

- **ADDRESS ERROR** is a general message telling you to type in the EPROM BEGIN & END and MEMORY BEGIN & END entry before pressing S again.
- **NOT BLANK** reports that the stated address area contains only bytes reading FF. The EPROM area is not copied into RAM.
- **NOT PROGRAMMABLE** reports that one or more bytes in the specified EPROM area do not read FF. The address counter displays the first incorrect address encountered, and the program is halted.
- **READING COMPLETED** speaks for itself. The contents of the EPROM are available for examination with DISPLAY MEMORY. For modification, you will probably want to resort to BASIC or a suitable utility package.
- **VERIFY ERROR** indicates that one or more differences exist between the contents of the EPROM and that of the RAM. The address counter displays the first incorrect address encountered, and the program is halted.
- **REPROGRAMMABLE** indicates that a verify error was found, but the relevant byte is reprogrammable, i.e., as long as its bits read logic 1 when it should be logic 0. Low levels in EPROMs can only be changed into logic high by exposing the chip to a dosage of ultra-violet light.

**NOT PROGRAMMABLE** reports that one or more bytes in the specified EPROM area do not read FF. The address counter displays the first incorrect address encountered, and the program is halted.

**READING COMPLETED** speaks for itself. The contents of the EPROM are available for examination with DISPLAY MEMORY. For modification, you will probably want to resort to BASIC or a suitable utility package.
ports that the address indicated by the address counter can not be loaded correctly, even after applying 25 programming pulses (see Table 4, intelligent programming only).

**EXECUTION STOPPED** is displayed in response to the pressing of the RESET switch on the EPROM programmer.

**DEVICE I/O ERROR** indicates that the computer is not receiving interrupts from the cartridge, which is possibly set to the wrong I/O address.

**NO PRINTER** is a message that speaks for itself.

**ILLEGAL COMMAND ORDER** informs you to re-do the YES/NO setting of one or more commands. Note that it is allowed to chose YES for BLANK CHECK, PROGRAM and VERIFY, the program performs these steps in the correct order, without the need for intermediate command starting with **S**.

As already noted, it is advisable to think well before pressing the **S** key and so start the program. If you get an error report, do not get into a panic, but study the command screen to trace the fault and understand its nature. Once you have worked with this EPROM programmer for some time, you will notice that it is highly user-friendly and easy to get going with the aid of the help pages, which are instantly available at the pressing of key **H**.

If you do not know how to program an EPROM which is not included in Table 1, simply begin with the lowest programming voltage, 12.5 V, to see if anything happens to the contents of the device, you can not damage it in this way, provided you do not select intelligent programming, as this causes the **Vcc** line to be raised to 6 V during the programming cycle. In conclusion of this section, a few more tips. When an EPROM is stated to be programmable in the normal (50 ms) mode, it is worth while to try out the effect of selecting fast-1 or fast-2 programming to save time. If you want to document the program settings for a specific EPROM, it is a good idea to use the screen dump option for the recording of the checksum and other relevant data. Remember that a Type 27312 (64 Kbyte) EPROM must be programmed in two 32 Kbyte passes.

Press **CONTROL-STOP** to return to MSX BASIC and type **CALL EPROMX** to run the programmer again. Use an assembler or a machine language utility package to write bytes into the RAM buffer for loading into an EPROM, but make sure that data is not overwritten by stack or buffer usage of any program you run in combination with the EPROM programmer software.

Keep in mind that running BASIC programs that use **PLAY** commands require the computer to be reset and hence the EPROM programmer software to be re-initialized. This is because the proposed program locates its jump table and variable map in the voice queue area. In more general terms, do not use the EPROM programmer software before you are sure that there are no other programs, or remnants thereof, still around somewhere in the computer's memory. The best way to avoid trouble is to reset the machine with the EPROM cartridge inserted.

Finally, Table 5 shows the control words for the various EPROM types. These 7-bit words are specific to the EPROM type to be dealt with, and can be used by anyone contemplating the writing of his own version of the control software.

We regret that we can not provide information on the use of this EPROM programmer with computers other than those in the MSX series.

Previous articles on MSX extensions have appeared in the following issues of *Elektor Electronics*:
- January 1986 (I/O bus, digitizer, I/O port);
- February 1986 (EPROM cartridge board);
- March 1986 (add-on bus board);
- January 1987 (I/O and timer cartridge).

**Getting started**

Commence with fitting jumpers **B, D, E and I** on the EPROM cartridge board, then mount EPROM ESS 552 in the 28-way socket. Plug this cartridge into a slot of the MSX computer, and plug the I/O & timer cartridge either in a remaining slot, or in the one provided on the EPROM cartridge board. Connect the EPROM programmer to the I/O & timer cartridge via the 50-way flat ribbon cable, and you have the system ready for use—see Fig. 10. Please note that it is not possible to use the add-on bus board for MSX computers in conjunction with the timer & I/O cartridge. Do not yet fit an EPROM in the ZIF socket, switch on the power, and call the program on completion of its initialisation. After viewing the welcome and copyright screen, go to the command screen and run the built-in test routine prior to working on any EPROMs. If all LEDs on the programmer's front panel can be seen to go on and off at regular intervals, there is good reason to assume that the hardware and software functions satisfactorily, and it is high time to set the system to work on any EPROM that you may have available.

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**Fig. 10.** One slot can hold both the EPROM and the I/O cartridge.
Local Area Networking

The proliferation of personal computers (PCs) as a business tool has driven the need for a distributed processing environment where many microcomputers can share expensive peripheral devices, such as printers and hard disk drives. The capability to network equipment also enables users to share files and programs and to centralize backup facilities and procedures.

