CHAT WITH YOUR COMPUTER!
Versatile allophone speech synthesis board with:

- four levels of inflection
- 2K of on-board RAM storing 100+ words
- speech reproduced as words, phrases or sentences
- simple interface requirements
- low software overhead

PLUS
Bench PSU – 5V @ 2.5A, ±15V @ 0.5A
Adding more memory to Z80 computers
A new generation of soldering irons?
Low-price robots from POWERTRAN
- hydraulically powered
- microprocessor controlled

The UK-designed and manufactured range of Genesis general purpose robots provides a first-rate introduction to robotics for both education and industry. With prices from as low as £425, even the home enthusiast can aspire to his or her own robot.

Each robot in the Genesis range has a self-contained hydraulic power source operated from single phase 240 or 120v AC or from a 12v DC supply. Up to six independent axes are capable of simultaneous operation and all except the grip axis have sensing devices fitted to provide positional control by a closed loop system based on dedicated microprocessors. Movement sequences can be programmed by means of a hand-held controller or the systems can be interfaced with an external computer via a standard RS232C link.

The top-of-the-range P102 has dual speed control, enhanced memory and double acting cylinders for increased torque on the wrist and arm joints. There is position interrogation via the RS232C interface, increasing the versatility of computer control and inputs are provided for machine tool interfacing.

All Genesis robots are available either ready-built or in kit form. The latter provides not only extra economy but also valuable additional training as an assembly project.

HEBOT II
Turtle-type robot

For under £100, Hebot II takes programming off the VDU and into the real world. Each wheel is independently controlled by a computer, enabling the robot to perform an almost infinite number of moves. It has blinking eyes, a two-tone bleep and a solenoid-operated pen to chart its moves. Touch sensors coupled to its shell return data about its environment to the computer enabling evasive or exploratory action to be calculated. The robot connects directly to an I/O port or, via the interface board, to the expansion bus of a ZX81 or other microcomputer.

HEBOT II
Weight 1.8kg
complete kit with assembly instructions £85
Interface board kit £10

MICROGRASP

A real, programmable robot for under £200! Micrograsp has an articulated arm jointed at shoulder, elbow and wrist positions. The entire arm rotates about its base and there is a motor driven gripper. All five axes are motor driven and four of these are servo controlled giving positive positioning. The robot can be controlled by any microcomputer with an expansion bus – the Sinclair ZX81 being particularly suitable.

MICROGRASP
Weight 8.7kg, max. lifting capacity 100g
Robot kit with power supply £145.00
Universal computer interface board kit £48.50
23 way edge connector £2.50
ZX81 peripheral/ram pack splitter board £3.00

GENESIS S101
Weight 29kg, max. lifting capacity 1.5kg
5-axis model (kit form) £475
5-axis complete system (kit form) £737

GENESIS P102
Weight 36kg, max lifting capacity 2kg
6-axis system (kit form) £1175.00
Powertran Cortex microcomputer self-assembly kit £295.00

For Genesis robot kits in kit form:
- GENESIS P101: Weight 34kg, max lifting capacity 1.6kg
  - 6-axis model (kit form) £675
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### POLYESTER RADIAL LEAD CAPACITORS:

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sised items are in stock), items out of stock in a few days — any
problems and you will be informed immediately.

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*For credit card orders, please provide the card number and expiration date.

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ETI FEBRUARY 1984
CABLE TELEVISION — ALL IT'S SUPPOSED TO BE?

A couple of years ago, cable television was described as a 'licence to print money' — exactly the same description that was applied to commercial television. Now the picture doesn't look nearly so bright. ETI will have a special report on cable television, taking the technical and financial issues that are deciding the future of our entertainment.

STEREO POWER METER
This device will give you a true indication of power, as it measures the current going to the load and multiplies it by the voltage to obtain the power — none of these cheats where you measure just the voltage and hope the impedance is what it says on the case! And once you know the power, and you've measured the voltage, you could work out the impedance. If you can also measure the current, you can then work out the phase angle as well...

Z80 DRAM CARD
Following on from this month's article on how to replace one set of DRAMs with a larger capacity set still within an existing system, here is a whole board full of memory, all for your Z80 system.

COMPLEX NUMBERS
Complex numbers are not as complicated as you think — in fact, once you get over your initial trepidation, you'll find that they make circuit calculations very much easier than they ever are by other means!

Articles described here are in an advanced state of preparation. However, circumstances may dictate changes to the final contents.
THE NEW MPF7 PLUS...

Just look at the specification:

Technical Specification

CPU: Z80A – 158 instructions
Software:
- Z80/8080/8085 machine code
- Z80 Assembler, line and 2 pass.
- 8K BASIC interpreter (Extra)
- 8K FORTH (Extra)
ROM: 4K Monitor (full listing and comments)
RAM: 8K CMOS (2 x 6116)
Input/Output: 48 system I/O lines
Speaker: 2.25" coned linear
Display: 20 character 14 segment green phosphorescent
Expansion:
- Socket for 8K ROM
- Cassette interface
- Connectors 40 way, complete CPU bus
Keyboard: 49 key. Full “QWERTY” real movement good tactile feedback
Batteries: 4 x U11 for memory back-up (batteries not included)
Serial Interface: 15 bps for read/write via audio cassette

Manuals

2. Specification (hardware and software).
3. Description of Operation.
4. Operating the MPF-1 Plus. 5. 44 Useful Sub-Routines.
5. The Text Editor.
6. Assembler and Disassembler.
7. System Hardware Configuration.
8. Monitor Program Source Listing with full commenting.
9. Also available the MPF-1 Plus Student Work Book (self-learning text).

Accessories

- EBP-MPF-1P: Copy/list/verify 1K/2K/4K/8K ROMs. Ready to plug in.
- SSB-MPF-1P: Speech Synthesizer. Inc. 20 words and clock program. 1200 words available.
- SGB-MPF-1P: Sound Synthesizer Board.

Yes! I now realise that I need an MPF1 PLUS and that it is the lowest cost Z80 SBC available with all these features.

I enclose £165.00 (£140.00 + £21 VAT plus £4 carriage). Overseas P.O.A.

Cheques payable to FLIGHT ELECTRONICS LTD.

Please debit my Barclays/Access Account No.

An invoice will automatically be sent.

Name
Address
Signature
Date
DIGEST

PORTABLE PROJECTION TV

For those who find Clive Sinclair's 2" marvel a little too small, Matsushita might just have the answer. Their latest addition to the portable TV market is a fold-flat projection colour television with a 6.5" screen.

The TV has been developed from Matsushita's large screen projection systems and uses three 5cm projection tubes for red, green and blue instead of the single CRT found in conventional TVs. When folded for carrying it measures 250 x 85 x 310 mm and when in use the size and weight of the resultant set is 1.8 kg, about half the weight of a conventional set.

Matsushita have released very little other information on the new TV and when we telephoned their UK press office they stressed that there are no plans as yet to introduce it here at all. Disappointed would-be purchasers will have to make do with either a Sinclair and a magnifying glass or a conventional 7" TV and a body-building course.

Exhibitions Galore

You've seen the best, now see the rest! No, but seriously, folks, the exhibition season doesn't end with Breadboard, and there are a lot more people out there waiting to show off their wares and expertise. There are exhibitions of general interest, exhibitions aimed just at the chosen few, big exhibitions, small exhibitions, conferences, seminars, the lot. So get out your diaries and make a note of some of the following.

First off is the Acorn User Exhibition which will take place in the Central Hall, Westminster, London, from the 25th January to the 27th January. As its title suggests, the exhibition is aimed at those involved in education, teachers, lecturers, administrators, etc. and will bring together some of the many companies offering educational software, peripherals, and services for Acorn's BBC microcomputer. Interested readers should contact Tim Collins, Computer Marketplace Ltd, 20 Orange Street, London WC2H 7ED, tel 01-930 1612.

The same people are also organising a Sinclair Education Exhibition in March, the second Acorn User Exhibition in August, and a robotics exhibition in November, and information on these can be obtained from the above address.

IFSSEC '84, the International Fire Security and Safety Exhibition and Conference, will take place at Olympia, London, from the 9th to the 13th April. Over 65,000 people are expected from all over the world to inspect the latest fire control and intruder detection products and services offered by the anticipated 700 exhibiting companies. There will also be seminars on such topics as the requirements of fire safety regulations and police policies toward intruder alarm installations. Details, conference programmes, etc. are available from IFSSEC Ltd, Cavendish House, 128-134 Cleveland Street, London W1P 5DN, tel 01-387 5050.

The British Robot Association are holding their 7th annual conference in Cambridge (no single venue mentioned) from the 14th to the 16th May. Representatives from both Eastern and Western countries will be taking part and the organisers expect it to be their biggest yet. They are still considering papers for presentation at the conference and welcome contributions from the industrial applications via circuit submitted within the next month. Details from the Conference Organiser, B.R.A.R., British Robot Association, 28-30 High Street, Kempston, Bedford MK42 7AJ, tel 0524 854477.

Micro City is described as an exhibition of computers, business systems and communications and will take place at the Bristol Exhibition Complex from the 15th to the 17th May. A major feature is the Offices Of The Future exhibition which will occupy an entire hall. Details from Steve Hybs, Tomorrow's World Exhibitions Ltd, 9 Park Place, Clifton, Bristol BS8 1JP, tel 0272 292156.

Interconnection '84 is a new conference and exhibition which aims to cover the entire field of interconnection under four main headings: board level interconnection, interboard connections, equipment-to-equipment, and techniques and board materials. It will be held at the Park Lane Hilton, London, on the 6th and 7th June. The organisers welcome papers for presentation at the conference, preferably concentrating on one of the above headings. Further details contact Brian Morgan, Marketing Manager, Benn Electronics Publications Ltd, 146 Midland Road, Coton Lane, BBL, tel 0582 417438.

Finally, and moving a little further afield, the second Electronic Displays exhibition and conference will be held at Frankfurt (most of the exhibits will be from the 5th to the 7th September, and will concentrate as before on display devices, display drivers, CRT monitors and other devices used in modern information systems for text and graphic display. Again papers for presentation will be welcomed and information on this and other aspects of the event can be obtained from Network GmbH, An der Friedens- wiehe 10, 3050 Wunsstorf 2, West Germany.

Spaghetti Eater

If your office, workbench, or audio system is fast being swallowed up by a whirling mass of unidentified cables, Inmac's new cable ties could be the solution you need. Not only do they neatly group cables into bundles, they also allow you to indicate each bundle, making it instantly identifiable.

The ties are available in both permanent and releasable form, and will hold up to six cables in a bundle of up to 19mm diameter and costs £5.00 for a packet of 35. A releasable tie is also available with a self-adhesive pad so that a bundle of cables may be secured to any suitable surface. This tie secures three or more cables in a bundle of up to 19mm diameter and costs £5.00 for a packet of 35. Inmac Ltd, Dasy Road, Ashtoem, Rochester, Cheshire WA7 1QF, tel 09285 67551.


**HOME CONTROL KITS**

These kits are designed to provide a range of home automation solutions, from simple switching to complex control systems. They are designed to be easy to set up and use, with clear instructions provided.

**DISCLOSET KITS**

These kits are designed for disc lovers, featuring a range of components for building your own disc player. They are perfect for those who want to customize their disc player to their specific needs.

**ELECTRONICS ETI**

Our range of electronics includes everything from simple switching to complex control systems. We have a wide range of products to suit all needs, from hobbyists to professionals.

**COMPUTER SHOWROOM**

Now open every Tuesday to Friday 9am - 5pm, Saturdays 9am - 3pm.

**MICROPROCESSOR CONTROLLED MULTI-PURPOSE TIMER**

Now you can control your home appliances with a single device. The timer is easy to set up and use, with a variety of features to suit all needs.

**DVM/ULTRA SENSITIVE THERMOMETER**

This new device is designed for those who need to measure temperatures accurately. It is easy to use and provides a clear display of the temperature.

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**FURTHER SAVINGS**

LOW LOW PRICES

No circuit is complete without a call to -

**ETI TELEPHONE 01-573 2942**

11-13 Boston Road London W7 3SJ
**Portable Oscilloscopes**

Electronic Brokers is introducing its range of laboratory performance, portable oscilloscopes which are purpose-designed for tough operating conditions. They are both dual trace instruments, the PM3254 with single timebase and the PM3256 with added delayed timebase. The trigger and timebase circuits have been developed to give over 100MHz bandwidth, with vertical amplifier bandwidth 5MHz over a wide temperature range. The ruggedised CRT generates an extremely bright, small spot which produces accurate traces even in high ambient light conditions. Operational capabilities included are separate variable control of main and delayed timebases, variable hold-off, X-Y display facilities and trigger as standard. The trigger-view function can also be used as a third channel. Both oscilloscopes can be operated from either AC or DC power supplies.

The oscilloscopes are constructed around a strong tubular chassis. Front and rear panels are rigid plastic mouldings, the side panels are tough ABS and thick rubber bumpers offer protection to the corners. A shoulder strap is provided for easy transportation from laboratory to alternative locations. The PM3254 costs £1,096 and the PM3256 costs £1,196. For further information contact Electronic Brokers Limited, 61/65 Kings Cross Road, London WC1X 9LN, tel 01-278 3461.

**New Maplin Catalogue**

The 1984 Maplin Electronic Supplies catalogue arrived at the EET office the other day and kept on arriving! We don't know exactly how many copies they've sent us but if any more arrive we'll have enough to build our new offices with. The new catalogue has nearly 500 pages, 20% more than the 1983 edition, and includes a section on the Heathkit range of electronics kits. For the first time, Maplin's prices appear on the page rather than in a separate supplement. The prices will hold until at least February when an update leaflet will be issued. The new catalogue costs £1.35 and can be purchased from branches of W.H. Smiths or Maplin's own stores, or by post from Maplin's Rayleigh address for £1.65 including postage.

The Maplin stores mentioned above continue to increase in number. In addition to their stores in Birmingham, Manchester, London and Southend, they have recently opened a new one in Southampton. The shop is at 46-48 Bovis Valley Road, which is quite close to the City University. The existing premises had previously been used for the sale of electronic components for over forty years, and will now stock the extensive Maplin range.

**Free Of Charge**

Taking the idea of low battery costs through the use of Ni-Cads to its logical conclusion, Sanyo have introduced a charging unit which doesn't need a supply of electricity. Their NC-AM1 charger for AA (HP7) size cells is solar powered.

Sanyo have used what they call amorphous silicon semiconductor technology, or AMORTON for short, to produce the solar panel which has made the new charger possible. They do not say just how much output the new panel gives nor how long the unit will take to fully charge batteries. The charger, complete with four AA size Cadnica cells, should be on sale in the UK soon at a price which Sanyo say will be 'within easy reach of the average customer'.

**Musical Spectrum**

Ricoll have introduced an addition for the Spectrum which, they claim, allows a sound to be stored in memory and then replayed at any pitch. The ‘Action Replay’ will accept an input from a microphone or other audio source and after storing it allows real-time replay using the Spectrum keyboard or an external keyboard and an external amplifier and speaker.

The unit comes in a box which plugs directly into the Spectrum and has sockets for audio input and output. The input signal is sampled at 32 kHz and stored in 32k of RAM in the unit. The pitch of the stored sound can then be controlled from the keyboard. Ricoll claim four octaves upward shift and no limit to the downward shift. Using various software options, the sound can be reversed, reproduced continuously to form a sort of glitch-free tape loop, and have effects such as echo and vibrato added. Audio bandwidth is 12 kHz, signal-to-noise ratio 66 dB, quantisation noise 72 dB, and the manufacturers claim that distortion is undetectable and that the audio quality generally compares favourably with that of a good hi-fi cassette recorder. The unit is intended to be used in conjunction with a monitor which displays such factors as input level/overload, and with some of the other software options available allows Fourier analysis and synthesis.

The complete unit with a set of demonstration software costs £99.00 including VAT and should be available from the beginning of January. A few fingers here at EET got a bit itchy at the thought of playing with such a device, and so we have persuaded Ricoll to let us have a sample to evaluate as soon as the first production units are ready. Watch this space! Ricoll Electronics Ltd, 48 Southport Road, Ormskirk, Lancashire L39 1Qz, tel 0695 79101.
### CRIMSON ELEKTRIK

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<tr>
<td>2506</td>
<td>CPR 1X Pre-Ampl Module</td>
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</tr>
</tbody>
</table>

**WE ALSO STOCK ALL THE POWER SUPPLIES TO DRIVE THESE MODULES**

**PS. THESE KITS AND MODULES ARE EXCLUSIVE OF VAT**

### VELLEMAN KITS

<table>
<thead>
<tr>
<th>No.</th>
<th>Description</th>
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<tbody>
<tr>
<td>K510</td>
<td>Mono CC using LEDS</td>
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<tr>
<td>K1790</td>
<td>Stereo CC using LEDS</td>
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<tr>
<td>K1874</td>
<td>Running Light Kit</td>
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<tr>
<td>K2571</td>
<td>Light Computer with EPROM</td>
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<td>K2586</td>
<td>Three Tone Changer</td>
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<td>K2535</td>
<td>Microprocessor Doorbell 25 tunes</td>
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<tr>
<td>K2544</td>
<td>Complex Sound Generator</td>
<td>10.26</td>
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<tr>
<td>K2033</td>
<td>Digital Panel Meter</td>
<td>10.61</td>
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<tr>
<td>K2557</td>
<td>Digital Thermometer</td>
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</tr>
<tr>
<td>K2565</td>
<td>Crystal Changer Time Base</td>
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</tr>
<tr>
<td>K615</td>
<td>High Precision Stopwatch</td>
<td>50.23</td>
</tr>
</tbody>
</table>

**CALL IN AT OUR SHOP AND SEE DISPLAYS**

### TELETEXT KIT

This unit will make your TV fully remote control (infra-red) and bring you closer to the amazing world of teletext. The kits can be also used to incorporate full Prestel, and with a keyboard this can give you full message facilities for ordering foods or sending and receiving messages (e.g. a shopping list). With a microcomputer as an alternative keyboard the world is even greater and adding bulk updating to viewdata computers an essential ingredient for implementation for any personal computer.

Even without the Prestel option, Telesoftware from the Teletext pages free!

The full features of Teletext including subtitles are included in the basic kit. An attractive stylized case is available to complement the finished kit.