Local Area Networking has two main requirements. It must be implemented in VLSI, to simplify design and lower the overall "per node" cost of connection to a network. Second, the LAN must also run standardized software and conform to an industry standard, so that end users can interconnect equipment from different vendors without worrying about protocols.

The IEEE 802.3 standard (Ethernet) has gained wide acceptance by both large and small companies as a high-speed (10 megabit/second) LAN. However, because of its cable requirements, it can be relatively expensive to implement. In response to this drawback, Thin Ethernet, also known as Cheapernet — was developed. Thin Ethernet uses less expensive coaxial cable and features a "node-integrated" transceiver. Thin Ethernet maintains full compatibility with Ethernet's 10 megabit/second data rate.

Another network sponsored by the IEEE 802.3 committee is StarLAN, a 1 megabit/second implementation that features a "star" configuration. Each node is connected to another central hub in point-to-point fashion.

Continuing development of LAN interface chips has driven the LAN connection cost per node down to new levels, making networks affordable at all business levels. Because of its cost-effectiveness, the personal computer connection segment of the LAN marketplace is forecast to grow faster than any other segment. According to Dataquest, revenues in 1990 will top US$528 million. Revenues in 1985 totalled US$181.7 million. The installed base of networked PCs will be 3.7 million in 1990, up from 338,000 in 1985.

Current Status
The decision by 3Com and Novell to port their LAN operating systems to National Semiconductor's DP3890 Network Interface Controller marks the first time a semiconductor supplier has taken an active role in making network software standard with their chips. This makes it easier for designers to use the chips in a network, rather than having to write software themselves. For original equipment manufacturers (OEMs), DP3890 compatibility with 3Com's 3+ network software and Novell's Advanced Netware means an easy path to LAN design for IBM-compatible PCs. OEMs can use National Semiconductor's tool kit containing DP3890 evaluation boards and 3Com 3+ network software to develop networking and workgroup computing products. Or they can use Novell's development kit and the DP8390 or the DP3890 LAN chip set, to design local area networks.

3Com and Novell are responsible for setting "de facto" standards in the PC LAN industry. 3Com is the leading vendor of LAN add-on boards for PCs, with a 19 percent share of the market, according to Dataquest. Novell's NetWare, with 60,000 installations, is the most widely used PC LAN operating system. It supports 35 local area network systems, including 3Com's Etherlink and Etherlink Plus, AT&T's StarLAN and IBM's PC Cluster and Token-Ring Network.

Support from two predominant LAN suppliers reflects the emergence of the DP3890 as the standard LAN chip set of choice among system designers.

National's Local Area Network Chip Set
Focusing specifically on the IEEE 802.3 local area network standard encompassing Ethernet, Thin-Ethernet (Cheapernet), and StarLAN compatible networks, National designers developed three integrated circuits: an Advanced Network Interface Controller (DP3890 NIC), a Serial Network Interface (DP3891 SN) and a Coaxial Transceiver Interface (DP3892 CTI). The chip set was the first complete VLSI implementation to meet the entire IEEE 802.3 standard. Its availability makes National Semiconductor well positioned to provide the rapidity expanding PC LAN market with its cost-effective chip set. In particular, the DP3892 was the first monolithic chip implementation of a cable transceiver. The high level of integration saves users a significant amount of board space. In fact, the network chip set is the only one that fits on a short-slot PC card.

The DP3890 NIC features two 16-bit DMA channels that deliver all the data-link layer functions required for data packet transmission and reception. The DP3891 features a patented digital phase lock loop for most reliable data reception. The DP3892 CTI implements all driver, receiver, jumber and collision-detecting functions required by the IEEE 802.3 cable transceiver. In addition, the DP3892 exceeds the one million hour MTBF required in the 802.3 specification for transceivers.

Illustrating National Semiconductor's technological breadth, three distinct process technologies were used in fabricating the chips: microCMOS for the DP3890, a high-speed oxide isolated bipolar process for the DP3891 and a junction-isolated bipolar process for the DP3892. The DP3890 evaluation board, containing the chip set, plugs into any IBM PC-compatible computer and incorporates all of the components required to provide a LAN interface to Ethernet or Thin Ethernet networks.

The entire LAN chip set and evaluation board are all currently in production.

Ethernet is a trademark of Xerox Corporation.
Cheapernet is a trademark of National Semiconductor Corporation.
StarLAN is a trademark of AT&T Bell Laboratories.

(Source: National Semiconductor)
From magnifying glasses to microscopes, callipers to computer interfaces, pipettes to pH meters: the range of equipment in the catalogues of educational laboratory suppliers is vast and continually changing in response to technological and educational developments.

The introduction of microcomputers such as the BBC B and the RM 380Z to schools in the United Kingdom has been rapidly followed by the development of computer interfaces whose purpose is either to enable data from school laboratory experiments to be captured, processed and displayed, or to control simple devices. Similarly, the rapid adoption by industry of biotechnological techniques has led Britain's major suppliers to sell kits by which these techniques can be simulated in schools. However, not all new equipment is stimulated by recent technological innovations: an educational concern to introduce science and technology to pupils aged five to 11 has led to much recent interest in construction kits.

There are several reasons why the range of educational laboratory equipment is so wide. First, science is taught in British schools over the age range of five to 18. Secondly, as the emphasis is on giving pupils hands-on experience, suppliers have learned how to provide equipment that schools can afford in quantities sufficient for classroom work. Some of it, of course, for demonstration by teachers but much is meant to be used by pupils working in groups of two and three. Pupil practical work is a cornerstone of education and so equipment must be strong and relatively inexpensive.

**Higher education equivalent**

The high degree of specialization by British pupils who stay on after 16, in many cases to prepare for a course at a university or polytechnic, is sometimes criticized but it has advantages. The level reached by these pupils is typical of first or even second year university students in some countries and so equipment that is useful for higher education is produced in the quantities that schools need and at prices they can afford. Britain does not have a centralized educational system and schools are given extensive choices in the courses they provide for their pupils. There are eight area boards offering examinations for the more academic pupils, and while procedures ensure comparability between these examinations, syllabuses do vary which increases the range of equipment needed. In the 1960s and 1970s, there was considerable support from money from the Nuffield Foundation or the government-funded Schools Council.
This stimulated corresponding innovations in equipment, another reason why the range is so wide. In the late 1970s and early 1980s, most of the new courses were revised and these revisions, together with restrictions on money for education caused by falling school rolls and the worldwide slump, have eliminated from the suppliers' catalogues anything that has proved unpopular. Much of what is left — still very extensive — has been refined over at least a decade. British schools tend to buy their laboratory equipment from three main general suppliers: Griffin & George (GG), Philip Harris (PH) and Irwin-Desman (ID). However, a number of specialist firms are also used. For example, interfaces for coupling equipment with microcomputers to capture data or demonstrate control are offered by all three of the major suppliers as well as the specialists.

Many functions
An example is the measurement module supplied by Educational Electronics (EE) which enables data from the outputs of a range of instruments held in a module for measuring magnetic fields, pH meter and so on — to be recorded and strikingly displayed in several forms on a television monitor. A range of sensors is being developed to go with this and other computer interfaces. One of the most interesting recent developments using microelectronics is the GIPS (Griffin Programmable Scientific instrument). There is concern that much of the more sophisticated equipment used in education spends much of its time on the shelf and is used only when its turn comes round in the syllabus so this instrument has many functions and will measure current, voltage, resistance, magnetic field, pH, light levels, and so on. The function wanted is selected by connecting a module containing an appropriately programmed read-only memory (ROM) and fitting overlays over the control panel makes it easy to use.

Another current growth area is electronics teaching kits. There are for many years been small components of electronics in some school physics courses but such physics teaching has recently been modernized and separate school electronics courses developed. The emphasis has shifted from simple introductions to semiconductor diodes and triodes to a systems approach to digital electronics and to operational amplifiers. There are many approaches to teaching electronics embodied in kits. The equipment for one very popular course, "Micro-electronics for All", intended for 11 to 13 year olds but in fact used for older pupils as well, is available from Unilab (U). Ideas underlying microelectronics — or information technology as it is sometimes called — are learned through solving simple control problems. Kits drawing interest are the Independent Schools Micro-electronics Centre (ISMEC) kits available from Griffin & George, Philip Harris, and Unilab. Unilab specializes in electrical and electronic equipment for education at competitive prices such as power supplies, meters, radiation counters, signal generators, and so on, all items that can, of course, be obtained from the general suppliers.

Move to plastics
It is easy to look just at recent major developments and forget that the bulk of purchases made by educational establishments are for consumables, notably glassware and chemicals, both supplied by Griffin & George and Philip Harris. Another company that specializes is BDH Chemicals. A development over the last few years has been the slow acceptance by schools of plasticsware in place of glassware. Early examples of plasticsware stolen too readily but recent products are more satisfactory and stand up to pupil use much longer than glass. Many of the top pan balances bought during the boom in science education in the 1960s and 1970s are now wearing out and schools are replacing them, as funds permit, with electronic balances with digital displays. These are very quick to use so that fewer are required for a class. Griffin & George, Philip Harris, and Irwin-Desman all supply balances but there are also several specialist suppliers, notably Oertling. There are several ranges of microscope and specialist firms such as Prior have suitable instruments for the educational market. Recently, biologists have shown interest in kits for environmental studies containing meters that measure pH, conductivity, temperature, light level, and so on. An example is an enzyme kit which provides insight into the industrial use of biotechnology.

A recent growth point has been equipment for primary school science. The educational emphasis is on using what can be found in the home and the classroom with the minimum use of special equipment but some is needed, such as simple kitchen-type scales, magnifiers, thermometers, construction kits, and so on. Specialist primary school companies such as E.J. Arnold and Osirmoid have equipment suitable for primary science education.

Checking for safety
The School Science Service provides information and consultancy on school science equipment and safety for the majority of British schools. Its task is to examine and test equipment and make recommendations to teachers. Copies of its reports can be obtained overseas through the British Council or through subscribing to the service as an overseas associate. Frequently the service is obliged to be critical of certain products but suppliers usually make modifications in the light of criticisms.

E.J. Arnold Ltd, Lockwood Distribution Centre, Parkside Lane, Leeds, West Yorkshire, England, LS11 5ID.

BDH Chemicals Ltd, Broom Road, Parkstone, Poole, Dorset, England, BH12 4NN.

Educational Electronics, 28 Lake Street, Leighon Buzzard, Bedfordshire, England, LU7 8RZ.

Griffin & George Ltd, Bishops Meadow Road, Loughborough, Leicestershire, England, LE11 0RG.

Philip Harris Ltd, Lynn Lane, Shenston, Staffordshire, England, WS14 OEE.

Irwin-Desman Ltd, 294 Purley Way, Croydon, Surrey, England, CR9 4QL.


Osirmoid, E.J. Perry Ltd, Gosport, Hampshire, England, PO13 0AL.

Prior Scientific Instruments Ltd, London Road, Bishops Stortford, Hertfordshire, England, CM23 5ND.

Unilab Ltd, Clarendon Road, Blackburn, Lancashire, England, BB1 9FA.