**TELETEXT KIT**

<table>
<thead>
<tr>
<th>Description</th>
<th>Price</th>
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<tbody>
<tr>
<td>79 STRAND CABLE per mtrs</td>
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### ACCESSORIES

**GLOBAL SPECIALIES**

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**ORGYX**

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### COMPONENTS

**Z80 E.C.**

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**ADC0161 (8 bit)**

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<td>3.50</td>
</tr>
<tr>
<td>2764(200ns)</td>
<td>11.00</td>
</tr>
</tbody>
</table>

We also stock 74 series 74LS, C mos, transistors, capacitors, resistors, LED's, diodes, jack plugs, mains plugs XLR plugs, connector plugs, make & break switches, bnc connectors, and infrareds. We stock multi-core solder for soldering, and sell miniatures. The temperature controlled power supply can be controlled within ± 0.1% within 1% at 10°C.

### BOOKS

**NEW BOOKS**

Price Note: Books are VAT exempt but add £1.00 to cover P/P.

- A-Z Transistor Equivalent book (2 volumes)
- The 9900 Family Data Book
- The Optoelectronic Data Book
- The Bipolar Microcomputer Data Book
- The Interface Circuits Data Book
- The TTL Data Book
- The MDS Memory Data Book
- The Linear Control Circuits Data Book
- The Voltage Regulator Data Book
- The Power semiconductor Data Book
- The Teletext Book Volume II

**ETI FEBRUARY 1984**
Red-u-ced!

Siemens have introduced four new LED digital displays which offer a considerable reduction in operating power over conventional types. Dissipation is limited to 80 mW per digit and Siemens claim that they are ideal for use with MOS devices and in CMOS circuitry.

The low power dissipation is achieved through the use of gallium arsenide phosphide as the semiconductor material. The luminosity is 1500 millilumens at 5 mA forward current and the forward voltage reaches a maximum of 2 V at 20 mA. The rated temperature range is 20°C to 70°C.

The emitters. The spectral response peaks at 820 nm, which is spectrally matched to the minimum attenuation region of most medium distance fibre optic cable. With a power output of 1.0 to 3.5 mW, the devices make short to medium distance, high-speed systems economically feasible. Applications are broad, and include industrial controls, computer systems, CATV and military.

For further information contact Motorola Ltd, European Literature Centre, 88 Tanners Drive, Blakelands, Milton Keynes MK14 5BP, tel 0908 614 614.

100MHz Fibre Optic Emitters

Motorola have introduced two new infrared emitters for fibre optic systems which are claimed to be the industry's first planar LEDs capable of data transmission at greater than 100 MHz bandwidth. The devices allow fibre optic system operation in areas previously reserved for expensive, edge-emitting LEDs and laser diodes at a significantly lower cost and a much improved operating life.

The new MFOE1201 and MFOE1202 infrared emitters are packaged in a TO-52 metal package which is hermetic, industry standard size and configuration and fits into commercially available fibre optic connectors. The internal lensing enhances coupling efficiency and provides a 250 µm diameter optical spot at 0.3 N.A. (numerical aperture) on the emitters. The spectral response peaks at 820 nm, which is spectrally matched to the minimum attenuation region of most medium distance fibre optic cable. With a power output of 1.0 to 3.5 mW, the devices make short to medium distance, high-speed systems economically feasible. Applications are broad, and include industrial controls, computer systems, CATV and military.

For further information contact Motorola Ltd, European Literature Centre, 88 Tanners Drive, Blakelands, Milton Keynes MK14 5BP, tel 0908 614 614.

1.5 µs, 12-Bit ADC

Burroughs have introduced a 12-bit analogue-to-digital converter with a maximum conversion time of only 1.5 µSec. Thought to be the fastest successive approximation A/D converter on the market, the ADC803 is accurate to ±0.015% of full scale range, operates with no missing codes over a 25°C to 85°C temperature range, and provides both serial and parallel outputs.

The converter incorporates a mix of proven IC and hybrid technologies and utilises state-of-the-art IC and laser trimmed thin-film components to achieve a complete A/D function including available resistance, clock and comparator. It is packaged in a 32-pin 42x23x5.5mm hermetically sealed DIP. Input scaling resistors allow internal selection of analogue input range from 0 to ±10V, ±5V and ±10V. Output codes are complementary binary for unipolar inputs and bipolar offset binary for bipolar inputs. All digital inputs and outputs are TTL compatible and power supply requirements are ±5V and ±15V. Because of its differential input comparator design, the ADC803 is very easy to use. The internal DAC drives a comparator input separate from the input signal so that the user’s driving circuitry does not have to handle the DAC’s large, fast transients.

For further information contact Burroughs International Limited, Cassiobury House, 11-19 Station Road, Watford, Herts WD1 1EA, tel 0923 33837.
Step by step fully illustrated assembly and fitting instructions are included throughout.

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**SPARKRITE**

**SELF ASSEMBLY ELECTRONIC KITS**

**SX 1000 Electronic Ignition**
- Inductive Discharge
- Electromagnetic switch circuit stores greater energy
- Double layer transistor switch
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- Easiest to assemble, easy to fit
- Contact breaker trigger input

**SX 2000 Electronic Ignition**
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- Electronic control circuit stores greater energy
- Two step transistor switch
- Contact breaker trigger input
- Potential step up fitting
- Fitted accessory complete kit
- Contact breaker trigger input

**TX 1002 Electronic Ignition**
- Inductive Discharge
- Electronic control circuit stores greater energy
- Three position transistor switch
- Contact breaker trigger input
- Easy to assemble, easy to fit
- Contact breaker trigger input

**TX 2002 Electronic Ignition**
- Two step electronic ignition
- Contact breaker trigger input
- Improved magnetic switch
- Easy to install remote sensitivity
- Daggers electrical energy
- High energy requirement
- Contact breaker trigger input

**AT 40 Electronic Car Alarm**
- Guards doors, boot, horn from unauthorised entry
- Armed disarm unit supervisedmovement: 30 second delay to arm: 7 second entry delay
- Can automatically be armed to enable key switch
- Specialised headlamps & sounds tone in deterrent length: 60 seconds when activated
- Security loop products
- Low current consumption
- C-MOS circuitry

**AT 80 Electronic Car Security System**
- Guards doors, boot, horn from unauthorised entry
- Almost 100% access denied by magnetic key.
- Armed disarm unit supervisedmovement: 30 second delay to arm: 7 second entry delay
- Can automatically be armed to enable key switch
- Security loop products
- Low current consumption
- C-MOS circuitry

**ULTRASONIC Intruder Detector**
- Supplementary to AT 40 & AT 80. Will work in conjunction with any door switch input for voltage warning alarm. DETECTS: Attempted break in, movement within passenger compartment & triggers alarm. Ejects high efficiency ultrasonic transducers
- Crystal control for low cost
- High current safety
- Low current consumption

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- 1 Function control by engine idle speed, temperature, distance traveled
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- Fuel consumption
- Mileage
- Speed
- Auxiliary alarms
- Security
- Warning
- Weather

**MAGIDICE Electronic Dice**
- Triggered by commuter headlight
- Travel display for 15 seconds
- Displays two numbers in communication
- Low current consumption

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IEEE Controlled Logic Analyser

The Hawk 3210 logic analyser interfaces with a host of microcomputers to give powerful diagnostic, processing display and hard copy facilities, and at £2495 is claimed to cost only about half as much as other machines offering less facilities.

The 3210 offers 32 channels of 1024 bits depth, with an internal sample clock programmable to 10 MHz. Triggers are programmable in binary, hex, octal, decimal, and ASCII for all 32 channels, including don't care states. Full pre and post trigger capability is provided, using delay of up to 1024 samples.

In timing mode, each screen page displays 128 samples of the 1024 bit storage and from any two of the four pods each carrying eight data probes. Pod 1 carries a dividable external clock input. Glitches are detected to 30MHz, with display detectable on or off. When displayed, glitches are shown as an overlay to data. In parallel state mode, binary, parallel, octal, hex, decimal and ASCII displays of 32 channels wide by 16 lines are available, with on-screen command prompt for control.

The unit has fully menu-driven operation and keyboard help for setting trigger words and selecting timing, hex, binary, decimal, octal or ASCII formats. All menus carry prompt instructions at the foot of the display.

Initially, the 3210 analyser is available for use with Apple II machines, a converter card giving the computer IEEE compatibility. However, software is now in development to allow the analyser to be used with Commodore, Sirius and other popular makes of microcomputer and controller. Hawk Electronic Test Equipment, Bircholt Road, Parkwood industrial Estate, Maidstone, Kent ME15 9XT, tel 0622 686811.

Triple Output Power Supply

The Kikusui PWC 0620 is a triple output power supply which offers 0 to 6 volts at up to 3 amps, and 0 to 20 volts and 0 to 20 volts, at up to 1 amp. The 20 volt outputs operate in a dual tracking mode and the unit has two large front panel meters, one for current measurement, the other for voltage. Any of the three outputs can be selected for display on the meter, and there are separate voltage and current controls for the 6 and 20 volts ranges. The power supply is operable either in constant voltage or in constant current modes. Ripple is only 0.5 mV on all outputs, and line and load regulation is within 3 mV. It costs £295 plus VAT, which is a lot more than you will have to pay for the only slightly less generously rated instrument which appears elsewhere in this issue. Telonic Instruments Ltd, 2 Castle Hill Terrace, Maidenhead, Berkshire, tel 0628 73933.

SHOTS

- The Scopex Instruments story, part 2: further to our recent report of Scopex’ demise, we are now assured that the company’s future is secure following the purchase of their assets from the Receiver by Bridgade Scientific Instruments Ltd. Bridgade say that all existing orders for Scopex products will be fulfilled as soon as possible. The new address for all enquiries is Scopex, 63-65 High Street, Skipton, North Yorkshire BD23 1EF, tel 0753 69511.

- Regisbrooke has issued a full colour brochure describing their wide range of opto-electronic devices, LED, LCD and vacuum fluorescent displays, keyswitches, display drivers, components and accessories. The brochure is available free of charge from Regisbrooke Ltd, Unit 5, Horshoe Park, Pangbourne, Berkshire, tel 0734 4841.

- Further doom and gloom. At a meeting of creditors which took place on the 8th November 1983, Jupiter Cantab Ltd, manufacturers of the Jupiter Ace microcomputer, was put into the hands of a liquidator. The business is now being offered for sale, and further details can be obtained from Charler & Myhill, Sussex House, Hobson Street, Cambridge CB1 1NJ, tel 0223 66692.

- The CM200 capacitance meter will measure capacitances between 1pf and 2,500uf, taking three readings per second and giving the result on its 4½ digit LCD to an accuracy of ±0.2%. It is lightweight, will run for several hundred hours from batteries or can be connected to the mains supply, and has a calibration control which allows the user to null out up to 25 pF test lead capacitance. It costs £89 plus VAT. Thrubury Electronics Ltd, New Road, St. Ives, Cambridgeshire, tel 0480 63570.

- In order to combat the shortage of skilled staff in the computing services industry COSIT, the Computing Services Industry Training Council has been given £600,000 by the government for its first year of operation. The programme will run for five years and the object is to pay firms to help them with their training. For details contact COSIT, 5th Floor, Hanover House, 73-74 High Holburn, London WC1V 6LE, tel 01-242 5049.

- The DPM60 4½ digit LCD module features auto-zero, auto polarity, and logic switched 200 mV or 2V FSD with 10µV resolution. It runs from a 7.5-15V supply, has 10mm high digits, and is available in kit form for £29.95 fully assembled. It is being used by Lascar Electronics Ltd, Model House, Whiteparish, Salisbury, Wilts SPS 2J1, tel 0794 48567.

- Galatrek’s combined fuse and 13A socket tester is about the size of a regular 13A plug and has two neon which indicate when connections are absent, reversed or correct. It costs £8.00 including VAT and post and packing from Galatrek International Ltd, Scotland Street, Llanrwst, North Wales.

- Ambit International have opened a new sales counter for their range of electronic components, books, kits, test equipment etc. The new counter is in the Broxlea building, near the High Street in Broxbourne, Hertfordshire. There is on-site parking and features include an on-line computer terminal and other advice and information services for customers. Ambit International, 200 North Service Road, Brentwood, Essex CM14 4SG, tel 0277 231616.

- The Beckman CT233 is a clamp-type Hall effect probe which, when used in conjunction with a multimeter, oscilloscope or other voltage indicating device, allows the measurement of AC and DC currents up to 600A. The unit handles conductors up to 45mm diameter, runs from a 9V battery, has an output of 600 mV for FSD, and an accuracy of 3% or better. Beckman Instruments Ltd, Mylen House, TI Wagon Lane, Shenot, Birmingham B26 3DU, tel 021-742 7761.

- Motorola have announced the adoption of the SOT-89 package for a broad range of microprocessor transistors, initially including general purpose high voltage Darlingtons and RF transistors. The new plastic package is an alternative to the much larger 1 watt TO-92 package, and in addition to the space saving involved Motorola say the preformed leads of the SOT-89 will facilitate pre-assembly testing. Motorola Ltd, RR Tanners Drive, Blakeland, Milton Keynes, tel 0908 614614.

- Gothic Crellon have published a 64 page catalogue covering their wide range of resistors, capacitors, semiconductor, relays, switches and the mini and micro computer systems sold by Crellon Microsystems. Copies of the A4 size catalogue are available free from the Sales Department, Gothic Crellon Ltd, 380 Bath Road, Slough, Berkshire SL1 6JE, tel 0628 4300.

- Bulgin are giving away 1984 calendar-cum-posters which illustrate their range of switches, fuse-holders and connectors. Copies are available from Brian Diggle, Advertising Manager, A. F. Bulgin & Co. PLC, Bypass Road, Barking, Essex IG11 0AZ, tel 01-594 5388.
**BBC Micro Computer System**

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Cartridge Lead £2.50 carriage

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MICROWAVE 14.1" RGB Mod Res £94
MICROWAVE 141" RGB Hi Res £400
MICROWAVE 204" RGB Mod Res £827
KAIG VISION 12" RGB Std Res £220
KAIG VISION II 12" RGB Hi Res £100
KAIG VISION III 12" RGB Hi Res £100
SANYO DVM 120A £99
All leads included. Cartridge £7

**ACCESSORIES**

Parallel Printer Lead £10 + £1 carriage
Serial Printer Lead £6 + £1 carriage
Serial Interface 2X £60 + £1 carriage
Serial Interface £60 + £1 carriage
Epson Printer Lead £6 + £1 carriage
Epson Pacer Holder £10 + £1.50 carriage
FX80 Tractor Attachment £7 + £1.50 carriage
FX Tractor Attachment £7 + £1.50 carriage

**PRODUCTION PROGRAM: P8000**

P8000 provides reliable gang programming of up to 8 EPROMs simultaneously with device sizes up to 16k x 8 bytes. Devices supported range from 2704 to 27128 in single and three array versions. Simple menu driven operation ensures easy access to EP and reliable minimum programming times. £856 + £6 carriage.

**BOOKS**

(no VAT; p&p £1)

Assembly Lang Prog for BBC Micro by Ferguson and Shaw. £9.95
Basic Prog for BBC. £5.95
BBC As An Expert Guide. £10.95
Easy Programming on BBC. £5.95
Further Programming on BBC. £5.95
Introducing BBC Micro. £5.95
Programming the BBC. £5.95
35 Educational Programs. £6.95
BBC Sound & Graphics. £6.95
Creating Adventure Programs. £6.95
Discovering Machine Code. £6.95
Structured Programming. £4.50
Beyond Basic BBC. £7.75

**TORCH Z-80 PACK**

Your BBC Computer can be converted into a business machine at a cost of £59.95, plus £2 postage. The Z-80A is a 8080A chip mounted in a 20 pin DIP socket, and includes a £2 Z-80A PROM. The BBC keyboard is interfaced to a standard Z-80A PROM card via a parallel interface. This Z-80A is a fully featured Z-80A computer, designed to run all BBC business software, including Wordwise 8k, BCPL, and Structured Programming. The Z-80A can be used as a stand-alone computer, or can be connected to the BBC via the Parallel Interface. The Z-80A comes complete with a 64k RAM card, and a 800k Floppy Drive. The complete package costs £59.95, plus £2 postage.

**TIME-WARP REAL-TIME CLOCK/CALENDAR**

A low cost unit offers the full range of Real-Time applications. With its full battery backup, it includes an Electronic Diary, automatic date and time setting, precise timing and control of scientific applications, recreational use in games etc., its uses are endless. A complete unit is £29.95, and a plug-in version is £25.95. Plug-ins are available for the BBC and the Acorn.

**EPROM ERASERS**

UV11 Eraser with a built-in timer and mains indicator. Built-in safety interlock to avoid accidental erasure of the harmful UV rays. It can handle up to 5 eproms at a time with an average erasing time of about 20 mins. £52 + £2 postage.

UV1 as above but without the timer £47 + £2 postage.

UV140 as above plus 14 Eproms £61
UV141 as above but with timer £79

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Help your computer to find its voice, with the ETI Mini-Mynah. Teach it words, phrases, sentences or even short stories — then have it repeat them back to you with a single command. Design, development, and awful name by Phil Walker.

The ETI Mini-Mynah is a speech generator with added extras — 100+ words of memory, inflection, and low software overheads are possibly the most important.

At the heart of the system is a General Instruments SP0256-AL2 speech processor IC. This is an NMOS LSI device, containing its own microcontroller, ROM, digital filter and pulse width modulator. The main attractions of this device are that it does not require vast amounts of data to produce understandable speech, it is easy to interface with other devices, its vocabulary is not limited, and it is available to the hobbyist.

The device uses allophone speech synthesis, which means that is provides for the generation of a basic speech sounds (including five silences) from which an unlimited number of words can be assembled. This, however, has the disadvantage that you have to work out exactly which sounds you need to generate to make the words you want to say — more on this later. Other versions of the SP0256 have more, different allophones.

The on-board 2K of RAM can store up to 2048 allophones, which can be in groups of up to 255 in length. The memory is set up by one program, which can then be deleted or over-written. To call up an allophone group thereafter requires only a single instruction within the program — the computer can then get on with other tasks while the sound generator churns out the vocals! However, reproduction is not limited to the set utterances stored by the initial program — individual words, phrases, parts of sentences can be picked out by single commands, and reproduced in any desired order; just because a group of allophones were entered together, they do not have to be reproduced together.