*David Tavney is director of the Brunel University-based School Science Service of Britain's Consortium of Local Authorities for the Provision of Science Equipment (CLEAPSE).*
New

shockproof

multimeter

New from ITT Instruments is the MX112, an analogue multimeter fitted with a rubber stock absorbing surround which makes it ideally suited to field service use in the electrical and automotive industries.

The MX112 is designed for ease of use, with only two input sockets provided for all functions and ranges and full protection on all ranges including the 10 A current range.

In addition to the rubber shock absorber, the MX112 incorporates a shockproof movement. The panoramic dial is backed by a parallax correction mirror, and a colour-coded range indicator is used with a patented slide switch to provide easy, unambiguous readings of functions and range scales.

The instrument offers eight multimeter functions on 42 ranges, plus capacitance and decibel measurements and a dwellmeter function for carrying out measurements on car engines. AC and DC voltages of up to 1600 V can be measured, while the current facility provides measurements from 50 μA to 10 A. Resistance ranges go up to 2 megohms.

The instrument's sensitivity is 20,000 ohms per volt on AC ranges. DC accuracy is ±2% of full-scale deflection, the corresponding figure for AC being ±3%.

All ranges are protected up to 230 V, and the instrument is designed to meet the IEC414 safety standard.

ITT Instruments
346 Edinburgh Avenue
Slough
Berkshire SL1 4TU
Telephone: (0753) 824131
Telex: 849808 ITTCOM G
Telefax: (0753) 824160.
(3582:7:F)

Versatile I/O System for IBM-PCs®

Users of IBM-PCs and other popular RS232-interfaced computers can now utilise a versatile and very economically priced expansion system to collect and generate digital and analogue inputs and outputs.

The system, available from Electronics and Computer Workshop Ltd. (ECW), is based on a series of multi-slot motherboards that accept standard I/O function cards. An intelligent RS232-interfaced version, the K2612, compatible with IBM-PCs, has been added to the range, allowing many more users to interface their machines to the outside world.

The system is a fully expandable method of connecting a wide range of analogue and digital signals to a computer for data acquisition and control of many types of electrical circuit. The plug-in series now includes an eight-channel analogue input multiplexer, A/D and D/A conversion, Centronics printer port, eight-channel logic input, real-time clock and a general-purpose output card with a choice of relay and triac outputs.

For the more adventurous, a ‘breadboard’ plug-in allows users to develop their own I/O projects.

IBM and IBM PC are registered trademarks of International Business Machines, Inc.

Electronic & Computer Workshop Limited
III Broomfield Road
Chelmsford
Essex CM1 1RY.
Telephone: (0235) 262149
(3582:8)

New Packet Radio TNC

Many amateurs do not realise how easy it is to get on the air with packet radio. All you need is a computer with an RS-232 interface (available on most home computers), a “Terminal Node Controller” (TNC) and a transceiver (or receiver for SWL’s). Most activity is on 2 metres although HF activity is increasing rapidly.

 Frequencies to listen on are 144.515 (data calling), 144.850 (packet repeaters) and 14.103 (main HF operation). Only a simple communications program is required for your computer, the TNC with its Z-80 processor handles the difficult bits! The majority of commercially available communications software will work without any problem, but there are some specially written programs available (which give split screen operation and other useful features) for the more popular machines. Some of these are available at a nominal charge or even free!

The TNC-220 is a newly designed successor to the TNC-200 and other TNC-2 "clones", giving more features at lower cost. It uses a single-chip modem that is software switchable between two radio ports, conveniently supporting both VHF and HF packet operation. Each of the TNC-220 radio ports may be configured with jumpers for 300 or 1200 bauds. Switching between ports is entirely done in software and no cable changing, no switch setting and no return is required! Both ports have provision for an active band-pass filter to optimise HF operation, one filter is standard. An optional tuning indicator will mount inside the cabinet. A standard modem disconnect header is provided to allow the use of accessory highspeed or satellite modems.

An assembled TNC-220 includes radio and power connectors, complete operator’s manual and command reference card. The kit also contains a detailed, step-by-step assembly manual.

The TNC-220 has the familiar TAPR command set and AX.25 Level 2 Version 2 protocol running on a Z-80 processor with 32 K bytes of EPROM and 16 K bytes of battery-backed RAM. A Zilog 8589 Serial Communications Controller performs all packet HDLC in hardware. The RS-232 port includes a jumper to select TTL interfacing to your VIC-20, C-64/128 or other TTL computer. Five large, colour-coded LED’s clearly indicate the TNC-220 status at a glance.

The power switch is located on the front panel. TNC-220 is enclosed in a rugged extruded aluminium cabinet. The attractive Fac-Conn two-tone blue front panel has large, clear labels on all indicators and controls.

The TNC-220 comes in kit form or ready assembled: prices are £149.95 and £169.95, respectively, inclusive of VAT and P&P.

Andrews Computer Services Limited
6 Ash Hill Close
Bushey Heath
Herts WD2 1BW.
Telephone: 01 950 9381. (3582:3)
New self-contained digital trainer

The FL102 Digital Training Laboratory from Flight Electronics provides a comprehensive workstation for those involved in advanced digital electronics courses.

Self-containment is the essence of the unit which provides total independence to users. Built-in features include a multi-rail variable DC supply, four-range digital voltmeter, function generator, seven segment displays, logic switches, function switches, pulse switches, and logic indicators. Time-effective and tidy circuit work soon replaces the unreliable 'birds nest'. Components with 0.3 to 0.8 mm leads can be plugged into the large 1680 tie-point breadboard which accepts all DIPs.

Having all support equipment so close to hand makes the unit ideal for all applications requiring an independent digital workstation. The range of inputs, displays and options ensures that a comprehensive coverage of digital circuitry can be achieved. The unit offers a thoughtfully built and reliable base, for all training establishment and individual requirements.

The built-in regulated DC supply is fully short-circuit protected. Ranges are ±5 V/1A, ±5 V/0.5A, and 0 to ±15 V/0.3A. The function generator provides 1 Hz to 100 kHz continuously, variable over five decade ranges. Wave outputs peak-to-peak are sine 0 to ±5 V, triangle 0 to ±3 V, and square 0 to ±5 V. DVM provides four ranges from 199.99 mV to 199.99 V. FSD. Pulse button generates 10 μs pulse. A 30-day evaluation period can be arranged. The FL102 costs £250.

Flight Electronics has recently launched its fifth annual catalogue, containing a comprehensive range of training systems and associated equipment. It is available free of charge from the address below:

Flight Electronics Limited, Ascupar Stree, Southampton SO1 1LU.
Telephone: (0703) 227721
Telex: 477389 FLIGHT G
Fax: (0703) 330039 (3582:17:F)

New miniature quartz crystal

A miniature ceramic packaged 8-20 MHz AT-cut quartz crystal, the ETA CXAT, is announced by Stanler Components Ltd., for both surface mounting and through-hole board applications. The CXAT is designed for use in simple Pierce oscillators and is manufactured with a photolithographic process using state-of-the-art equipment and MicroCrysat's know-how acquired in producing millions of crystals for ETA's famous watch movements.

The rugged miniature ceramic package is one quarter the size of an eightpin min-DIP. These crystals have low aging, high stability and low power consumption and can be supplied with standard frequency tolerances down to ± 1/-50 ppm with tighter tolerances available on request. They can also be released to full military specifications.

Stanler Components Limited
21 Benfield way
Lakes Road
Braintree
Essex CM7 6YS.
Telephone: (0376) 40692
Telex: 987911 STANCO G (3982:15:F)

Coupler/Splitters for Fibre-optic LANs

Edward Fletcher & Partners, who recently announced a range of terminated fibre-optic data link cables starting at a length of 100 mm, now say that they have the facilities to make low-loss fibre-optic coupler/splitters (biconical taper couplers). In optical sensing, and local area networks (LANs), their main use is to tap data from a computer or other node into a ring network linking offices together, or to take data out of the ring. The use of fibre optics in the LAN provides high-security interference-free communication for high-speed data exchange between computers and other digital devices in the network.

Coupler/splitters can be supplied in either of two grades of plastic-coated silica fibre (p.c.s.): 50/125 or 65/125 grade. Standard types have four 200 micron fibre tails. These accept light down any of the four tails, splitting it equally into the two opposite tails. Very little light is transmitted through the fourth tail, providing a 50:50 or 3 dB splitter. Other splitting ratios can be supplied to order, including p.c.s. couplers with more than four tails.

With cleaved fibre ends, and input to one port only, the insertion loss (excess loss) is typically 1 dB, with a maximum of 2 dB. The output/input signal ratio is ~0.5 dB and directivity (backscatter into the adjacent input port) typically 40 dB, with a minimum figure of 16 dB. Couplers can be spliced into a system or can be terminated with specified connectors. Different diameters of coupler are available, and electrically non-conducting materials can be supplied if required. As well as computer applications, coupler/splitters can be used for the effective intercommunication or networking of word processors, facsimile machines, tele terminals, electronic mailbox devices, printers, and much more, permitting maximum use of available computer power and bulk memory resources.

Edward Fletcher & Partners Limited
25 West Park Road
Kew
Surrey TW9 4DB.
Telephone: 01-876 2204
Telex: WTC, LDN 884721 (EFP) (3982:4:F)
Programmable VHF millivoltmeter

The 3440A is a reliable and cost-effective programmable RF millivoltmeter with advanced circuitry. Manufactured by Ballantine, and available from UX distributors PPM, the instrument provides superior performance, speed and convenience in a meter that is unrivalled in its class. Advanced circuitry and stability make the flexible unit well suited to system measurement, field, and laboratory use. The easy to operate true RMS instrument features high resistance to hostile RF environment, shock, and vibration. Reliability is further enhanced using a solid state monolithic chopper stabilized amplifier, audible noise is reduced to zero. Inside the probe a self-regulating heater keeps the detector diodes at a constant temperature eliminating calibration errors caused by temperature variation.

Signals over the frequency range 10 kHz to 12 GHz are measured in eight ranges from 1 mV to 3 V (FSO). Up to 30 mV response is true RMS permitting highly accurate non-sinusoidal waveform calibration. From 30 mV to 3 V response changes from true RMS to peak-to-peak linear. An analog 'curve matching' circuit performs the changing characteristics and corrects it providing a high-linearity meter response over the higher ranges. Ranges are programmable with TTL logic or optional IEEE488 bus coupler.

Probe design is enhanced utilizing a spring tip, a 50 ohm terminated adaptor mates with BNC or N-type connectors. Also available are a 50 ohm tee adaptor, an unterminated (BNC/N) adaptor, and a 100:1 capacitive divider.

Traceable true RMS from 100 µV to 30 mV, 10 kHz to 1.2 GHz. Volts and dB level operation is 100 µV to 300 V and -60 dB to +60 dB, 10 kHz to 1.2 GHz. Simplified relative gain/loss measurements — zero dB reference continuously adjustable over 3 dB range.

PPM Instrumentation Limited Hermitage Road St. Johns Woking Surrey GU21 1TZ. Telephone: (04867) 80111 (3582:10:F)

Dual power supply unit has true parallel mode

The PL230 Quad-Mode Dual from Thurlby Electronics is a dual 30 V 2 A laboratory bench power supply whose outputs can be automatically configured into any of four modes including true parallel.