The Circuit

The circuit consists of a 2K block of memory, a speech generator chip, clock generator and output filter together with some control and interface devices.

The main requirements of the system is that data can be put into the memory (and read from it) under control of a common home computer. Having placed the required data in the memory, it is then possible to select a block of data by defining its start address and length. This data block will then be read by the speech generator to produce words, phrases or complete sentences without further action by the controlling computer.

During the design stage, it was noted that only six bits are required to specify one of the 64 allophones provided by the SP0256. For this reason, and because it provides a TTL compatible square-wave output, it was decided to use a 74LS624 VCO to provide the clock frequency for the speech generator; the two spare data bits from the normal eight-bit word are used to provide a four-level control voltage for the VCO. This has the effect of varying the pitch of the reproduced speech as each allophone is being reproduced. The rate of change of the control voltage is slowed down by a large capacitor to give a smooth final result. Adjustment
of the ‘normal’ pitch and of the degree of pitch variation can be made on the board. Additionally, a VCO is rather cheaper than a crystal!

For the following discussion we will assume that the 2K memory block is normally accessed in the address range 8192 to 10239 (decimal) for normal read and write operations and in the range 10240 to 12287 (decimal) for control functions (2000, 1, 27FF, a, 2800, a, to 2FF FF, respectively).

By reading and writing from and to addresses in the range 8192 to 10239 the RAM can be loaded with digital data representing the sounds to be made. The data consists of bytes of eight data bits in which the lower six select which tone of sound is to be made while the top two affect the pitch of the preceding allophone. This slight convenience is caused by there being no latch on the upper two data bits (this would have necessitated an extra chip had it been included).

In order to start a particular data string being rendered into speech, 2048 (decimal) is added to its starting address and a byte representing its length is written to the resulting address. When this has been done the speech generator will read out the data string in sequence and generate the required sounds. This process will continue until the full number of bytes has been dealt with without any further interference by the controlling computer.

What actually happens is that the write operation loads the address counters with the lower 11 address bits and the byte counter with the data on the data bus. After this operation the speech generator chip is enabled and generates the clock and loading signals by interaction with the byte counter and a simple gate circuit until the byte counter reaches zero. At this point the operation will stop.

If for some reason the controlling computer needs to know the current status of the unit (i.e. whether it is still talking or not) this can be done by a read operation to any address in the range 10240 to 12287 (decimal) and testing the state of data bit 7. This will be high for busy or still talking and low if the Mini-Mynah is ready to accept a new command. Note, however, that a false result may be obtained when the last byte is being processed as the byte counter will be zero before the speech generator has finished sounding (this will not cause a problem if the last byte was a pause).

We have not shown a power supply or audio amp for this project as there are so many simple circuits available. A power supply of 5V at about 300mA should be adequate.

<table>
<thead>
<tr>
<th>Word</th>
<th>Allophone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zero</td>
<td>ZZ/VR/OW</td>
</tr>
<tr>
<td>One</td>
<td>WW/AX/XX/N1</td>
</tr>
<tr>
<td>Two</td>
<td>TT/UW2</td>
</tr>
<tr>
<td>Three</td>
<td>TH/RR/YY</td>
</tr>
<tr>
<td>Four</td>
<td>FF/IF/OR</td>
</tr>
<tr>
<td>Five</td>
<td>FF/IF/IV</td>
</tr>
<tr>
<td>Six</td>
<td>SS/SH/HH/PA3/KK/SS</td>
</tr>
<tr>
<td>Seven</td>
<td>SS/SH/EH/HH/VV/HH/N1</td>
</tr>
<tr>
<td>Eight</td>
<td>EF/PAP/T2</td>
</tr>
<tr>
<td>Nine</td>
<td>NN1/AA/NN1</td>
</tr>
<tr>
<td>Ten</td>
<td>TT/EH/EH/NN1</td>
</tr>
<tr>
<td>Eleven</td>
<td>IH/EH/EH/VV/HH/N1</td>
</tr>
<tr>
<td>Twelve</td>
<td>TT/HW/HH/EH/HL/LLV</td>
</tr>
<tr>
<td>Thirteen</td>
<td>TH/EI/PAP/PA3/T2/T2/YY/NN1</td>
</tr>
<tr>
<td>Forty</td>
<td>TT/EW/EH/EH/NN1/PA2/P3/TT/2</td>
</tr>
<tr>
<td>Fifty</td>
<td>TT/EW/EH/EH/NN1/PA3/T2/T2/YY</td>
</tr>
<tr>
<td>Hundred</td>
<td>HH2/AW/XX/EH/PA1/PA1/P2/TT/D2/DD/DO1/HH/HH/PA1/DD</td>
</tr>
<tr>
<td>Thousand</td>
<td>TT/AA/AW/ZZ/HH/PA1/PA1/NN1/DD1</td>
</tr>
<tr>
<td>Million</td>
<td>MM/HH/HH/LU/YY/AA/NN1</td>
</tr>
</tbody>
</table>

Table 1 Some useful words as allophones.
Construction

Construction should pose no great problem here so long as care and sensible precautions are taken. The first thing to note is that the board is double sided but without plated through the holes. So some of the holes need wire links through them soldered on both sides. In other places the leads of decoupling capacitors must be soldered on both sides instead. This is necessary to complete the power supply wiring so make very sure it is done. We recommend the use of IC sockets especially for the more expensive devices. Make sure all polarised components are inserted the right way round. The order of construction we recommend is:

1. wire links;
2. IC sockets;
3. decoupling capacitors;
4. resistors, capacitors, diode, transistor, potentiometers;
5. power connector;
6. 34 way connector;
7. ICs into sockets (after checking for shorts, etc.).

Make doubly sure the ICs are the right way round, as they don't all point the same way.

We used a fairly expensive 34-way connector for this project, but it did save us having to solder an awful lot of wires, and
HOW IT WORKS

There are two main phases in the operation of this project: the first phase is the loading of the speech information into the memory (IC3); the second phase is the reading of the information from the memory to the speech processor to generate the required sounds. These two phases will be discussed in turn.

In phase one, IC1.2 and 3 and b are used to decode the control and more significant address lines from the computer. In this phase only pin 11 (Y4) of IC2 will be active (low). This enables data to be read from and written to IC1. The memory address select inputs of IC13 is via data buffer (IC9) and IC6, 7 and 8 which act as address buffers.

When IC1 pin 11 goes low, IC4a is enabled and the signal on the WR line is transferred to the WE input of IC5. Also, as IC2 pin 11 is low, the CS and OE pins of IC5 are driven high by the output from IC1 pin 13 until either the W/O or RD inputs to IC5 go high, forcing IC4a pin 12 high and thus IC1 pin 12 low. This enables the RAM until a specific condition is set up but it will keep the RAM in the READ mode when it is not being accessed externally.

The low on IC2 pin 11 enables the bidirectional buffer IC9 and also forces the output of IC10 low via IC3b. This causes the output of the outputs of IC6, 7 and 8 to follow the inputs from the address bus. These devices are actually four 5-bit binary counters which can be loaded asynchronously by taking their pin 11 low, which is the condition of IC4b.

In phase two, once suitable data has been loaded into IC5, a WRITE operation is performed by the control computer such that IC2 pin 10 (75) is sent low and the WR input line is also low. Under these conditions the output of IC4c will be low forcing the output of IC1d low via IC8 and thus loading the current contents of the lower address lines into IC6, 7 and 8. Also the low on IC4b output causes the contents of the data bus to be loaded into IC10 while holding the output of IC3c high.

At the end of the WRITE operation, the IC10 pin 14 (CARRY OUT) will normally be high indicating a non-zero counter. The output of IC1 pin 8 is high indicating that the speech generator is ready to accept data and since the output of IC4b will now be high the output of IC3c will go low indicating to IC11 that data is available from the RAM (IC5). A short time later this condition appears at IC11 pin 20, IC11 pin 8 will go low indicating that the data has been accepted. The output of IC3c to go high until IC11 pin 8 goes high again.

The rising edge of the output from IC3c triggers IC13 which is a monostable set to give a negative going pulse of about 1 usec. The output from IC13 drives the clock inputs of IC6, 7, 8 and 9 which are high.

These devices act on the rising edge of their clock signal. The purpose of IC13 is to trigger IC11 after the data has been captured. The first prototype produced some very strange noises without IC13!

The rising edge of the output from IC13 increments IC6, 7, 8 and decrements IC11. This then sets up the RAM address to the next byte of data, ready for the next sound. When the speech generator is ready for the next data, the process will repeat, and will carry on repeating until IC1 pin 14 goes to the low state to indicate that all the bytes have been read out. At this point the action will stop and new data will be written at.

At any time the status of the Mini-Mynah can be tested by doing a READ operation which sets IC2 pin 10 low. This will cause the output of IC4c to go low which will cause the current state of IC11 pin 4 to be transferred to IC4d pin 11 and thus onto the data bus (D7). A high will indicate that the speech generator is still in progress while a low level will indicate that a new command can be sent.

As only the 2K of on-board memory while IC1 is low. When IC1 is high the same address lines specify the starting address of the speech data string. A2, 13, 14, 15, MREQ and RFSH are all treated as select lines and must be 0, 1, 0, 0, 0, respectively, to enable any action to occur. This does not mean that all of them have to be driven individually. You may find it more convenient to use only one or two of them and connect the rest to +5V as appropriate. The RD and WR signals must be provided by your control system. If you have only a single R/W line you must provide an inverter for the RD signal.

The data lines, D0 to D7, can be considered as standard short cycle READ operation with A1 high (examining the status flag) only D7 will be active (high or low), the others will be floating at undefined levels. Also in this type of operation the address lines A0 to A10 will be irrelevant as the same data is returned whichever address is accessed.

Interfacing

Making the most effective use of this project requires a memory map space of 4K. This can be in one block, things are much simpler; however, any method of presenting 8 data bits and 12 address bits together with READ, WRITE, and SELECT (of SELECT) signals could be just as effective.

As described, the project is very easily interfaced with Z80 systems especially the Sinclair ZX81. To assist with the connection to the ZX81, the Mini-Mynah generates a signal on the ROMCS line which pulls high via a pull-up resistor when the device is being accessed. This signal temporarily turns off the ZX81 ROM to avoid a conflict between the devices we are adding.

Whatever host computer is used, address lines A0 to A10 are used as the 2K of on-board memory while IC1 is low. When IC1 is high the same address lines specify the starting address of the speech data string. A2, 13, 14, 15, MREQ and RFSH are all treated as select lines and must be 0, 1, 0, 0, 0, respectively, to enable any action to occur. This does not mean that all of them have to be driven individually. You may find it more convenient to use only one or two of them and connect the rest to +5V as appropriate. The RD and WR signals must be provided by your control system. If you have only a single R/W line you must provide an inverter for the RD signal.

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Setting Up

After building up the board carefully checking it through for wrongly placed components, etc., set RV1 fully clockwise and RV2 fully anti-clockwise, connect an audio amplifier to the output terminal and apply power. You will probably hear a random selection of burbles, hisses and squawks — this means that the Mini-Mynah is working. The noise should stop after a short while. If this does not happen, switch off and try again before carrying out the usual checks for component orientation, broken or shorted tracks, etc.

When it works this far, connect your computer (make very sure of your connections) power up the Mini-Mynah and then power up your ZX81 or whatever you are using. Once the noise has stopped (a momentary short across C4 will clear the problem) you are ready to try it out. Use the demo program or something similar to put data into the RAM and away you go. Try the effect of varying RV1 and RV2 until you get the best result. The sound can vary from a rapid robot voice to a growing monster-from-the-swamp effect.
Speech Synthesis

The spoken word is a very effective way of communicating information in small quantities to and from humans. For many years and for many reasons people have been trying to imitate the sounds of speech. Early attempts used collections of (mechanical) valves, pipes, resonators and noise sources which were thought to approximate to the human vocal tract. Later on these models could be implemented electronically which greatly eased the control problems.

Another system of making machines talk was also tried in which short sections of actual speech were preserved in some recording medium and played back in the sequence required. A notable example of this type of machine was the GPO (as it was then) speaking clock, TIM. This started life with the phrases recorded on glass discs.

With the boom in popularity enjoyed by the home computer has come the demand for speech synthesis systems which allow them to communicate with people. This can be done relatively easily by recording words and phrases in digital form (PCM — pulse code modulation) and playing them back on demand. The trouble with this is that to get good quality speech requires typically 70,000 bits of data per second. Methods have been developed which reduce this requirement (for example, LPC — linear predictive coding) by predicting what happens next partly from what has gone before, but even here the data rate is of the order of one to two thousand bits per second.

The two first methods described often have the feature that speech is available only in pre-set words or phrases; this of course makes them easy to use but on the other hand sets a limit to their applicability. Also, while memory devices are getting cheaper all the time, they take up space and consume power.

The allophone method breaks down speech sounds into individual components, so that a word such as ‘zero’ would have its sound broken into three parts — one for the z sound, one for the er sound and one for the o; the individual speech components are called allophones.

There are a very large number of potential allophones, as many different sounds as the human voice can generate! However, for any one language, the number of sounds used (or, rather, the number of distinguishably different sounds used) is relatively small. In this case, it is necessary for a speech synthesiser to be told a reference number for each of the three or more allophones it has to produce per second, and this reduces the bit rate to around 100 bits per second. However, the allophones themselves are fairly complex, so

<table>
<thead>
<tr>
<th>Sound Type</th>
<th>Symbol</th>
<th>Code</th>
<th>Duration</th>
<th>Example</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silences</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Short vowels</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>/PA1/</td>
<td>00</td>
<td>0</td>
<td>10ms</td>
<td>s</td>
<td></td>
</tr>
<tr>
<td>/PA2/</td>
<td>01</td>
<td>1</td>
<td>30ms</td>
<td>l</td>
<td></td>
</tr>
<tr>
<td>/PA3/</td>
<td>02</td>
<td>2</td>
<td>50ms</td>
<td>t</td>
<td></td>
</tr>
<tr>
<td>/PA4/</td>
<td>03</td>
<td>3</td>
<td>100ms</td>
<td>c</td>
<td></td>
</tr>
<tr>
<td>/PA5/</td>
<td>04</td>
<td>4</td>
<td>200ms</td>
<td>u</td>
<td></td>
</tr>
<tr>
<td>/IH/</td>
<td>0C</td>
<td>12</td>
<td>70ms</td>
<td>slt</td>
<td>These vowel sounds can be doubled to lengthen them.</td>
</tr>
<tr>
<td>/EH/</td>
<td>07</td>
<td>7</td>
<td>70ms</td>
<td>End</td>
<td></td>
</tr>
<tr>
<td>/AE/</td>
<td>1A</td>
<td>26</td>
<td>120ms</td>
<td>hAT</td>
<td></td>
</tr>
<tr>
<td>/UH/</td>
<td>1E</td>
<td>30</td>
<td>100ms</td>
<td>bOOK</td>
<td></td>
</tr>
<tr>
<td>/AO/</td>
<td>17</td>
<td>23</td>
<td>100ms</td>
<td>AuGht</td>
<td></td>
</tr>
<tr>
<td>/AX/</td>
<td>0F</td>
<td>15</td>
<td>70ms</td>
<td>sUcced</td>
<td></td>
</tr>
<tr>
<td>/AA/</td>
<td>18</td>
<td>24</td>
<td>100ms</td>
<td>hOt</td>
<td></td>
</tr>
<tr>
<td>Long Vowels</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>/IY/</td>
<td>13</td>
<td>19</td>
<td>250ms</td>
<td>sEE</td>
<td></td>
</tr>
<tr>
<td>/EY/</td>
<td>14</td>
<td>20</td>
<td>280ms</td>
<td>trAy</td>
<td></td>
</tr>
<tr>
<td>/AY/</td>
<td>06</td>
<td>6</td>
<td>250ms</td>
<td>kte</td>
<td></td>
</tr>
<tr>
<td>/OI/</td>
<td>05</td>
<td>5</td>
<td>420ms</td>
<td>sVoice</td>
<td></td>
</tr>
<tr>
<td>/UW1/</td>
<td>16</td>
<td>22</td>
<td>100ms</td>
<td>tO</td>
<td></td>
</tr>
<tr>
<td>/UW2/</td>
<td>1F</td>
<td>31</td>
<td>260ms</td>
<td>fOOD</td>
<td></td>
</tr>
<tr>
<td>/OW/</td>
<td>35</td>
<td>53</td>
<td>240ms</td>
<td>zOne</td>
<td></td>
</tr>
<tr>
<td>/AW/</td>
<td>20</td>
<td>32</td>
<td>370ms</td>
<td>dOWn</td>
<td></td>
</tr>
<tr>
<td>R-coloured vowels</td>
<td>/ER1/</td>
<td>33</td>
<td>51</td>
<td>160ms</td>
<td>lettER</td>
</tr>
<tr>
<td></td>
<td>/ER2/</td>
<td>34</td>
<td>52</td>
<td>300ms</td>
<td>fERn</td>
</tr>
<tr>
<td></td>
<td>/OR/</td>
<td>3A</td>
<td>58</td>
<td>330ms</td>
<td>fORTune</td>
</tr>
<tr>
<td></td>
<td>/AR/</td>
<td>3B</td>
<td>59</td>
<td>290ms</td>
<td>alARm</td>
</tr>
<tr>
<td></td>
<td>/YR/</td>
<td>3C</td>
<td>60</td>
<td>350ms</td>
<td>hEAr</td>
</tr>
<tr>
<td></td>
<td>/XR/</td>
<td>2F</td>
<td>47</td>
<td>360ms</td>
<td>stARe</td>
</tr>
<tr>
<td>Resonants</td>
<td>/WW/</td>
<td>2E</td>
<td>46</td>
<td>180ms</td>
<td>We (See also /WH/)</td>
</tr>
<tr>
<td></td>
<td>/RR1/</td>
<td>03</td>
<td>14</td>
<td>170ms</td>
<td>Read</td>
</tr>
<tr>
<td></td>
<td>/RR2/</td>
<td>27</td>
<td>39</td>
<td>130ms</td>
<td>cRane</td>
</tr>
<tr>
<td></td>
<td>/LU/</td>
<td>2D</td>
<td>45</td>
<td>110ms</td>
<td>Like</td>
</tr>
<tr>
<td></td>
<td>/EL/</td>
<td>3E</td>
<td>62</td>
<td>190ms</td>
<td>angLE</td>
</tr>
<tr>
<td></td>
<td>/YY1/</td>
<td>31</td>
<td>49</td>
<td>130ms</td>
<td>cUte,</td>
</tr>
<tr>
<td></td>
<td>/YY2/</td>
<td>19</td>
<td>25</td>
<td>180ms</td>
<td>Yes compUter (Y-sound)</td>
</tr>
</tbody>
</table>

Table 2 The allophones that the sound generator IC used offers.
what is needed is a table where the generator can 'look up' the composition of the allophones it is being required to produce. The data that is sent to the speech processor is not, therefore, the actual allophones themselves, but the address (or a pointer to the address) of the code for the allophone, which is stored within the device itself.

The device used does not use PCM or LPC, as these systems would still require a very large amount of stored data. The data is actually used by the on-board processor which controls noise sources and filters, as well as the basic tone generators. The quality of speech produced is not as good as PCM or LPC systems, but it is quite intelligible.

The device is used with the SP0256-AL2 which provides us with a set of 64 allophones. This imposes some restriction on what we can do, but this is not too severe.

It should be understood that in a language such as English, there is no absolute correspondence between what is written and the sounds generated when the same word is spoken. Also, it is often difficult to decide where one sound finished and another starts. To some extent the same basic sound will vary a little depending on its position within a word and also on what sounds are adjacent to it.

When programming the Mini-Mynah it is necessary to decide what sounds you require rather than the letters or words as written. Experiment with alternatives where they are available to get the right sound in the right position. Table 2 shows the 64 speech sounds available from the SP0256-AL2. These are broken down into groups of similar types and are shown with their decimal and hexa-decimal addresses (these correspond to the six LSBs of the data you put into the on-board RAM).

The table also shows the duration of each sound at a nominal 3.12 MHz clock frequency and gives an example or two of the sound in a word context. Notice that alternatives are given for some sounds and that short pauses are recommended before some and after others to make them effective. Try the example words to get a feel for what constructions are needed in different circumstances.

Once you have mastered the allophone set, and can produce understandable speech, you are ready to give it some life. This is where the two MSBs of the data come in. With these you can change the pitch (and duration) of the allophone immediately preceding the one whose six LSBs you are setting. By experimenting carefully, you should be able to make much more natural sounding speech rather than the monotonous, flat sound usually associated with computer speech.

<table>
<thead>
<tr>
<th>Sound Type</th>
<th>Symbol</th>
<th>Code</th>
<th>Duration</th>
<th>Example</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voiced Fricatives</td>
<td>/VV/</td>
<td>23 35</td>
<td>190ms</td>
<td>Vest</td>
<td></td>
</tr>
<tr>
<td></td>
<td>/DH1/</td>
<td>12 18</td>
<td>290ms</td>
<td>His</td>
<td></td>
</tr>
<tr>
<td></td>
<td>/DH2/</td>
<td>36 54</td>
<td>240ms</td>
<td>baTHe</td>
<td></td>
</tr>
<tr>
<td></td>
<td>/Z1/</td>
<td>28 43</td>
<td>210ms</td>
<td>Zoo</td>
<td></td>
</tr>
<tr>
<td></td>
<td>/ZH/</td>
<td>26 38</td>
<td>190ms</td>
<td>pleaSure,</td>
<td>aZure</td>
</tr>
<tr>
<td>Voiceless Fricatives</td>
<td>/FF/</td>
<td>28 40</td>
<td>150ms</td>
<td>Food</td>
<td></td>
</tr>
<tr>
<td></td>
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<td>10 29</td>
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Table 2 continued.
TOTAL ENERGY DISCHARGE ELECTRONIC IGNITION

IS YOUR CAR AS GOOD AS IT COULD BE?

- Is it EASY TO START in the cold and the damp? Total Energy Discharge will give the most powerful spark and maintain full output even with a near flat battery.
- Is it ECONOMICAL or does it “go off” between services as the ignition performance deteriorates? Total Energy Discharge gives much more output and maintains it from service to service.
- Has it a point or is it flat at high and low revs, where the ignition output is marginal? Total Energy Discharge gives a more powerful spark from idle to the engines maximum (even with 8 cylinders).
- Is the PERFORMANCE SMOOTH. The more powerful spark of Total Energy Discharge eliminates the “near misfires” whilst an electronic filter smooths out the effects of contact bounce etc.
- Do the PLUGS and POINTS always need changing to bring the engine back to its best? Total Energy Discharge eliminates contact arcing and erosion by removing the heavy electrical load. The timing stays “spot on” and the contact condition doesn’t affect the performance either. Larger plug gaps can be used, even wet or badly fouled plugs can be fired with this system.

TOTAL ENERGY DISCHARGE is a unique system and the most powerful on the market - 3 times the power of inductive systems - 3 times the energy and 3 times the duration of ordinary capacitive systems. These are the facts:
- Performance at only 6 volts (max. supply 18 volts)
- Spark Power - 140kV
- Spark Energy - 36mJ
- Spark Duration - 500µs
- Stored Energy - 135mJ
- Loaded Output Voltage - 50F load - 38kV, 50F + 50k - 28kV

We challenge any manufacturer to publish better performance figures. Before you buy any other make, ask for the facts. It’s probably only an inductive system. But if an inductive system is what you really want, we’ll still give you a good deal.

All ELECTRONIZE electronic ignitions feature:
- EASY Fitting: STANDARD ELECTRONIC CHANGEOVER SWITCH, STATIC TIMING LIGHT and DESIGNED IN RELIABILITY (14 years experience and 3 year guarantee).

IN KIT FORM it provides a top performance system at less than half the price of comparable ready built units. The kit includes: pre-drilled fibreglass PCB, pre-wound and varnished ferrite transformer, high quality 2µF discharge capacitor, case, easy to follow instructions, solder and everything needed to build and fit to your car. All you need is a soldering iron and a few basic tools.

Most NEW CARS already have electronic ignition. Update YOUR CAR.

ELECTRONIZE ELECTRONIC CAR ALARM

HOW SAFE IS YOUR CAR?

More and more cars are stolen each week and even a steering lock seems little help. But a car thief will avoid a car that will cause him trouble and attract attention. If your car has a good alarm system - well there are plenty of other cars to choose from.

LOOK AT THE PROTECTION AN ELECTRONIZE ALARM CAN GIVE:

- MINIATURE KEY PLUG A miniature jack plug attached to your key ring and is coded to your particular alarm.
- 2425 INDIVIDUAL COMBINATIONS The key plug contains two 1% tolerance resistors, both must be the correct value and together give 2425 different combinations.
- ATTRACTS MAXIMUM ATTENTION This alarm system not only intermittently sounds the horn, but also flashes the headlight and prevents the engine being started.
- 60 SECOND ALARM PERIOD Once triggered the alarm will sound for 60 seconds, unless cancelled by the key plug, before resetting ready to be triggered again.
- 30 SECOND EXIT DELAY The system is armed by pressing a small button on a dashboard mounted control panel. This starts a 30 second delay period during which the owner can open and close doors without triggering the alarm.
- 10 SECOND ENTRY DELAY When a door is opened a 10 second delay operates to allow the owner to disarm the system with the coded key plug. Latching circuits are used and once triggered the alarm can only be cancelled by the key plug.
- L.E.D. FUNCTION INDICATOR An LED is included in the dashboard unit and indicates the systems operating state. The LED lights continuously to show the system is armed and in the exit delay condition. A flashing LED indicates that the alarm has been triggered and is in the entry delay condition.
- ACCESSORY LOOP - BONNET/BOOT SWITCH - IGNITION TRIGGER These operate three separate circuits and will trigger the alarm immediately, regardless of entry and exit delays.
- SAFETY INTERLOCK The system cannot be armed by accident when the engine is running and the car is in motion.
- LOW SUPPLY CURRENT CMOS IC’s and low power operational amplifiers achieve a normal operating current of only 2.5mA.
- IN KIT FORM it provides a high level of protection at a really low cost. The kit includes everything needed, the case, fibreglass PCB, random selection resistors to set the code and full set of components etc. In fact everything down to the last washer plus easy to follow instructions.
We publish a superb project like Bob Campbell’s 64K DRAM board for 6502/6800 systems and instead of gratitude, all we get are hundreds of letters asking for a Z80 version. Here it is then, you ungrateful lot, and don’t forget to say “thank you”!

When I set out to design the DRAM Board (published in ETI Sept. 83) I had no intention of considering its use with the Z80 processor. However, the question “Can it be done?” provides a good introduction to the many considerations that must be given to the peculiarities of the Z80 when designing almost anything for it, not least a dynamic memory system.

Since this is to be an add-on or an extension to an existing system we must first consider the probable target system and the alternative solutions to the ‘maximum memory objective’.

Probable target computers include:
- Z80 Systems with some dynamic memory, 16K eg. TRS-80, Video Genie;
- Z80 systems with little or no memory, eg. Home Brews, µ-Professor;
- ZX80, ZX81, ZX Spectrum, are not worth considering as they already have very comprehensive and cheap support.

There are three distinct solutions to satisfy the first two users. They are:
1. Modify the DRAM Board to suit the Z80.
2. Design a new board to take in all the advantages of the Z80 using similar techniques and with the same overall objectives.
3. Replace and extend an existing 4116 based system with 64K chips (this applies to the first user only) using the original PCB, with either complete re-decoding using a PROM or modifying the existing TTL decoding on board. This option will probably end up with the system ROM still within the memory map, ie. decoding 16K blocks and upgrading to 48K from 16K.

Modifying the DRAM Board

Consulting the circuit diagram from the original article, it can be seen that only three signals other than the address and data buses are taken from the system. These are R/W, Φ1 and Φ2. To use the board with the Z80 these signals must be mimicked in such a way that they satisfy both the requirements of the board and the processor itself.

Assuming for the moment that the discrete refresh counter, IC1, is to be retained, then the following observations can be used as a guide to the final design:
- R/W — this signal is high during a read cycle and low during a write to memory cycle;
- Φ1 — this signal, or more accurately, the rising edge of it initiates the refresh cycle; and also clocks the refresh row address counter;
- Φ2 — this is slightly more complex as it signifies both a valid address and the start of a memory access cycle, read or write.

Obviously the R/W line is the simplest and in fact WR can be substituted directly in its place. RFSH, the Z80 signal, performs a similar function to Φ1 although it is inverted, ie negative true, and thus must be inverted before substitution. MREQ is very similar to Φ2 although again it is inverted, ie active low. One other slight complication is that MREQ becomes active during the refresh cycle RFSh.

Obviously this situation must be distinguished from a true memory access cycle.

Combining all these conditions, the two necessary logical signals can be arrived at, namely MC and RC Memory and Refresh cycle start; note that both have active rising edges. The two equations are:

\[
\text{MREQ} \land \text{RFSh} = \text{MC} \\
\text{RFSh} = \text{RC}
\]

These two equations can be resolved into a logical circuit in the usual way, ie. hard slog, copy someone else, intuitively or by guess work. However it is arrived at, it should look something like Fig. 1. The prime (’) on any signal indicates that it is a substitute.

This solution will work in principle; however the timing constraints of the board as a whole,
and particularly those of the 74LS608, are such that it will probably not work without adjusting the timing components around IC17.

A slightly better solution becomes apparent from the timing diagrams of the Z80. Consider the same situation which we have just tried to avoid, MREQ becoming active during RFSH. Taking cycle T3 in Fig. 2,

![Diagram showing the timing of the Z80's MREQ and RFSH functions.](image)

...only in the worst possible case can MREQ become active before RFSH. Thus MREQ could be used as a cycle start directly, and that means for both refresh and memory access cycles. In fact most systems using dynamic memory use MREQ as RAS and generate ROW/COL and CAS by delay lines from that active edge. Delay lines are to be avoided if at all possible, but unfortunately this is not always so in DRAM design. The second solution now looks like Fig. 3; this is much simpler than all the others and should work very well, in theory at least. The need for the two signals φ1 and φ2 to control the address and data buffers means that the circuit is still more complex than it might be.

Further improvements can still be made to the circuit by using the Z80's on chip refresh row address counter.

During RFSH, the CPU puts out on the lower seven address lines a refresh row address which is cycled through 0-128, incrementing once very M1 cycle. Using this address the 393, IC1, can be dispensed with, and the 244 that goes with it, IC2. Since the Z80 refresh address is only seven bits wide, the TMS 4164 cannot be used as it requires an eight bit, 256 cycle refresh. The 4864 64K x 1 bit memory and its derivatives (see Table 1) use a 128 cycle 2ms refresh cycle and thus only require seven refresh address bits, and these should be used instead.

Using the Z80 refresh address counter in this way requires the primary address buffer IC 11 to be enabled on both the refresh and memory access cycles, and the address multiplexers, IC 12 and IC 14, to present the lower 8 bits A0-A7 and the upper 8, A8-A15, of any address separately. In other words, the lower 8 should be on the "a" side and the upper 8 on the "b" inputs to the multiplexers, or vice versa but not intermixed. All these modifications could be made, and the timing corrected to suit and a PROM programme devised etc, but unless there is a pressing reason for the DRAM board to be used in this way for a Z80 application, I would advise against it. There is a great deal more to be gained by using a purpose designed Z80 RAM Board.

Such a design is presented here and the advantages are clear, but first some notes on converting the 16K 4116 system such as that of a TRS-80 or Video Genie.

### 16-48K Upgrade

Those computer systems already using the 4116 dynamic RAMs obviously have the necessary circuitry to produce the signals to drive the RAMs properly. Those signals, including the address multiplexing, are usually controlled by the decoding circuitry, by gating either CAS and/or the enable for the output/input buffers. The main difference between a 16K 4116 and a 4K 4864 memory array is the 'width' of the decoding, A7 and the supply rails. Looking at the pin configuration of the two RAM chips reveals that only three pins are different, see Fig. 4. So with the minimum of modifications it is a relatively simple matter to swap the two using the original PCB.

![Pinouts of the 4116 and 4864 DRAMs.](image)
inclusive connected to the
inputs of the multiplexers. Both
A14 and A15 must now be
added to these and should cor-
respond to the new output just
connected to A7 pin 9 on the
RAMs. Thus the final circuit
should look something like Fig.
5. The main thing is that A0-A6
are all on one side of the mul-
tiplexer’s inputs, ie, all a’s or all
b’s.

Finally, the last modification
is to the decoding circuitry, and
this is probably the most
machine dependent modifica-
tion of all. Of the numerous sys-
tems in use, the most common is
to gate the CAS signal to the
appropriate RAM block through
a tri-state buffer. It is necessary
only to increase the decoding to
this buffer to enable the new
areas of RAM.

Modifying the power supply
lines is the first and the simplest
of the changes necessary:
PIN 1 \( V_{bb} \): this track should
be disconnected, at both ends of
the RAM array, from the \(-5\) V
supply; furthermore all the
 capacitors on this line between
it and the circuit should be removed. The
track now takes no further part
in the circuit until we upgrade to
256Ks!

PIN 8 \( V_{dd} \): this now becomes
+12V, the +5V line on the 4864;
thus should be disconnected
from the original +12V supply
and reconnected to a suitable
point on the computer’s +5V cir-
cuit. Any capacitors between it
and ground should be retained;
there is usually one per IC, and if
there is not, additional ones
should be added; 1\( \mu F \) tants or
0.1 \( \mu F \) MKC will do.

PIN 9 \( V_{aa} \): finally, this track
becomes the additional address
line A7. It should be disconnected
from the +5V supply and all the
attached capacitors
removed. The now isolated track
should be connected to the
next output of the address
multiplexers. Normally these are
a pair of 74LS157s. The remain-
der of the circuitry around the
RAM array is identical to the
original 4116 regime.

The modification to the
address multiplexers, which
usually consists of two
74LS157s, is dependent upon
the specific system. The normal
approach is to have only A0-A13

Fig. 5 Modified address multiplexer
arrangement.

Fig. 6 Decoding circuitry of the Video Genie a) before and b) after modification.

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Table 1 Comparison of 64K DRAMs.
There are two distinct ways of doing this; one is to extend the existing decoding and the other is to use a PROM in a way similar to the original DRAM Board design. The latter approach would follow almost exactly the DRAM design, and those of you wishing to attempt that will find enough information in the original article.

The much simpler approach, if not as profitable in terms of added memory, is to modify the existing decoding. Normally the memory map is decoded into four 16K blocks at the primary decoding level, and by using the unused blocks within the memory map the usable RAM can be expanded. Using the Video Genie as an example, the original circuit is shown in Fig. 6a, and the modified one in Fig. 6b. In the latter the two unused outputs of the 74LS139 (Z25) are combined to give a total RAM area of 48K. Note that there is an unused 16 pin socket on the main PCB which can be used for the additional IC.

It can be seen then that the 4864/4116 replacement technique is relatively simple and produces a very neat and reliable 32K expansion to the average system. To go further than the 32K addition requires more effort and the advantages of retaining the RAM on the original PCB become less: the purpose-built Z80 64K RAM card then comes into its own. As with the original DRAM Board design, it can be designed to be as flexible as possible, thus allowing for all the vagaries that can and do exist in the original target system. The power on jump vector, which tricks the CPU into thinking that there is EPROM at 0000 hex at restart only where there is actually RAM, is the most common difficulty to overcome. Note that this is a must for CP/M systems.

The concluding part of this article in next month’s ETI will describe the new DRAM board for use with Z80 microprocessors.
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REVIEW: EC50 SOL

There could be a whole new generation of soldering irons just around the corner. Dave Bradshaw has been trying his skills on the EC50 iron from Litesold.

It is one of my few beliefs that one of the largest impacts that electronics will have on the world is to make hitherto 'stupid' devices 'intelligent'. By this, I mean that vacuum cleaners, as an example, may have the ability to modify the power going to the motor to prevent the usual off-load 'racing' that often occurs, and, possibly, to reduce the noise (if you have ever used an industrial cleaner, you'll understand the need for this latter point).

So it is not a little ironic (if you will excuse the impending pun) that soldering irons haven't changed all that much — most of those in use in hobby circles are pretty primitive specimens.