The four modes are selected by a bank of push-button switches. In isolated mode, the two PSUs operate entirely independently of each other. In series mode, the two outputs can be set independently but are internally linked, whilst in series-tracking mode the master voltage control sets up equal voltages on both supplies. In parallel mode, the master unit is converted into a true 30 V, 4 A PSU with the current being measured on one meter and no discontinuity occurring at any point.

In independent mode, each PSU has an output range of 0-31 V and 0-2.2 A. Both line and load regulation are better than 0.01% and ripple and noise are below 1 mV. Operation can be constant voltage or constant current with automatic cross-over and indication. Remote sense terminals are provided to maintain regulation at high currents. Voltage and current levels are simultaneously monitored to high resolution (10 mV and 1 mA) using twin 3/4 digit (3999 count) meters per output. A damping switch incorporated on the current meter to enable rapidly fluctuating currents to be averaged out. A DC output switch enables each output to be set precisely in terms of both voltage and current levels before connection to the load.

The PL230 Quad-Mode Dual measures 10 x 6.9 x 13.6 in. (255 x 175 x 345 mm) and weighs 19.1 lbs (9 kg). It costs £339. A dual 30 V 1 A version is also available costing £289.

Thurlby Electronics Limited New Road St. Ives Huntingdon Cambs PE17 4BG. Telephone: (0480) 63570 (3582:23:F)

Power line filters protect sensitive circuitry

A 3-pole wide-bandwidth power line filter from Rendar is designed for protection of sensitive circuitry against supply-borne interference. Featuring very high insertion loss, and offering a range of current ratings, the filter is suitable for many applications including protection of logic circuitry and radio interference suppression of appliances. This high-quality product is made by Feller of Switzerland and is approved to UL, VDE and SEV specifications. A very high degree of protection against interference coupling is provided by the rustprotected metal enclosure. The compact unit, with climatic classification to DIN 40040-HVF, is portable or rack-mountable, and offers the option of universal tab or solder connection.

Power line filters

Voltage rating is 230 VAC, current rating 1, 3, 6 or 10 A.

Rendar Limited
Durban Road
South Bersted
Bognor Regis
West Sussex PO22 9RL
Telephone: Bognor Regis (0243) 825811
Telex: 86120 (3582:24:F)

1/2 Watt power supply on a chip

New from broadline distributor Verospeed is an AC to DC power converter IC which only requires a single filter capacitor to make a complete 5 Volt, 100 mA power supply. Ideal for applications where size, weight, component count and low cost are all important, the MAX610 IC can function directly from a 110 V or 240 V AC mains supply with the addition of a current limiting resistor and capacitor to provide up to 1/2 Watt of regulated power.

Packaged in an 8 pin plastic SIP, the device can dissipate 750 mW at 25°C and can accept various repetitive or non-repetitive AC inputs. Operating temperature range is 0 to 70°C and maximum output current is 150 mA.

The MAX610 is a power supply IC and as such must be enclosed to avoid any shock hazard.

Verospeed
Stansfield Road
Beattwood Industrial Estate
Eastleigh
Hants SO5 4ZT.
Telephone: 0703 641111 (3582:21)
New battery-operated, portable oscilloscope

Electronic Brokers has introduced the Thandar SCI10A battery-operated, portable oscilloscope which has a bandwidth of DC to 10 MHz and a sensitivity of 10 mV/div to 50 V/div in 12 ranges.

Ease of use and battery powering enable this instrument to be effectively employed in service applications where conventional mains powered instruments cannot be used.

The SCI10A can be mains or battery-operated and has a typical power consumption of 350 mW, with bright line auto and economy triggering modes

The instrument has a 32 mm x 26 mm screen with a blue-white phosphor display and five horizontal and four vertical graticule divisions. External adjustments include intensity, focus, and traceloute.

Timebase sweep times are 0.1μs/div to 0.5 μs/div in 21 ranges and the calibration accuracy is ±3% for 0.2 μs/div to 0.5 μs/div ranges with ±10% for 0.1 μs/div.

Coupling is switchable d.c., a.c., TV frame or TV line. The input impedance is 1 MΩ in parallel with 47 pF, with maximum input being 350 V DC and peak AC provided the DC component does not exceed 250 V.

A range of optional accessories are available including AC adaptor, carrying case, rechargeable battery units, probes and bench instrument racks.

Electronic Brokers Limited
140-146 Camden Street
London NW1 9PB.
Telephone: 01-267 7070
Telex: 298694
Fax: 01-267 7363

New cable identification system

A low cost approach to cable identification has been taken by TMK Instruments with their brand new TEM 6000 TraceIT Cable Identifier. Designed and manufactured in the UK the instrument could not be easier to use with just the ON/OFF switch, operating instructions and battery low indication on the TEM 6000 which acts as the signal transmitter for the system.

Costs are reduced and flexibility increased by using a standard Digital Multimeter as the receiver to identify up to 10 lines of any length and size, with the DMM being available and probably necessary for other tests. Ideal for all cable tracing applications this lightweight handheld or "hang on" device saves time and hence money in sorting out three phase installation and line communication wiring.

TraceIT is powered by a single 9 volt battery, housed in a high impact resistant ABS case measuring only 102 x 61 x 26 mm and weighs a mere 170 gms. This latest instrument from TMK comes ready for use with eleven numbered test leads 155 mm long fitted with croc-clips, battery, operating instructions and a carrying case.

The TEM 6000 costs £99.75, exclusive of VAT.

Harris Electronics (London)
138 Grays Inn Road
London WC1X 8AX.
Telephone: 01 837 7937

New high-speed RAM

Rapid Silicon have added the new IMS 1630 high-performance 8 K x 8 static RAM to their range of INMOS memory devices.