Actually, manufacturers have a somewhat impressive term for the sort of iron that just about everyone has — they call them thermally balanced; this means that the iron's temperature will settle at the point where the heat input is equated by the convection and radiation losses from the bit and barrel and conduction losses into the handle.

When the iron is applied to a workpiece, the temperature of the tip will inevitably drop. The iron will then have to recover after removal off the job. The heat that goes to the job comes from both the heat stored in the iron before contact (the heat is stored in the thermal capacity of the materials in the bit and element) and from the heat being generated in the iron.

It is here that there is a conflict of design requirements. A fairly massive iron would be able to solder larger jobs than one with a lower capacity, because it would have a larger reservoir of stored heat to give to the job. However, it will take a lot longer to heat up a more powerful iron (as well as to cool it down) and it will, after a fairly largish heat outflow, take longer to recover; also it will probably be less convenient to use because it will be 'bit-heavy'.

To get around this you can increase the power of the element. If you've ever had to solder with a more powerful iron than you would normally use, you'll probably have found, as I have, that in some ways it's a lot more convenient than using a small iron. The element is so hot that anything you apply the tip to is heated up in no time at all, and you can work a lot faster than normal. However, the crunch is that a larger power almost invariably means a longer barrel, or a much hotter tip, or both. A longer barrel means that soldering any number of joints is very tiring, because it's that much more difficult to position the bit accurately. A hotter tip means that you run the risk of destroying delicate components or of stripping off PCB foils.

All this said, it's really quite surprising that simple, thermally balanced soldering irons work as well as they do! However, if you're going to be a serious constructor, it's almost inevitable that you will have to buy two or possibly even three irons of different sizes to make it possible to deal with all the soldering requirements you are likely to meet.

**Soldering Electronic**

Well, the obvious thing to do is to have some form of electronic control over the heat supplied to the soldering iron element. This is relatively simple in principle — a temperature sensor in the element is linked to some electronics that turns the element on whenever the temperature drops below a selected value. The problem is that the way that this is usually built is to have a separate control unit, with a special iron that can be used with only that particular unit. This is done because it is easiest to control a low voltage — so the control units have large transistors in them to supply the low-voltage soldering iron element as well as the control electronics (it goes without saying that the element of a controlled soldering iron is usually rather more powerful than that of the equivalent thermally balanced unit, otherwise the controlled iron would actually be worse than the balanced unit).

This has two main disadvantages: firstly, it makes the soldering iron/control unit expensive — you'd be hard put to buy a controlled iron with control unit for under £50; secondly, it makes the iron a lot less convenient to cart around.

Even with a separate control unit, you don't always get a particularly flexible unit — with many of them, to alter the bit temperature you have to change the bit itself. This means that you have to let the iron cool off first!

Some irons have been made that have a controlled temperature and don't need a separate unit; however, until recently, so far as we know these were not electronic — they used either the Curie point or some sort of thermal expansion effect to open and close mains contacts, with the resulting questionable applicability to delicate (particularly CMOS) electronics.

**Enter The EC50!**

It is on to this scene that Litesold have launched the EC50. This is an electronically controlled soldering iron but with all the electronics mounted in the handle. Don't worry, there isn't a mains transformer in there too, the element operates at mains voltage and is switched on and off by a triac at zero crossing.

To supply the electronics, Litesold have come up with a rather neat trick — and before other manufacturers copy it, I must point out that it is the subject of
The soldering iron is shown at about 65% actual size here.

DERING IRON

The heat supplying capabilities of the iron were not exactly taxed by this trial, so off I went, scurrying down into my cellar to see what I could find. After beating off monstrous spiders, creepy-crawlies, etc., I eventually uncovered two items of valve gear — one was an oscilloscope that I built many moons ago, and the second was an old “Williamson” valve amplifier that had been donated to me by a father of a friend (it’s amazing how junk cupboards give up their wares to you when you mention that you’re interested in electronics!). The oscilloscope had been assembled using a 25W iron, coincidentally also made by Litesold but a rather older vintage, so it was not that surprising that I could find nothing in it to tax the iron. However, the amplifier was a different matter.

It was built using a hefty piece of copper wire as a busbar earth line; besides this it used paper smoothing capacitors as these used to be a time when people thought that unpolaredised capacitors ‘sounded’ better than electrolytic ones (I’ve heard that somewhere before...). These capacitors have massive metal terminals, and it looked as though they had been soldered to the busbar using a blowtorch (perhaps I exaggerate a little, but only a very little!). Here was a test!

However, the iron copped admirably with these joints, making it possible to dismantle them and make them up again — though this was the only time that I saw the second section of the indicator neon on for any noticeable period.

Finally, I used the iron to solder some rather awful cheap PCB board that I was foolish enough in my youth to build a whole audio amplifier with. The board is made from paxolin, and the copper has a very bad tendency to lift off when any heat is applied to it, making periodical repairs to the amplifier a nightmare.

At first, I used the iron at its temperature setting as delivered (this is the setting that it was used on for the other jobs in this report). With this setting, the foil lifted fairly quickly after application of the iron. However, turning the iron’s temperature down to minimum made it possible to solder without the foil lifting — although the fluxes in the solder will

a patent. Like all really good ideas, it seems so obvious that you wonder why no one thought of it before.

The trick is this: to get the correct supply voltage for the electronics, some sort of mains dropper is required. A dropper resistor is used, but rather than being in the handle, where its eight watts of dissipation would make the iron uncomfortable to hold, it is wound onto the element itself, as a separate winding, so it contributes towards the heating of the element.

The temperature of the element is monitored by a thermistor mounted right up at the top end of the element, so it actually sits inside the bit. According to Litesold, this thermistor is the single-most expensive bought-in component in the iron! The temperature of the iron can be set using a control on the side of the handle.

Inside is a rather friendly neon (I’m afraid that I’m an old reactionary in that I prefer neon to LEDs as indicators!) which indicates both when the mains is applied to the iron and when the element is on. One gripe I would make about soldering irons in general is that there is no indication of when mains is being applied — how many of you (like me) have picked up a soldering iron by the wrong end, thinking that you’d switched it off some time before? Wouldn’t it be a good idea if more irons had indicators in their handles?

In Use

Well, no matter how elegant the ideas that went into the iron, the crunch issue is how well it performs. This I, and a few other members of the ETI team, were only too pleased to put to the test.

First of all, I tried some PCB assembly work using the standard bit. The PCB I assembled did have 0.1” spaced DIL ICs on it; however, there was no tracking inbetween the pins. Using the standard bit, soldering was a bit tight, although possible to get a reasonable job (I’m not the world’s most fussy solderer anyway!). Later, Phil Walker assembled one of our 64K DRAM boards using the iron but with a special fine-work bit, and his conclusion that this was actually easier than using his usual iron, which is a soldering station with a pointed bit.
Please ignore the grubby hand and concentrate instead on the small screwdriver-setable temperature control. There are no calibrations, but this, in practice, should not cause problems.

Ian Pitt reports that he tried using the iron for a number of unusual jobs, including soldering together the joint of a small pair of scissors and soldering metal contact straps onto RR size NiCads, all of which the iron did successfully.

The only grumble that we all had about the iron was that the handle got slightly warm in one place—

not so warm as to ever be uncomfortable (but not like a certain iron that is very common but also sometimes very difficult to hold!), but enough to be noticeable.

Conclusion

In my opinion, this is rather an excellent tool that is a pleasure to use (in fact I hope that Litesold don't want the test iron back). Although it is a lot cheaper than a soldering station, it is still around four times the price of a conventional soldering iron, so you would have to do quite a lot of soldering to justify the cost. That said, for use away from the bench, it is obviously much more convenient to be able to carry just one iron rather than several.

The EC50 costs £26.19 direct from Litesold, and this price includes VAT and VAT. Litesold's full name is actually Light Soldering Developments Limited, and they may be found at 97/99 Gloucester Road, Croydon, Surrey CR0 2DN, telephone 01-689 0574/5/6.

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Bench power supplies rarely come high on the electronics enthusiasts' list of essential test equipment. There must be many who, having acquired a multimeter, 'scope, and possibly a signal generator, are then content to go on powering their high-tech lash-ups from a string of dry batteries. Yet for the really serious experimenter a power supply is virtually an essential, the only practical means of obtaining multiple and dual rail supplies which are reasonably stable and can be varied in voltage. Even people who only use their equipment and skills to construct projects from magazine articles (ours of course!) or to repair ailing electrical equipment are bound to wish they had one sooner or later. How many pieces of battery-operated equipment have you tried to repair in which the battery compartment becomes unusable as soon as the case halves are separated?

Fear not, gentle ETI readers, salvation is at hand. The ETI bench power supply does just about everything you could reasonably ask of such a unit, costs much less to build than equivalent commercial designs, and is even available as a full kit of parts. It has outputs of +5V, +15V and -15V all of which can be varied, and two meters measuring voltage and current which can be jointly switched to monitor any of the outputs. The +5V supply gives 2.5A and is variable over the range 3-8V. The +15V and -15V supplies give 0.5A each and are variable over the range ±8 to ±16V; a single control varies both supplies, the negative output accurately tracking the positive one to ensure that the two are balanced at all times. All supplies are protected against overload and against external voltages injected into their outputs.

Construction
The PCB should be assembled first, inserting solder pins then small components such as resistors and semiconductors before the capacitors. Ensure C5 and C11 have M4 fibre washers fitted over their legs before soldering them onto the board. This will prevent solder flowing through PCB holes. Check the polarity of all the components, particularly diodes and capacitors as these will be destroyed if fitted incorrectly. All wirewound resistors and diodes need to be mounted at least ¾" clear of the board to prevent heating of the SRBP material. This is particularly important with D1, D2, D3 and D4.

If you are not building the power supply from the kit, you
Fig. 1 Circuit diagram of the bench power supply unit.
Reservoir capacitor voltages

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Power transistor voltages

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IC voltages

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Table 1 Voltage check list to aid trouble-shooting. The measurements were made with the unit running from 240V mains, the outputs set at +5, +15 and -5V, no output loads, and with respect to OV.

Fig. 2 (left) Equivalent internal circuit of the MC1723.

BUYLINES

A complete kit of parts for this project will be available from Grenson Electronics Ltd, High March, Long March Industrial Estate, Daventry, Northants NN11 4HQ, tel 03272 5521. The kit will cost £48.50 plus £3.55 post and packing plus VAT, making a total of £59.62. Alternatively, the unit is available built and tested for £82 plus post, packing, and VAT, making a total of £98.15. Note that the PCB for this project will NOT be available through our PCB service.

HOW IT WORKS

10V is produced from the secondary of T1 and is full wave rectified via D1, D2, D3, D4. The resulting voltage is then smoothed by C1 and fed to Q1 collector, Q1 being biased on by Q2 which is in turn controlled via pin 10 by IC1. The output from pin 10 is determined by pins 4 and 5, both being inputs to the control amplifier on the IC. Pin 6 is a fixed reference of 7V and is trimmed by PR1 and fed to pin 5, while pin 4 senses the output voltage via the divider chain R12, R13 and R14. Therefore Q1, which is situated on the front panel, controls the output voltage over the range 3V to 8V. The capacitor C4 is used as an output filter.

The voltage produced across wire wound resistor R6 at high loads, i.e. greater than 2.5 amps, is used to operate the over current protection circuit. This circuit consists of Q9, Q3, Q11, Q12, R20 and pins 2, 3, on the IC. The over current trip level is set using PR2 and is kept constant over the voltage range by the action of Q3. The over current mode on the +5V line has a foldback characteristic, which results in a short circuit current of approximately 1 amp.

The +5V line is protected from +ve or -ve voltages injected back into its output by D5 and D6. Full current and voltage metering is provided and is calibrated using PR3 to set the current meter and PR4 the voltage meter.

The +15V output is produced in the same way as the +5V output using the 723 linear regulator. The only difference in circuit terms is Q6 which ensures a smoother supply to run IC2 and the absence of Q3, which is due to the difference in over current protection. Whilst the +5V has a foldback mode the +15 and -15 both go into a constant current mode. The overload limit on the +15V is adjusted with PR5.

The output voltage is adjusted in the same way using RV2, and as on the +5V line the output is fully protected against misuse and the injection of other voltages by D12 and D13.

The -15V is produced in a different way to that of the +5V and +15V. It does not use an IC but has the control circuit constructed with discrete components. Q13 and Q10 are in a long tailed pair configuration and function as a virtual earth amplifier to control the base of Q11. Any error in the -15V output is corrected by reducing or increasing the drive on Q9 via Q8. Fine adjustments to align the -15V are made using PR10. Hence, when RV2 on the front panel is adjusted the -15V should track the +15V across it's entire range of 8-16V. Overcurrent on the -15 is the same as on the +15; constant current is adjusted by PR9. The circuit Q7, Q28, Q31, Q12, Q36, PR8 is used in place of the IC as in +5, +15 for over current protection on the -15V. The -15V supply is protected against misuse and injected voltages by D18 and D19. Full current and voltage metering is provided for the ±15V lines and is adjustable using PR12 and PR11 for ±15 and PR7 and PR8 for -15V. The 3 pole, 3 way rotary switch SW2 provides switching between outputs for the meters so that they can indicate voltage and current simultaneously for each line.
## PARTS LIST

**Resistors (all \( \frac{1}{4} \text{W}, 5\%, \text{unless otherwise stated})**

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**Capacitors**

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<tr>
<td>C2</td>
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<tr>
<td>C3</td>
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<td>50V ceramic</td>
</tr>
<tr>
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**Capacitors**

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<td>mains toggle, 2A</td>
</tr>
<tr>
<td>SW2</td>
<td>3 pole, 3 way rotary switch</td>
<td></td>
</tr>
</tbody>
</table>

PCB: IC sockets; M4 fibre washers; Heatsinks; insulated terminals; mains fuseholder and fuse; knobs; mains neon; Case; mains cable and strain-relief bush; solder tags; insulating kits for the power transistors; nuts, bolts, washers, etc.

---

**Fig. 3 Overlay diagram of the PCB.**
will have to find and drill your own case. The case supplied with the kit and used in our prototype measures about 265 x 130 x 180 mm, and almost any case of about the same size or a little larger should be suitable. However, you should bear in mind the weight of the transformer and choose a fairly sturdy case, preferably steel rather than aluminium. Drill out your case to suit the components, if possible following the layout used in the prototype and shown in the photographs, but don't worry if this proves difficult because the layout is not critical.

Mount all the front panel components except the two meters which are fragile and best left until last. The rotary switch, SW2, is best wired before fitting into place, but don't terminate the ends of the wires to PCB pins yet. Take care when tightening RV1 and RV2 as overtightening will cause damage to the potentiometers.

Wire RV1, RV2 and all of the output sockets to form a loop which passes horizontally behind the front panel slightly above the components concerned. Make up the two heatsink assemblies ensuring that each power transistor (Q1, Q4, Q9) is properly insulated using mica washers and bushes. A smear of silicone grease under each transistor and mica washer helps heat transfer from the transistor case to the heat sink. Take the three leads from each power transistor through their respective grommets, the collector connection being via a solder tag on the transistor mounting screw.

Mount the transformer and use a large capacitor clip to mount C1 vertically near the front panel. Fit the mains fuse holder and cable clamp to the rear panel, then wire the fuse, switch, neon and the transformer primary, taking care to ensure that a good earth is established by cleaning paint off under the heatsink mounting screw and using a solder tag.

Wire the transformer secondary and C1, using the solder tags. The PCB can now be fitted into place, and all wires terminated to the relevant solder pins. Start with the transformer secondary and power transistors followed by the output sockets and voltage pot and finally the rotary switch.

It is best to leave the meters off until the unit has been tested so as to avoid the risk of damage. When all has been checked and found to be working, wire the meters to the appropriate connections on the rotary switch SW2.

Setting up

When the time for switch on comes there are two options; a) use a variac and wind the input up slowly or b) just switch straight on!

If a variac is available, initially supply the unit with a few volts only. Having ensured that the unit is not taking large amounts of mains current, check that the polarity of the DC unstabilised voltages across the terminals of C1, C5 and C11 are correct. If all is well, increase the mains supply slowly whilst measuring the outputs to ensure that they are rising a few volts behind their respective unstabilised supplies and are correctly polarized. With RV1 and RV2 set at midway, the outputs should start to stabilize at their nominal values. If the outputs are correct, increase the mains supply to 240V and proceed with the setting up.

If you intend to switch the unit straight on, double check the connections throughout the unit, paying particular attention to the mains fuse, transformer, smoothing capacitors C1, C5 and C11 and the power transistors Q1, Q4 and Q9. Make sure all the diodes and ICs are the right way round! Set pots RV1 and RV2 to mid range. If all is well, 2.5V-4V should appear at the 5V output, with 8V-11V on the ±15V terminals.

With the unit switched on and working, rotate RV1 on the front panel and check that the +5V output varies from approximately 3V to 8V. Adjust PR1 on the PCB to set the upper and lower limits accurately.

Compare the voltages on the +15 and -15 volt outputs and adjust PR10 on the PCB until the -15V output agrees with the +15V output. Rotate RV2 on the front panel and check that both outputs swing in tandem from approximately ±8V to ±16V, then adjust PR6 on the PCB to set the upper and lower limits accurately.