The IMS 1630 is a very high speed CMOS device that complies with 1.6 micron design rules. It requires no external clocks or timing strobos, features equal address access and cycle times and is fully TTL compatible.

A Chip Enable function is provided and can be used to place the device in a low-power standby mode, thereby reducing power to 25 mA (TTL levels). By using CMOS levels, standby power can be decreased even further to only 14 mA.

The IMS 1630 is available in three versions with address access cycle times of 45, 55 or 70 nsec. Device characteristics include common data inputs and outputs, single +5 V ±10% operation, and a fast write cycle when outputs are disabled.

All versions of the device are supplied in a JEDEC standard 28-pin 600-mil ceramic DIP.

Rapid Silicon
Rapid House
Denmark Street
High Wycombe
Bucks HP12 2ER
Telephone: (0494) 26271
New high-performance computer parts

Now available from Bedford-based RR Electronics is the Siemens SAB80286 high-performance microprocessor, with up to six times the performance of the SAB8086.

Designed for multi-user and multi-tasking systems, the SAB80286 has built-in memory protection which supports operating system and task isolation as well as program and data privacy within tasks. It is upward-compatible with SAB8086/8088 software.

The SAB80286 also supports virtual memory systems by providing a segment-not-present exception and restartable instructions. Also new in the RR range of microprocessor parts is the SAB82258 advanced DMA controller for 16-bit microcomputer systems. It is designed especially for the 16-bit microprocessors SAB80286 and SAB8086/8088/188. Operation with other processors is supported by a remote mode.

The controller has four independent DMA channels which can transfer data at up to 8 Mbytes/sec at 8 MHz clock frequency in a SAB80286 system or up to 4 Mbytes/sec at 8 MHz in a 8086/186 system. This wide bandwidth enables fast data transfer or the use of multiple peripherals at the same time. The device is fabricated in advanced +5 V N-channel Siemens MYMOS technology, housed in a 58-pin CLCC package.

16-channel ADC card for IBM PC®

Model PC26 from Amplicon Liveline Limited is a low cost, 16-channel, 12-bit ADC card for the IBM PC® or equivalent computer.

Supplied complete with sampling software and user manual, the analogue inputs may be sampled at up to 200 times per second using Basic, 2,000 per second using Turbo Pascal or from one per hour to 30,000 per second using an additional software package PC28A.

Input voltages may be uni/polar or bi-polar, the conversion technique is successive approximation with 35 micro seconds conversion time. The PC26 is suitable for use with any compatible colour graphics card enabling data to be easily displayed and assimilated.

Economically priced at £193, the PC26 occupies one slot in the computer and is dispatched the same day for orders received up to 5pm.

IBM and IBM PC are registered trademarks of International Business Machines, Inc.

Integrated programmable temperature sensor

I.D.E., a division of Beamlist Limited, announces the introduction of an integrated programmable temperature sensor circuit. The TEMPO1 is a low operating voltage (down to 1.2 V) monolithic temperature sensor that can be externally set to any desired set point (-5°C to +85°C). At the preset level, the device will give a frequency output (which is also programmable) that will directly drive most types of audio transducers.

To operate the device, all that is required are 4 resistors 2 low value capacitors and a transducer (output). The device itself needs to be in contact or close proximity to the surface to be monitored.

In addition the product has a monostable action which 'self checks' the operation by outputting a different frequency during the positive temperature gradient.

The part is designed with low voltage and low current consumption in mind and is ideal for battery-powered applications. The TEMPO1 is available in both 8-pin DIP and 8-pin small outline package.

Further information is available from:

Beamlist Limited
Unit 2
The Holloway
Bath Road
Littlewick Green
Berkshire SL6 3QT.
Telephone: 062 882 2529
Telex: 649910
Fax: 07357 5257 (3582:14)
Real-time graphics package

There are currently many Graphics Packages available that attempt to exploit the BBC Micro's graphics facilities, many of which can produce impressive pictures. This is fine if you are content with the 'picture' being the final product with no further real application of your efforts.

The REALTIME GRAPHICS SYSTEM, however, promises much more. This unique package allows you to create any 3D wireframe object and then to use the resulting 3D objects with the REALTIME GRAPHICS language ROM in your Basic or Assembler to produce some stunning animated sequences.

The system is supplied on a 32K Graphics Rom and five discs with a 115 page Manual which features an integrated set of design and applications facilities. These consist of the main 3D Design System Disc, Multi-plotter Driver Disc, Applications Disc, Database Library Disc, a Realtime Demonstration Disc and the REALTIME GRAPHICS language ROM. On bootup the main Design System displays a main menu which leads the user through a hierarchy of well designed & interactive sub-menus.

Although the Design system works perfectly well with single disc drive setups, a 'Configuration' option allows the user to take advantage of dual drives so that a larger database library of models can always be on-line during a design process. The 'System Editor' is the heart of the Design system and provides some sophisticated facilities to create complex structures with a minimum of data entry. These include an interactive 'Editor' for creating & editing models using a simple 3D Move & Draw vector format with each 3D line having its individual colour and linetype (solid or dotted) specified for multi-coloured objects. The most powerful feature of the Design system is undoubtably the 3D Macro' facility which allows any object created by the 'Editor' or 'Profile' to be used as a macro, i.e. a building block, which can be generally modified in different ways by stretching, rotating & positioning it to form part of a more complex object. The complete object can then be turned in a macro to form part of an even more complex object. This is another particularly powerful recursive feature. In this way complex objects can be built up with the minimum of data entry.

Hence a designer can easily create a huge database library of models, assuming an unlimited supply of disks, to provide a varied selection with which to make the design process easier. A 'File' option provides facilities to maintain these libraries.