The next stage is to set the overload protection circuits on each output to the appropriate trip values, and this is most easily accomplished using variable resistors as the loads. However, don't worry if you can't get hold of any variable resistors with a high enough power rating because, with a little care, it is perfectly possible to set the levels using only a few odd fixed
wirewound resistors.
Assuming the use of a 10 ohm 20 watt variable load resis-
tor and a current meter in series between the +5V output ter-
main and the 0V terminal, set PR2 fully anti-clockwise and
the resistor to minimum load, ie 10 ohms, and switch on. With
RV1 set to give maximum output, adjust the load resistor to give
2.75 A current reading on the external meter. Slowly turn PR2
clockwise until the current just starts to fall. If the load is now
increased the output voltage and current should collapse.
Leaving PR2 set, return the load resistor to 10 ohms and
repeat the test first with RV1 set fully in one direction and then
the other, checking that the current limit remains the same
from 3 to 8V output. The short circuit current should be equal
to or less than one amp.
If you only have fixed value wirewound resistors to hand, choos
one or more to give a value which will draw 2.75 A at between
3 and 8V. Thus a 1.2
10 watt, a 2.7 ohm 25 watt, or anything in between would be suitable. Connect this resistor or
resistors in series with the meter across the +5V output and
adjust the voltage until the meter reads 2.75 A. Slowly turn
PR2 clockwise until the current just starts to fall, then reduce the
value of the load resistance either by shorting it or, pre-
ferably, by picking another similar value of resistance in
parallel with it. The output voltage and current should now
both collapse. If you have suffi-
cient wirewound resistors to hand, make up another load
resistance of a different value so that you can repeat the test at a
different output voltage.
The procedure for setting
the +5V current limit is the
same as for the +5V except for the values and the constant
current characteristic of the 15V
lines. The ideal load would be a
50 ohm, 50 watt variable resistor in
conjunction with a 1 amp FSD
meter connected between the
+15V terminal and the 0V ter-
minal. With PR5 turned fully anti-
clockwise with no output current
set to 0.55 A and PR5 slowly
adjusted clockwise until the
voltage just starts to fall. The
output current should remain
the same at any overload level.
Check the current limit is the
same across the +15V output
range, and note that the -15V
line should collapse with the
+15V line even though it is not
loaded.
The -15V output is set up in
exactly the same way as the
+15V output, except of course,
that the meter and load resistance
are connected between the -15V
and 0V terminals. With PR9
turned fully clockwise adjust the
load resistor to give 0.55 A, then
slowly turn PR9 anti-clockwise
until the voltage just begins to
fall. Again, the output current
should remain the same at any
overload level, and you should
check that limiting takes place at
the same point across the -15V
voltage range.
As with the +5V output, the
±15V outputs can be set up
without variable loads by choosing suitably rated resistors
whose value is such that they
will draw 0.55 A at between 8
and 16 volts. A 15 ohm 5 watt,
27 ohm 15 watt, or anything in
between could be used. The pro-
cEDURE is then the same as that
given above except that the
current is set to 0.55 A using the
output voltage control, RV2, and
you will have to check that the
current remains the same for all
overload levels by placing resis-
tors in parallel with the load to
reduce it in value.
If all is well so far, you are
now ready to install the meters.
M1 is the current meter and M2 is
the current meter, and they
should be connected to SW2 in
accordance with the circuit
diagram and taking great care to
observe polarity. Set both
meters mechanically to zero
using their centre screws, then
switch on the supply and set the
+5V output to 5V exactly using
an accurate external meter. Set
SW2 in the +5V position and
then adjust PR4 until M1 reads
correctly. Connect an ammeter
and variable load resistor in
series across the +5V output
and adjust the resistor to give
exactly 2A reading on the meter (if you don't have a variable
resistor with a high enough rat-
ing, choose one or more
wirewound resistors to give 2A
or a similar current which is
clearly marked on both meter
scales). Adjust PR3 until M2
agrees with the reading on the
external ammeter.
Turn SW2 to the +15V posi-
tion and use an accurate
circuit with one variable load resistor or a network of fixed wirewound
resistors across the +15V output so that a current of 0.5 A is
drawn, then adjust PR7 until M2 reads 0.5 A. Repeat the pro-
cEDURE for the -15V supply with
SW2 set to -15V and using
PR12 to adjust the voltage
reading on M1 and PR11 to
adjust the current reading on
M2.

**Trouble Shooting**
The bench power supply is
quite straightforward in its con-
struction, and provided you have
followed the guidelines given you
should have no problems getting it to work first time. If, however,
you are unfortunate enough to
encounter difficulties, the follow-

ing notes should help you to sort
it out.
If, on switch on, the fuse
blows immediately, check very
carefully the mains wiring up to
the primary of the transformer; it
is very unlikely that a fault on the
secondary of the transformer will
cause the mains fuse to blow. If
the fuse remains intact but the
unit gives no output at all, check
the wiring around C1, C5, and
C11 and the orientation of the
rectifying diodes. The correct
voltages to be found on these
capacitors are given in
Table 1. Check also the wiring of the
circuit and make sure that the voltages
on them agree with those given in
Table 1. Next, check the +15V
circuit in detail since a fault here
will prevent any voltage
appearing at the +5 and -15V
outputs even if these are work-
ing correctly. This is because the
+15V line supplies the drive for
the +5V line, and the -15V line
is designed always to mirror
exactly the voltage appearing on
the +15V line. The +15V cir-
cuity is also the first place to look
if the unit works correctly on the
+5V output but not on the +15
and -15V outputs. The voltages
which should appear on IC1 in
the +5V circuitry and IC2 in the
+15V circuitry are shown in
Table 1.
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Happy Memories

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MODULAR PREAMPLIFIER - PART THREE

In this final part, we give constructional details of this expandable audio project. Designed by Barry Porter.

As with the smaller preamplifier described in December, assembly is based on the use of a mother board with the individual modules plugged into mating connectors. The pins for these are on a 0.1" pitch, so it is quite acceptable to use a length of veroboard to carry the interconnection busses between modules.

Details of the disc amplifier, muting relay control and power supply were given in part 1, and will not be repeated here. If it is required that insertion of the headphone jack plug should cause the output relay to cut off the unbalanced output, the 6V zener diode in the delay circuit should be connected to earth via the common contact switch on the jack socket as shown in Fig. 10. So that the headphone amplifiers are not powered when they are not in use, their supply voltages should be obtained from the switched rails of the delay relay.

Other constructional comments in part 1 may be applied to this larger unit, which may be built into one of the standard rack-sized cabinets obtainable from a number of suppliers.

Once the preamplifier is working (again, see part 1) the output balance pre-set must be adjusted to give equal voltages from the two outputs. The easiest way to do this is to temporarily connect two equal value, close tolerance resistors in series with the output and adjust the respective pre-set for zero volts at their junction when a 1 kHz signal is applied. (Fig. 11.)

In use, the performance of this pre-amplifier is virtually identical to the more basic unit described in part 1. With the tone controls switched into circuit the noise increase is only about 1 dB with negligible additional distortion. The limited amount of control has caused no problems — in practice, if more than 10 dB of lift or cut is required, it's not hi-fi you've got but a potential advertising copy for exchange and mart!

The situation that displays the advantages of the tone control most is when small bass-light loudspeakers are being used. Applying a limited amount of bass lift, with the frequency control set to about 50 Hz, will usually make it possible to increase the speakers' bass extension without encountering overload problems — something that is impossible to do when the turn-over frequency is fixed.

Although not detailed here, the individual 'building blocks' method of construction lends itself to a number of possibilities — for example, it is quite easy to modify the tape connections to allow for two recorders with cross dubbing, even providing balanced record outputs if required. A further enhancement could be to include record level controls on the front panel, with suitable VU or LED monitors displaying the signal level being sent to the recorder. Indeed, with a little thought, that Concorde flight-deck look might not be too far away . . . .

Some Changes
There have been some relatively minor changes between the circuit diagrams published last month and the PCB layouts printed here. They are:

- on the tone control module: C2 was left off the circuit diagram in error; this is a compensation capacitor for IC1 (as C5 is for IC2) and is included on the overload; C13 and C14 have been added in the leads to the wiper of RV2 and RV4; these are to prevent any offset voltages being passed around and amplified;
- IC4 and IC5 have been combined into a single dual op-amp rather than two single op-amps;
- on the balanced output stage: IC1a and b have been interchanged;
- on the headphone amplifier: the input filtering to IC1 has been changed and the values of R1 and R2 are different; however, the PCB allows the original circuit to be used if desired;
- on all modules: supply line decoupling capacitors have been added; these were not shown on the circuit diagram last month (except for the headphone amplifier, where unpolarised capacitors have been added in parallel with the existing electrolytics). Note also that the tone control stage is split over three boards for stereo operation. Unfortunately, it wouldn't quite fit onto two, so it was decided to split off the filter sections so that at some future date, constructors could alter...
these, for example, to include a 'mid' control.

Swings And Roundabouts
It is possible to modify the component values of the disc amplifier and of the unbalanced output stage so that it is not necessary to use E96 series resisters. This will actually give a less accurate response technically (degrading the error on the RIAA characteristic to 0.3 dB), but for most people this will not be noticeable (if it is noticed at all)!

For the disc amplifier, the modified component values are as follows:

- **R2**: 4k7
- **R3**: 6k8
- **R6**: 12k
- **R10**: 7k5
- **R11**: 560R or 1k0
- **R12**: 39R or 82R
- **R13**: 6k8 or 6k2
- **R14**: 3k3 or 1k5
- **R15**: 82k
- **R16**: 15k/310k (T3 = 3179.5µs)
- **C7**: 10n
- **C11**: 33n

* For R11, 12, 13, 14 the first figure given is for moving coil cartridges and the second is for moving magnet.

The value of R9 that should be used will depend on the required sensitivity of the input stage; for moving coil cartridges, the appropriate values are as follows:

<table>
<thead>
<tr>
<th>R9 Value</th>
<th>Sensitivity</th>
</tr>
</thead>
<tbody>
<tr>
<td>10k</td>
<td>0.11 mV</td>
</tr>
<tr>
<td>5k6</td>
<td>0.2 mV</td>
</tr>
<tr>
<td>3k3</td>
<td>0.33 mV</td>
</tr>
<tr>
<td>2k2</td>
<td>0.49 mV</td>
</tr>
</tbody>
</table>

For moving magnet, the following values are appropriate:

<table>
<thead>
<tr>
<th>R9 Value</th>
<th>Sensitivity</th>
</tr>
</thead>
<tbody>
<tr>
<td>820R</td>
<td>2.17 mV</td>
</tr>
<tr>
<td>560R</td>
<td>3.01 mV</td>
</tr>
<tr>
<td>270R</td>
<td>5.43 mV</td>
</tr>
<tr>
<td>150R</td>
<td>8.0 mV</td>
</tr>
</tbody>
</table>

Additionally, IC1 (LM394) can be replaced with a parallel pair of

---

Fig. 1 PCB overlays for the tone control: the main board above is for a single channel, so two of these are required, whilst the filter board (below) is a stereo board, so only one of these is required. Note carefully which parts you need two of for stereo.
PROJECT: Modular Preamplifier

Fig. 2 Overlay of the PCB for the balanced output driver — this is a stereo board, so only one is required, but note the components that you have to obtain two of.

Fig. 3 Overlay diagram for the headphone amplifier; again, this is a stereo board, and again, you will have to sort out which components you need two of.

2SD786 transistors, which are available from XCEL Audio Parts Ltd, and they are somewhat cheaper than the LM394.

For the unbalanced output stage, the modified component values will depend on whether it is to be used as a tape output buffer or as an output stage to feed the power amplifier. For use as a tape output buffer, the values shown in Table 1 apply.

<table>
<thead>
<tr>
<th>Record Output Level</th>
<th>Gain</th>
<th>R6</th>
<th>R4</th>
<th>C2</th>
</tr>
</thead>
<tbody>
<tr>
<td>999.5 mV</td>
<td>7.95 dB</td>
<td>1k5</td>
<td>1k0</td>
<td>100µ</td>
</tr>
<tr>
<td>976.9 mV</td>
<td>11.77 dB</td>
<td>3k9</td>
<td>1k0</td>
<td>100µ</td>
</tr>
<tr>
<td>1.2 V (0 VU)</td>
<td>15.65 dB</td>
<td>5k6</td>
<td>1k1</td>
<td>100µ</td>
</tr>
</tbody>
</table>

Table 1 Revised component values for the tape output buffer.

ETI FEBRUARY 1984
Fig. 4 Here is the overlay diagram for the mother board of the preamp as featured in the first part of the description in December '83; this board will be available through the PCB service. However, we have not reproduced a lay-out for the mother board of the extended system because the whole idea is for it to be adaptable to your needs — so everyone can make up their own, customised preamp using the same basic blocks.

Table 2 Characteristics of the balance control.

<table>
<thead>
<tr>
<th>Control Callibration</th>
<th>Imbalance</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>1.94dB</td>
</tr>
<tr>
<td>4</td>
<td>3.91dB</td>
</tr>
<tr>
<td>6</td>
<td>6.02dB</td>
</tr>
<tr>
<td>8</td>
<td>8.29dB</td>
</tr>
<tr>
<td>10</td>
<td>10.88dB</td>
</tr>
</tbody>
</table>

For use as an output stage, R4 can be 180R and R6 can be 220R. The revised balance control characteristics are shown in Table 2.

After all that, all that remains for us to do is to wish you happy listening!

ETI
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- **VERSATILE**: Deliver more than 1KW into 1/2 ohms.
- **8200W** into 2 to 8Ω
- **4 x 300W** into 2 to 8Ω (200W into 8Ω)
- **1 x 600W** into 2 to 8Ω
- **1 x 300W** into 2 to 4Ω
- **1 x 150W** into 4 to 8Ω

Having been closely involved with a wide variety of OEM applications of their amp boards, Pantecnic have become aware of the need for more power and efficiency. By including the PA2 & PAN1397 to the total array of power amplifiers, efficiency and the performance of the amplifier can be greatly improved.

The PAX2/24 80V amplifier offers exceptional efficiency and performance when used with the PAN1397. This amplifier is capable of delivering 1.2KW of power in a space of 180mm x 102mm x 77mm, excluding PSU and Fan.

Pantecnic present the most adaptable seriesed (bridged pair) amplifier. The PAN1397 is a 21.96 coupl. amplifier, ultra-threshold, low distortion, capable of delivering 2x600W into 8Ω with a THD of 0.01%

Pantecnic have become aware that customers are looking for a compact amplifier that can deliver high power with minimal heat output. The PAN1397 meets these requirements, delivering 1.2KW of power in a compact 180mm x 102mm x 77mm package.

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Pantecnic have also developed the PAN1397C, a 21.96 coupl. amplifier that can deliver 2x600W into 8Ω with a THD of 0.01%

Pantecnic have also developed the PAN1397D, a 21.96 coupl. amplifier that can deliver 2x600W into 8Ω with a THD of 0.01%

Pantecnic have also developed the PAN1397E, a 21.96 coupl. amplifier that can deliver 2x600W into 8Ω with a THD of 0.01%

Pantecnic have also developed the PAN1397F, a 21.96 coupl. amplifier that can deliver 2x600W into 8Ω with a THD of 0.01%

Pantecnic have also developed the PAN1397G, a 21.96 coupl. amplifier that can deliver 2x600W into 8Ω with a THD of 0.01%

Pantecnic have also developed the PAN1397H, a 21.96 coupl. amplifier that can deliver 2x600W into 8Ω with a THD of 0.01%

Pantecnic have also developed the PAN1397I, a 21.96 coupl. amplifier that can deliver 2x600W into 8Ω with a THD of 0.01%

Pantecnic have also developed the PAN1397J, a 21.96 coupl. amplifier that can deliver 2x600W into 8Ω with a THD of 0.01%

Pantecnic have also developed the PAN1397K, a 21.96 coupl. amplifier that can deliver 2x600W into 8Ω with a THD of 0.01%

Pantecnic have also developed the PAN1397L, a 21.96 coupl. amplifier that can deliver 2x600W into 8Ω with a THD of 0.01%

Pantecnic have also developed the PAN1397M, a 21.96 coupl. amplifier that can deliver 2x600W into 8Ω with a THD of 0.01%

Pantecnic have also developed the PAN1397N, a 21.96 coupl. amplifier that can deliver 2x600W into 8Ω with a THD of 0.01%

Pantecnic have also developed the PAN1397O, a 21.96 coupl. amplifier that can deliver 2x600W into 8Ω with a THD of 0.01%

Pantecnic have also developed the PAN1397P, a 21.96 coupl. amplifier that can deliver 2x600W into 8Ω with a THD of 0.01%

Pantecnic have also developed the PAN1397Q, a 21.96 coupl. amplifier that can deliver 2x600W into 8Ω with a THD of 0.01%

Pantecnic have also developed the PAN1397R, a 21.96 coupl. amplifier that can deliver 2x600W into 8Ω with a THD of 0.01%

Pantecnic have also developed the PAN1397S, a 21.96 coupl. amplifier that can deliver 2x600W into 8Ω with a THD of 0.01%

Pantecnic have also developed the PAN1397T, a 21.96 coupl. amplifier that can deliver 2x600W into 8Ω with a THD of 0.01%

Pantecnic have also developed the PAN1397U, a 21.96 coupl. amplifier that can deliver 2x600W into 8Ω with a THD of 0.01%

Pantecnic have also developed the PAN1397V, a 21.96 coupl. amplifier that can deliver 2x600W into 8Ω with a THD of 0.01%

Pantecnic have also developed the PAN1397W, a 21.96 coupl. amplifier that can deliver 2x600W into 8Ω with a THD of 0.01%

Pantecnic have also developed the PAN1397X, a 21.96 coupl. amplifier that can deliver 2x600W into 8Ω with a THD of 0.01%

Pantecnic have also developed the PAN1397Y, a 21.96 coupl. amplifier that can deliver 2x600W into 8Ω with a THD of 0.01%

Pantecnic have also developed the PAN1397Z, a 21.96 coupl. amplifier that can deliver 2x600W into 8Ω with a THD of 0.01%
When it comes to the reel issues of audio recording, John Linsley Hood has got it taped.

Although the tape recorder, in its cassette form, is now so common a part of our lives that we can take it almost for granted, in reality, recording on magnetic tape is beset with so many problems, and hedged round with so many restrictions and limitations, that it is surprising that it even works at all, let alone that it gives the superb results which, when all is done well, it can!

Having said that, it is difficult to find any descriptions of this technique which explain these problems and limitations in a way which is at all easy to follow — so before I proceed to look at the types of circuitry which are needed for tape recording, I propose to try to explain, as simply and lucidly as I can, just what it is that we need to do.

**The Process**

If we pull a piece of unmagnetised iron oxide coated tape past a recording head, as in Fig. 1, and we apply an alternating current to the electrical winding on this head, we will leave a series of magnetised regions, as indicated by N-S-N-S-N-S, ..., produced by the magnetic field at the trailing edge of the record head gap. These will have a'wavelength' along the tape given by \( \lambda = \text{tape speed} \times \frac{1}{\text{frequency}} \) (Hz). If we try to replay this, with a head having a gap length \( X \), we will have zero output when \( X = \lambda \) since both ends of the gap will be sitting on parts of the tape which are identically magnetised (i.e., both N or both S). This is **Problem No. 1**: the gap length of the replay head imposes an absolute limit on the upper frequency response.

It is a characteristic of magnetic induction that the voltage induced in a coil of wire is linearly proportional to the speed with which the magnetic flux through that coil is changed. In mathematical terms this is expressed as

\[
V = L \frac{dI}{dt}
\]

where \( L \) is the inductance, \( B \) is the flux density, and \( t \) is time. \( dI/dt \) is the mathematical notation for a rate of change with time.

The result of this is that if we were to record at a constant remanent flux level on the tape, which we will assume will be given by a constant level of (RMS) current through the record head, we will end up with a replay characteristic as shown in Fig. 2, in which the output increases linearly with frequency. This will necessitate a replay characteristic such as Fig. 3 if we are to get a level final frequency response; this, in itself, would not present any great circuitry difficulty.

In the same way in which an internationally agreed standard is employed in the manufacture and replay equalisation used for 33 RPM and 45 RPM gramophone records (the RIAA standard) there is an internationally accepted standard for record and replay equalisation for tape and cassette recording (the NAB standard). This requires effective record and replay characteristics of the type shown, with the appropriate time-constants for the turn-over points on the frequency scale, in Figs. 4 and 5. When the replay equalisation curve is superimposed

![Fig. 1 The basic principle of tape recording.](image1)

![Fig. 2 (left) The theoretical AC output from a tape replay head.](image2)

![Fig. 3 (right) An idealised replay amplifier characteristic.](image3)

![Fig. 4 (left) NAB recommended record characteristic (effective).](image4)

![Fig. 5 (right) NAB recommended replay response (effective).](image5)

\[
V = L \frac{dI}{dt}
\]

**Table 1** Equalisation time constants of various standards:

<table>
<thead>
<tr>
<th>Standard</th>
<th>Frequency (Hz)</th>
<th>Time Constant (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NAB</td>
<td>15/sins/sec</td>
<td>0.00057</td>
</tr>
<tr>
<td></td>
<td>38/sins/sec</td>
<td>0.0034</td>
</tr>
<tr>
<td>NAB</td>
<td>5/sins/sec</td>
<td>0.01</td>
</tr>
<tr>
<td>NAB</td>
<td>9.5/sins/sec</td>
<td>0.05</td>
</tr>
<tr>
<td>NAB</td>
<td>19/sins/sec</td>
<td>0.15</td>
</tr>
<tr>
<td>BSI</td>
<td>7/sins/sec</td>
<td>0.04</td>
</tr>
<tr>
<td>BSI</td>
<td>3.75/sins/sec</td>
<td>0.17</td>
</tr>
<tr>
<td>CCIR</td>
<td>9/sins/sec</td>
<td>0.22</td>
</tr>
<tr>
<td>CCIR</td>
<td>9.5/sins/sec</td>
<td>0.22</td>
</tr>
<tr>
<td>DIN</td>
<td>7 or 120/3180 BSI</td>
<td>0.22</td>
</tr>
<tr>
<td>DIN</td>
<td>35/DIN/CCIR</td>
<td>0.22</td>
</tr>
<tr>
<td>DIN</td>
<td>70/DIN/CCIR</td>
<td>0.22</td>
</tr>
<tr>
<td>DIN</td>
<td>140 CCIR</td>
<td>0.22</td>
</tr>
<tr>
<td>DIN</td>
<td>35/DIN/CCIR</td>
<td>0.22</td>
</tr>
<tr>
<td>DIN</td>
<td>70/DIN/CCIR</td>
<td>0.22</td>
</tr>
</tbody>
</table>

(Cassette only.)
on the curve of Fig. 3, we get the practical replay equalisation characteristic of Fig. 6, which is what we will hope to find if we do some measurements on the replay side of a commercial tape or cassette recorder.

To avoid the need for a replay gain characteristic which continues to rise as frequency decreases, the NAB curve provides for an LF turn-over point of 50 Hz, expressed as a 3180 µs time constant, and an HF turn-over point that depends on tape speed as listed in Table 1. Turn over frequency, f, is given by \( f = \frac{1}{2\pi RC} \); the value of CR is the time constant, and this is normally expressed in microseconds (µs) so that Cs in nanofarads and Rs in kilohms can be used directly for calculations, avoiding the need to throw in factors of \( 10^4 \), etc.

**Problems**

The above has assumed an ideal world; however there are a number of problems, as follows (this is not a complete list!).

1. **Maximum replay frequency**: As already mentioned, the size of the replay gap imposes an absolute limit on the upper frequency response.

2. **Effect of replay head gap spacing**: Since it is the trailing edge of the record head gap which leaves the remanent magnetic domains on the tape, to a first approximation, the width of the recording head gap is not very important. However, this is not true of the replay head (as we’ve already seen). Below the maximum replay frequency, the HF response is very dependent on gap width, as I have shown in Fig. 7. Unfortunately, the output from the head also falls as the head gap-width is reduced, partly because there is less magnetic material in the gap, and partly because of the magnetic shunt effect due to the proximity of the two sides of the head gap.

3. **Effect of tape speed**: The differing equalisation characteristics quoted above tacitly recognise that the performance of the recorder, other things being equal, will be very strongly influenced by the speed at which the tape passes under the replay head. Not only will the output signal fall as the speed is reduced, the HF performance will also be impaired, as I have shown in Fig. 8.

4. **Tape magnetic non-linearity**: All of the above problems pale into insignificance in comparison with the high degree of non-linearity of the magnetic tape itself. The characteristics of this are shown in Fig. 9. If a small signal current is applied to the windings of the recording head (which is an electro-magnet with a small parallel gap held in contact with the tape, set as accurately as possible perpendicular to the direction of motion of the tape), the remaining flux on the tape (B) will be related to the applied magnetising force (H, which is proportional to the current flow through the winding on the head) in the way shown in Fig. 9a.

Clearly, this would not lend itself to hi-fi reproduction. At small signal levels the recording would be very inefficient, with hardly any remaining magnetism on the tape at all. At higher levels there would be the equivalent...
of a large amount of 'crossover' distortion, and at greater recording levels still, there would be a lot of 3rd and other high-order harmonics generated as the tape magnetisation was pushed into the regions where the curve flattened again. Also, to add to the problems, if the tape is magnetised fully, there is a 'hysteresis' loop in its magnetic characteristic, as shown in 9b.

Fortunately, after a lot of early experimentation with this medium, a trick was found which would solve this snag. This scheme was known as 'HF bias', or, in normal tape parlance simply as 'bias'. I will explain.

5. Need for bias: If a suitable high frequency AC signal is simultaneously applied to the recording head with the signal which it is desired to record, and if this HF signal, which will typically be somewhere in the range 30 kHz-250 kHz, is a good bit larger than the recording signal (typically 20 to 100 times) so that it sweeps the BH characteristics of the tape backwards and forwards across the non-linear region of the BH characteristic, one can, surprisingly, end up with a quite linear magnetisation of the tape, as shown in Fig. 10a. However, as you will by now expect, there is another snag, and this is that the final recording characteristics of the tape depend on the size of the applied bias waveform. If we apply more, we get the curve shown in Fig. 10b., which is one of reduced recording sensitivity. Also, too much bias tends to 'erase' the higher audio frequencies which we are trying to record. Moreover, the 'correct' level of bias depends on the actual tape being used at the time, and, without previous experience, we cannot know what that will be!

6. Problems with bias: The dependence of recording characteristics on bias level is shown in the graph of Fig. 11. In this curve (a) shows the relationship between recorded level and bias current at 1 kHz, and (b) the same thing for an input recording signal at 10 kHz. Clearly, the bias setting has a large effect on the flatness of frequency response of the tape recorder. Curve (c) shows the effect on the distortion of the recorded signal of the bias level. Good HF response is not readily compatible with low THD. The effect of bias level on tape modulation noise is shown in Fig. 11, curve (d). Here, happily, low noise levels fit in fairly well with other needs.

The actual frequency of the bias signal is not very important, though there is some evidence that the recorded noise level on the tape, and the distortion at the upper end of the audio spectrum, may both be lessened by the choice of the higher bias oscillator frequency. The snag here is that it is the current through the head which is important, and because the windings have inductance, a higher bias frequency will require a higher applied bias voltage. Also, the head will work progressively less efficiently at higher frequencies, which contributes to this effect.

7. Design of bias oscillator: The tape cannot distinguish the source of the signal which is applied to it. It will therefore record small noise voltages present on the bias voltage waveform just as easily as it will record the noise components present on the incoming signal. So, if the bias voltage waveform is 20 times the size of the signal being recorded, its signal-to-noise ratio will need to be a lot more than 20 times better if it is not to degrade the S/N ratio of the incoming signal. You will note that I have referred to bias voltage, not to bias current. This is because the noise signal will be wide band, and will not be restricted by the inductance of the head to the same extent as the HF bias waveform. Therefore, the higher the bias frequency, the better the S/N ratio which is demanded of the bias oscillator.

The actual waveform of the bias oscillator is not so important, provided that it is symmetrical. If it is unsymmetrical, it will have the effect of the B-H curve, which will reduce the available undistorted output. Also, an unsymmetrical waveform contains an implicit DC component, which will magnetise the head, greatly reducing its effectiveness, and possibly causing partial erasure of the tape.

In the early 1970s, when I was very interested in cassette recording, I did some experiments with both square wave and sawtooth bias waveforms. Both worked, and the square appeared to be quite effective. However, for reasons of practical convenience, it is desirable that the erase oscillator should operate at the same frequency as the bias oscillator, and it is easier to get large voltages at a good S/N ratio from an LC sine-wave oscillator. Square wave (RC) generators tend to have a fairly poor S/N ratio, due to jitter on the 'flip' times.

8. Effect of head inductance: Our aim, in recording, is to record all the frequencies in the audio band equally. However, the recording head has inductance, which will restrict the flow of current at higher frequencies. It is necessary, therefore, to find some way around this problem. Of the possible solutions, the simplest is to put a resistor, say 47k, in series with the output from the recording amplifier, to swamp the effect of the changing impedance of the recording head with frequency. This also helps keep the bias HF voltage out of the recording amplifier. Bias voltages in excess of 20 volts do no harm provided that they did not push the record amplifier into a non-linear or overload condition.
Other useful solutions, which make lesser demands on the size of the signal output from the recording amplifier, are to design this amplifier so that it has a high output impedance, or to use a current NFB loop to make the amplifier look like a constant current source. All DC components must be rigorously excluded from the head windings to avoid head magnetisation. If a DC blocking capacitor is used, it should be of good quality, and switch-on current surges through this must be prevented.

9. Head alignment: The way in which the width of the replay head affects the HF response of the recorder has been shown above (Fig. 7). This presumes that the head is accurately aligned so that its gap is at right-angles to the direction of travel of the tape. If the gap is skewed, its effective length will be greater, and the HF output will be less. The same applies if the record and replay heads do not have the same alignment. This may be less important if one records ones own tapes, but on pre-recorded tapes this is vital. Happily, alignment tapes are fairly easy to buy. On these, though a double-beam oscilloscope makes matters simpler, one can do quite a good job by just adjusting head azimuth for maximum HF output, usually by working upwards through the frequency test bands provided.

10. Noise and noise reduction: Because of the granular nature of the oxide coating deposited on the tape, all tape recordings will suffer from some degree of background noise. In addition to this, any parts of the record process which tend to clump, or otherwise disturb, the uniformly random distribution of the magnetic domains will make this background noise worse. Erase oscillator systems are not perfect in this respect, as can be shown by listening to the background noise on a bulk erased tape, as bought, and after it has been 'erased' by ones own recorder following the recorder of a zero signal.

The output from the tape recorder will depend on the tape speed and (although not discussed so far, this is a fairly logical extension of the arguments above) on the tape width at the head; so, the lower the tape speed and the narrower the tape head width, the worse the output noise will be. This becomes a particular problem with cassette recorders, where the tape creeps past the head at 1.875/second, and the track width is only 30 thou. or so anyway. The signal output from a cassette recorder replay head will be minute, and will demand a lot of skill in the design of the replay amplifier.

The poor basic S/N ratio of the reproduced signal from a cassette replay head (though this is now improved by better heads and better tapes) has brought into prominence the various noise reduction schemes, of which the most common is the Dolby B system, used by most cassette recorder manufacturers under license from the Dolby Laboratories. In this a degree of HF pre-emphasis is applied to the record signal, in which both the amount of HF pre-emphasis and the turn-over point above which this pre-emphasis is applied, is automatically adjusted in response to the measured level of the incoming signal. The reverse compensation is applied on replay to restore a flat frequency response.

There is a snag, of course. This is that, unless some means is provided for monitoring the tape output which is only possible on relatively expensive three-head cassette machines, some assumptions must be made by the cassette recorder manufacturer, in setting up the Dolby B replay operating levels, about the actual signal level which his recorder will give on replay for a given input recording level. This will depend on the actual tape chosen by the user, and on the appropriateness of the bias setting. Nevertheless, in spite of these objections, the Dolby B system does work surprisingly well, even on simple machines, and can give a 6-10dB improvement in overall S/N ratio.

Nowadays, predictably, Dolby B processing circuitry is available on a single IC chip, the LM1011, which, complete with application circuitry, can be bought by the experimentally minded for a few pounds. The use of these for any commercial gain would however, require a license from the Dolby laboratories.

In many commercial machines, the relay amplifier is muted while the tape is not moving to avoid drawing the attention of the listener to the background hiss of the replay amplifier. This is a refinement I wish I had thought of in the middle 1970s when I published my own cassette recorder design. One lives and learns!

11. Head losses: We have assumed, so far, that the recording and replay heads — which are often the same unit in cassette recorders — behave in a perfect manner. They don't. Mainly because of the finite gap width, their HF performance is poor. This means that some form of HF pre-emphasis has to be applied, during recording, to assist in achieving a satisfactory HF output. This recording pre-emphasis, of 15-25dB magnitude, will be applied, as shown in Fig. 12, at the point where it is expected that the replay HF response will start to fall. This is not a good thing, since it will tend to cause HF overload, and increased distortion and intermodulation effects, but is feasible because signal amplitudes at HF are generally low.

Practical Circuit Design

We have seen from the above what some of the problems are in tape recording. Since these are exaggerated in cassette recorders, because of the narrow low-speed tape tracks, a look at the design of the electronics in a cassette recorder — excluding the Dolby processing — will show the types of circuit layout which will be needed in all these systems.

Replay Amplifier

The over-riding consideration here is of low noise in the amplifier, since the input signal will only be about 0.5 mV, and a 60dB S/N ratio will demand an effective input noise of 0.5 µV, from the amplifier and input circuitry. Figure 13 of Part 2 (ETI October 1983) we saw that this
will depend on the input circuit resistance, the bandwidth, and the input devices. Fortunately, the effective bandwidth of the replay amplifier, because of its downward slope with frequency, is only 1 to 2 kHz. Nevertheless, this necessitates an effective input resistance of only some few thousands of ohms. We must be careful, therefore, that we do not needlessly include input resistive components, to add to the 300-600 ohms of the head-resistance. The required equivalent input noise resistance required by the desired S/N ratio does put most of the audio ICs out of consideration; however, there are a few, such as the Signetics/Mullard NE5533/5534, the Precision Monolithics/Raytheon OP27, and the Hitachi 12017, which would be satisfactory electrically. Of these, the latter has a non-standard base connection, which would make it awkward to substitute, whereas the ICs with the standard 741 type connections could be upgraded as better devices appeared.

In commercial units, for reasons of economy it is customary to use the same amplifier for both record and replay, with appropriate component changes accomplished by multiple switching. However, one view of the amateur constructor, and certainly for the ease of explanation, it makes life easier to show the record and relay circuits as separate entities. I have shown a suitable circuit design, based on a low-noise op-amp, in Fig. 13.

In this circuit, the output of the replay head (through a suitable switching if it is combined with the record head) is taken directly to the input of IC1. The gain-frequency characteristics of this stage are determined by the RC network in its negative feedback loop. Referring back to Fig. 6, we see that the LF gain is rolled off at 50 Hz (a 3180µs time constant), at a gain of 500. From this we can infer that the total resistance in the feedback path, from output to input in, must be 500k, if R1 is 1kΩ. Also, the time constant of R1C2 must be 3180µs. If R1 is 1kΩ then C2 must be 3180 nF or 3.18µF. This shows how simple the use of ‘time constants’ makes the task of working out circuit component values.

Now, we require the gain to decrease linearly from 50Hz to 1.33 kHz (in the case of the 120µs equalisation) or 2.27 kHz (for 70µs). This we can accomplish by means of C3 and R2 and R3, switched by S1. If C3 is 5n0 — this must have an impedance greater than 500 kΩ at 50 Hz, but we can’t afford to go too high (Zc for 5n0 is 636k) — then the 120µs time-constant will be given for a value of R2 + R3 of 120/5 = 24k. Also, the 70µs time constant will require R2 on its own, to be 70/5 = 14k. So R2 = 14k and R3 = 10k.

IC2 is a simple output buffer stage, to give an adjustable gain of 1 to 11, depending on the setting of RV1. RV5 gives some output isolation, and the value of C4 is chosen so that the LF response is adequate. Since 3.18µF gives a -3dB point at 50Hz, 22µF will give a -3dB point at 7Hz, which is low enough.

A small circuit refinement is the inclusion of C1 across the cassette head to tune the head, with its internal inductance, to some 15 to 18 kHz. The actual value will depend on the head inductance, and can be calculated from the formula f = 1/2π√LC. A value of 680-820pF will be in the right order. This limits the wideband noise output from the head, and reduces the chance of noise being worsened by cross-modulation within the input IC amplifier.

C5 across the first amplifier stage performs a similar band limiting function. This may not be acceptable for the NE5533 or 5534, so regard it as an option.

Record Amplifier

This has to meet five design requirements. The output must be large enough to drive the cassette record head through the 47 kΩwamp series resistance. An normal IC op-amp will do this quite well, with very low distortion, when operated from ±12 or 15V supplies. It has to provide a means for adjusting the record signal level. It has to provide a modicum of bass lift, say +3dB at 50Hz and +6dB at 30Hz, to compensate for the specified roll-off in the replay curve. It has to provide the specified de-emphasis at 70µs or 120 µs as required, and finally, it has to generate a peak, of +15dB or so, at 15kHz, to offset the head losses.