The complexity of your designs is only limited by your imagination and the Beeb's memory. The 6802 Second Processor is fully supported so even more complex objects can be created. Hardcopy facilities are also provided for Epson compatible printers while a graphics to disc dump allows use of other printer drivers and further image processing by screen-image oriented software such as 'AMX ART'. Incidentally the system's menus are controlled entirely by cursor keys hence it is also 'AMX MOUSE' compatible.

A Data Converter is also provided to allow the REALTIME GRAPHICS SYSTEM to be interfaced to other CAD Systems or applications. Hence design or scientific data from other systems can be read into the Realtime Graphics System for 3D Manipulation. Data from this system can just as easily be output to a textfile for processing by other applications.

The Realtime Graphics System/language package costs £79.95, inclusive of VAT, and is available from Silicon Vision Limited 47 Dudley Gardens Harrow Middlesex HA2 0DQ. Telephone: 01 442 2274 (5582.5)

Miniature printer for portable instrumentation

Ideal for use in portable instrumentation applications, a miniature desktop printer unit from Electronic and Computer Workshop Ltd. (ECW) provides 40 characters/line text and high resolution graphics output for all types of portable instrumentation.

The printer, the MP-234-40, is contained in an attractive black moulded case and contains the printhead mechanism with the 12x10 roll. It is provided for a controller board, such as the MP-IBI parallel interface board, while the front panel can include a calculator-style keypad and display, if required.

The MP-234-40 utilises a high reliability plain-paper printing mechanism which uses 56 mm wide plain paper roll and gives 240 graphic dots per line, with a dot spacing of 0.2 mm. The mechanism gives a quality print appearance of use in portable equipment, instrument front panels and other data printing applications.

ECW offers the MP-234-40 printer at a mail-order price of £145.50, including post/packaging and VAT.

Electronic and Computer Workshop Limited 111 Broomfield Road Chelmsford Essex CM2 1BY. Telephone: (0245) 262149 (3582-16)

New software for electronic design

Schema, a new low-cost schematic capture program, offers a complete solution to electronic circuit design from concept to printed circuit board. Easy-to-use, Schema enables even first time users to draw schematics quickly and efficiently and create design documentation automatically.

The package is supplied by Engineering Solutions Limited, which specialises in a range of low-cost hardware and software tools for professional engineers.

The Schema package forms a highly-integrated engineering tool, consisting of a Drawing Editor, Object Database and Post Processors. The powerful Drawing Editor, accessed through a mouse-driven interface, features real-time interaction, three zoom levels for optimum viewing, regional editing and command repetition.

The Object Database contains a library of the most popular analog, discrete, CMOS, microprocessor and memory devices, as well as many general purpose objects which simplify the creation of schematics and flow charts. Schema's post-processors can generate hardcopies of the drawings, bills of materials, wire and net lists and design rule check and usage reports.

The package runs on IBM PC/XT/AT® computers and compatibles and supports most popular graphics cards, printers, plotters and mouse devices. Schema operates efficiently from either dual floppy disk or hard disk-based systems, and is also designed for local area network configurations.

An interactive evaluation disk and instructions are available at nominal cost from Engineering Solutions Limited.

IBM and IBM PC XT/AT are registered trademarks of International Business Machines, Inc.

Engineering Solutions Limited King's House 18 King Street Maidenhead Berkshire SL6 1EF. Telephone: (0628) 30652 Telex: 849462 TELFAC G Fax: 0628 74928 (3582.9)
Bakers Dozen Parcels
Price per parcel is £10.00, but if you order 12 or more, you will get a 10% discount.

Parcels contain a selection of electronic components.

- 1. 5hp 15v transformer
- 2. 12v 20w bulb
- 3. 8w 240v filament indicator
- 4. 15w 240v filament indicator
- 5. 40w 240v filament indicator
- 6. 25w 240v filament indicator
- 7. 15w 240v filament indicator
- 8. 20w 240v filament indicator
- 9. 25w 240v filament indicator
- 10. 30w 240v filament indicator

This month's snap is the motor starter charger 1987 model. This could be used for starting a car battery and is designed for the motorist. Special snap price of £5.50, available in this month's issue.

Two Pounds
SP1 - 12 volt submersible pump is complete with a tap switch.
SP2 - Sound-metre is complete with 3m long cable and 3PST socket.
SP3 - 220 volt isolating transformer to suit your needs.
SP4 - 220v-110v step-down transformer with 25mm diameter transformer windings.
SP5 - 220v-110v step-down transformer with 25mm diameter transformer windings.

Over 400 Gifts
You can choose from a vast selection of electronic components and accessories.

- Electronic components
- Microcontroller
- LED strips
- Resistors
- Capacitors
- Transistors
- Diodes

Don't miss out on our special offers!
Pocket Digital Multimeter
A calculator size autoranging DMM which reads 1mV-400V DC, 1mV-400V AC, 0.1Ω-2MΩ and has a continuity buzzer. Overall size only 120 x 75 x 15mm. Order Code YN78K Price £24.95

Hobby Digital Multimeter
A very high quality multimeter at a very low price! 14 selectable ranges covering AC and DC volts, DC current and resistance. Also has a diode junction test range. Order Code YM63T Price £28.95

Auto Ranging Digital Multimeter with Transistor Tester
A 6 position rotary switch selects off, volts, ohms/continuity, 20MΩ, 200mA/hFE or 10A. Features include display hold, NPN and PNP transistor tester, autorange override and low battery indication. Order Code YM64U Price £45.95

All prices include VAT. Please add 50p towards postage. Prices firm until 9th May 1987. Subject to availability.