The circuit which will meet these requirements, and give a high quality performance, is shown in Fig. 14. In this IC3 is a simple unity gain buffer amplifier, which has a low output impedance but yet allows a high impedance input to the record level control. R9, R10, C6 and S2 generate the 70 and 120µs de-emphasis characteristics.
Since we have calculated suitable values for these for the replay amp., we can use these again. R11 is a trimmer resistor which we can use to assist in getting an optimally flat overall frequency response, by lessening the extent of this de-emphasis. IC4 is a gain stage with a low-frequency gain of 5.7. However, the LCR network formed by L1, C8 and RV4 is tuned to resonate at 15 kHz: this makes the gain increase at this frequency to an extent which is governed by the Q of the circuit, which can be adjusted by RV4 (for the tuned circuit, f1 = 1/2πL1C8).

R11, R12 and C9 generate the boost at 50 Hz (3180 μs, the time constant of C9R11) and the levelling off at 30 Hz (5300 μs, the time constant of C9(R11 + R12)). IC5 is another straight gain stage, with a gain of 5.7, and this drives the record head through C11 and R19.

Overall, the gain of this amplifier is 30 at 1 kHz, which allows a 5 V RMS output from IC5 for a 170 mV input. Bias is applied to the head directly from the bias oscillator circuit.

Bias and Erase Oscillator
In reel-to-reel recorders, and in the rather more up-market cassette decks, a separate transformer would be used, both as the coil in the LC erase oscillator, and as a transformer coupling from a secondary winding to drive the erase coils and HF bias circuitry. However, in cassette recorders, provided it is not proposed to use 'metal' tape (for which very high erase voltages across the erase head are needed to achieve the required 60 dB erasure of previously recorded signals) it is quite satisfactory to use the erase head itself as the coil in the oscillator circuit, and up to 25V RMS can be generated by the oscillator circuit shown in Fig. 15. A small proportion of this is then bled off through an RC network to bias the record head.

The actual RMS bias voltage across the head for optimum recording characteristics must be determined by experience for the record head and tape being used, but it will probably lie somewhere between 5.5 and 10 V RMS, as measured by a wide-bandwidth AC millivoltmeter. Understandably, from Figs. 10 and 11, there is no such thing as a 'correct' bias voltage setting. All that one can do is to try to choose a voltage at which all of the conflicting tape characteristics are partially satisfied, in your own judgment. As simple a solution as any is to design the record and replay amps so that they give a reasonably good frequency response, and then trim the 'bias' voltage so that the overall frequency response is as level as possible. Obviously, if one has good instruments and a lot of time to experiment, a better compromise value could be found.

In Conclusion
These are the basics of tape recording, and the circuits shown above, when used with a suitable cassette mechanism, an adequate power supply (derived for example from a pair of + and — output 12 or 15 V AC stabilisers and a decent quality pair of supply line bypass capacitors) and some form of recording level indicator which could well be a simple one-IC AC millivoltmeter of the form shown Fig. 16, could be used to make a quite high performance DIY cassette recorder. However, being realistic, I do not really believe that anyone in the UK at the moment would want to build himself a cassette recorder — unless, of course, he had most of the parts already to hand — when he could buy one, ready built, and with all the trimmings, for about two thirds of the wholesale price of the components.

Nevertheless, it is useful to know what kind of circuitry is employed in tape recorders, and what the problems and limitations are, so that one might rebuild or modify existing unsatisfactory equipment, or simply so that one can know where the strengths and weaknesses of the method lie. Also, because every tape or cassette recorder represents the end product of a very large number of design compromises, which affect distortion, modulation noise, overload characteristics, flatness of response and background noise level, as well as the straightforward HF bandwidth, cassette and reel to reel tape recorders differ in sound quality one from another, very much more than, say, audio amplifiers or tuners do.

Evaluation of the effect of these many compromises is truly an appropriate field for the 'subjective' listener.

I have tried, in this series, to take a brief look at the types of circuitry which are used in audio equipment, to try to show how the designer might do his circuit calculations, and to attempt, where possible, to remove the mystery from this subject. During this, I have been aware that one of the major areas of calculation, that involving capacitors and resistors, has been skirted round rather hurriedly, and the reader has been left with just a few useful landmarks, rather than a map. This is because more detailed calculations require the use of algebra employing 'complex numbers'. However, speaking as one who is really a very poor mathematician, I honestly do not think that there is anything in this which should frighten anyone (especially if they have a pocket calculator to do the sums for them) — indeed, some of the calculations are really quite fun to do. I am therefore very pleased that the Editor has indulged my wish to try to show that this is really quite simple, in the next part of this series.
T.V. SOUND TUNER
BUILT AND TESTED

In the cut-throat world of consumer electronics, one of the greatest things that any manufacturer can do is to keep prices down and quality up. Phil's T.V. Sound Tuner is one such product. It is priced at £13.95, yet it offers a quality of performance that is rarely found in tuners selling for several times as much.

The T.V. Sound Tuner is packed in a sturdy cardboard box and contains all the necessary components for assembly. The kit includes a printed circuit board, a power supply, a PHILIPS tuner module, and a selector switch. The kit is supplied complete with instructions, which are clear and easy to follow.

The T.V. Sound Tuner is designed to work with any television set that has a stereo input, and it is simple to install. It is powered by 12V DC, and it is recommended that a transformer be used to ensure that the correct voltage is supplied.

FEATURES:
- Tuning range 400kHz to 7MHz
- Stereo receiver
- Built-in muting circuit
- True RMS to 10Amp, Battery operation
- Optional accessories:
  - External speaker
  - Remote control

The T.V. Sound Tuner is a must-have for any television enthusiast. It is easy to assemble, and it offers a quality of performance that is difficult to find in a kit at this price. It is a perfect addition to any home cinema system, and it is sure to enhance the enjoyment of any television program.

ETI FEBRUARY 1984
MACHINE CODE PROGRAMMING

Every month we plunge deeper into the arcane mysteries of machine code — taking our readers with us, we hope. This month, Bob Bennett goes beyond the index registers.

Last month I gave examples of instruction of the form \texttt{Ld (pq),A} etc., and showed how two bytes are pushed back onto the stack. I also left you with the question of what happens if you push HL and pop DE. The answer is that both HL and DE now hold the data that was in HL originally.

One last thing, for the moment, regarding the stack: when you have finished with your machine code program and wish to return to BASIC, for example, then you must make sure that everything that you pushed onto the stack has been popped off. This is because when you GOSUB, and call to USR (machine code) program is a GOSUB, then the return address is pushed onto the stack. When the time to return comes along then the address is popped off the stack, but if you have left some pushes un-popped, so to speak, then some very funny things can happen.

Whether you use pg to represent an address, or mn a number, doesn't matter a jot, as long as you, the programmer, know what is happening. However, what is significant is the presence or absence of brackets in the instruction, as I mentioned last month. Fig. 11 shows part of a program with a Z80 instruction to load HL with 30,000d or 7530h. Note how the low byte, the one in L, goes straight after the instruction. Some of you will be familiar with the BASIC instruction, \texttt{PRINT PEEK(address) + 256 \times PEEK(address + 1):} now you can match up the request with Fig. 11. The difference between the two instructions \texttt{2A - Ld HL,(Pq)} and \texttt{21 - Ld HL,mn} should now be apparent. The first instruction loads the contents of the address \texttt{pq} into \texttt{L}, and the contents of \texttt{Pq + 1} into \texttt{H}; the second instruction loads the byte \texttt{n} into \texttt{L} and the byte \texttt{m} into \texttt{H}. If the two bytes \texttt{mn} represent an address, then HL is said to be pointing to that address.

Taking The Indirect Route

The Z80 instruction \texttt{77 - Ld(HL),A} is an example of indirect addressing, which if you work it out, means load the contents of the A register into the address which is pointed to by the HL pair. This is the machine code equivalent of the BASIC instruction \texttt{POKE (address), with whatever. Earlier I explained that the display file is a series of addresses, with each address holding a byte of information relating to the screen display. I also gave the address \texttt{16384d - 400Ch} as being the address of screen position 0,0 for no particular computer. Fig. 12 shows how to poke the code for the letter A onto the screen at position 0,0 using one method, and Fig. 13 shows a different method. However, an explanation is required for the method used in Fig. 13.

![Fig 12 One way of printing a screen position 0,0.](image)

Suppose that you didn't know the address of the position 0,0 on the screen, but the system variable called D File held the address. If the address of D File was \texttt{19634d - 400Ch} this would mean that \texttt{400Ch} would hold the low byte of the address of position 0,0 and \texttt{400Dh} would hold the high byte.

One last example in this section is the Z80 instruction \texttt{7E - Ld A,(HL)}, which is the machine code equivalent of the BASIC instruction \texttt{PEEK (address)}. Of course, registers other than A and HL can be used, but you should by now be able to identify the other instructions. Just in case you are wondering about the term indirect addressing, the instruction \texttt{77 - Ld (HL),A} pokes the contents of register A into the address \texttt{via the HL pair}. What I haven't mentioned yet is the use of such operations in a program, so here is
a short explanation using the two instructions given above.

Suppose instead of poking the letter A onto the
screen, we had poked the code for 1 (this could be
the start of a score, or the first try at something or
other). Later on in the program we will want to test for
the limit, say 9, and if we have reached it then finish,
otherwise increase (increment) the score and carry on.
The instruction 7E — LD A,(HL), where HL points at
the screen position of the number, will load A with the
number on the screen. Comparing register A with the
limit, 9, we can either finish if A equals 9, or increment
A, poke it back onto the screen, and carry on with the
program. I'll be covering the compare instructions
later on, but it does involve the use of the flags. Things
should be starting to fall into place now, but it does
require a little thought.

**Fingering The Index**

Because the index registers X and Y allow great
flexibility in machine code programming, this section
will cover a lot of ground. As you get to know how the
index registers work the easiest way to visualise them
is as pointers to a table, the X registers moving
horizontally, and the Y registers moving vertically. This
doesn't happen literally of course, but the table concept
can easily be programmed. Because I wrote about indirect addressing in the last section, I'll give a
couple of examples from the 6502 set using indirect
and indexed addressing together. Pre-indexed indirect addressing is the grand title of the first
example, and Fig. 14 will make what's happening
clearer.

The instruction A1 — LD A,(I,X) requires a second
byte after the op-code (A1). This second byte is
added to the contents of the X register to get the
address of the first of two sequential bytes in zero
page of the memory. These two bytes form the
address of the byte to be loaded into the accumulator
(or A register). In the example I've assumed that the X
register holds 70h and that the second byte of the
instruction is 0Ah. These two are then added together
to get 7Ah (any carry bits will be lost) which is used as
a pointer to locations 007Ah and 007Bh in the
memory. The contents of these two locations are
treated as a 16-bit address (low byte in the lower
address) and in our example this is 4000h. This is the
address which holds the byte to be loaded into the
accumulator, in this case FFh, to finish the instruction.

Note that the X register still contains 70h at the end of
the instruction. A most useful mnemonic would be A —
(byte 2 + (X)) which illustrates quite clearly what is
happening. Although I mentioned zero page address-
ning above, you could have reasoned out what was
going on without it, because the X register will only
hold one byte.

The second example from the 6502 set is B1 — LD
A(I),Y which is a post-indexed indirect instruction,
with the mnemonic A — ((Y) + (byte2)). Before you
look at Fig. 15, and before you read my explanation,
see if you can work out what it does; think of the use
of brackets.

The second byte, in this case BE, is address 00BE,
and 00BE and 00BF hold the two bytes of an address,
in this case 4000h. The byte in the Y register, which is
FFh, is now added to 4000h to make 40FFh, and in
address 40FFh is the data that is loaded into the A
register. What could be simpler?

Please note that only certain index registers can do
particular jobs in the 6502 set. I leave it as an exercise
for you to work out how the two prefixes pre- and
post- are justified.

The Z80 CPU has a host of instructions involving
index registers IX and IY. The instructions for the IX
and IY pairs are the same as those for the HL pair with
the prefix DD for IX and FD for IY instructions. As an
example I'll take the Z80 opcode 77 — LD (HL),A
which I used in the previous section; the instruction
DD 77 — LD (IX + d),A is the indexed equivalent. This
is quite straightforward; it means: poke the contents
of A into the address formed by adding d to IX. That
letter "d" means that there are three bytes in the
instruction and "d", for displacement, is the third
byte. This byte is treated as an 8-bit signed 2's com-
plement number and thus has a value between
-128d and +127d. (80h = -128d, 00h = 0d and 7Fh
= +127d.) If IX held 4000h and we wanted to load

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**Fig. 14 Pre-indexing addressing from the 6502 set.**

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**Fig. 15 Post-indexing indirect addressing from the 6502 set.**

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**ETI FEBRUARY 1984**
the A register into address 4079h, then the full instruction would be: DD 77 79.

By now you should be able to recognize just about every addressing mode that you may come across. Before I carry on, though, I would like to just clear up something I just touched upon at the beginning of this month’s article, when I was discussing pushing and popping.

Apart from the fact that we can’t use line numbers in machine code, we do have the equivalent to GOSUB instructions where we GOSUB to an address (location). The 6502 instruction set has only the one instruction to GOSUB and that is 20 — JSR where JSR means jump to subroutine. Now don’t confuse this jump with the relative jumps and the like, that I wrote about earlier. Just as in BASIC, this jump to a subroutine expects a RETURN which with the 6502 is 60 — RTS or return to subroutine (I always think of it as return to sender).

The Z80 set has quite a few GOSUB instructions, although they are labelled CALL, with the simplest being CDpq — Call pq. All of the flag conditions can be used for Calls in the Z80 set; for example, CCCpq — CALL Zpq, which means, when the result of the last instruction is zero, GOSUB pq. Again flag conditions can be used for a return, such as DB — RET C, when carry flag is set. The straightforward return in the Z80 set is C9. A word of warning, though: keep tracks on your calls to subroutines, and make sure that the returns match up. If in doubt, re-read this month’s opening section.

A Logical Conclusion

A seemingly innocuous one-byte instruction is increment, or add one to. This can apply to single registers, pairs, index registers and even inc.(HL). The 6502 has single byte instructions for incrementing its X and Y registers only. Increment is one of three add instructions which involve the use of absolute binary arithmetic. All that means is that we will be using binary, but with no fractions and no negative or positive numbers. This will become clearer as we go along anyway.

Taking a single register first, as you would expect, increment will just add 1 to the contents of that register. This is all very well until the contents of that register reach FF, which is the maximum number that one register can hold. So now what happens? Fig. 16 should be of some help, and if you don’t understand binary addition then this explanation will put you right. Remember that a binary digit, or bit, can only be either 1 or 0, if we add two 1s together the answer must be 0 and carry one over to the left. Starting at bit 0, the one on the right in Fig. 16, work your way to the leftmost bit which is bit 7.

![Fig. 16 Incrementing the contents of a full register.](image)

You should finish up with all the bits at 0, which means that the register now holds zero. So you see, incrementing a full register, or register pair, simply means that we start at zero again, and the zero flag should be set. I say should be set because it’s always advisable to check on the flags situation in the instructions set.

By the way, what happened to the last carry to the left, the one after we added 1 to bit 7? The answer in the case of incrementing is that it was discarded, but with the next two add operations it is important, as it affects the carry flag. The 6502 also has 2 and 3-byte instructions for incrementing (and decrementing) memory locations directly and indirectly.

In the Z80 set, you can add register to register, such as ADD A,B, or add pairs such as ADD HL,DE. Again, index registers can be involved, and even an instruction such as ADD A,(HL). Usually the only register that you can add a constant to is register A, in instructions such as ADD A,n. Fig. 17 shows the simple addition of two registers, which is quite straightforward. Again, when the two numbers added together come to more than one register can hold then the register that is being added to will pass through zero. This time, something different happens, so let’s take a look at an example.

![Contents of register A = 50 decimal = 00110010 binary](image)

![Contents of register B = 100 decimal = 01101000 binary](image)

![Contents of register C = 150 decimal = 10010100 binary](image)

![Fig. 17 Adding two full registers together.](image)

Suppose register A held D1 or 209, and register B held 80 or 176 and the instruction was ADD A,B. Fig. 18 shows what happens, but I’ll put it into words as well. Adding 209 and 176 gives an answer of 385; subtracting 256 leaves 129, which is what finishes up in register A.

Just to prove what a glutton for punishment I am, I will now go through the binary addition in Fig. 18. Bit 0, the rightmost bit, is where we start, and 0 + 1 equals 1 so a 1 goes on the bottom line. Bits 1, 2 and 3 are 0 in both registers so 0 goes on the bottom line in each case. Bit 4 in both registers is 1 so down goes 0 and a carry to the left. Two 1s make a carry from bits 5 and 6, this 1 goes into bit 7 position on the bottom line. Those two 1s above the bottom line in bit 7 position give a carry to the left, and this last carry sets the carry flag 7.

![Contents of register A = 299 decimal = 11010001 binary](image)

![Contents of register B = 176 decimal = 10110000 binary](image)

![Contents of register C = 129 decimal = 10000001 binary](image)

![Fig. 18 What happens when two registers added together come to more than 255 decimal.](image)

The third add instruction is ADC, which stands for add with carry, and is really straightforward. What happens is that all the above rules apply plus the fact that the current value of the carry flag is added onto the total, and the carry flag altered according to what happens during the current instruction. In other words, if there is a carry over from bit 7 then the carry flag will be set, otherwise reset. The 6502 has no register to register arithmetic, but uses memory locations — especially zero page locations — instead, but always with ADC.

The subtraction instructions follow exactly the same pattern as the addition instructions with regard to the registers, etc. The first SUBtraction is DECrement, or decrease by 1, then SUB and finally SBC or
subtract with carry. As you might expect, if you decrement a register, or register pair, which holds zero, then the number will zoom round to FF or FFF. Rather than me give you an example of subtracting in binary, why not have a go yourself? Write down two decimal numbers, take the smaller from the greater, convert the two numbers to binary, underneath write down the answer from the decimal subtraction converted to binary. Now work out how you can arrive at the answer.

AND The Rest

Usually there are three logical instructions that you can use which are AND, OR and XOR. Taking AND as the first example, it usually comes in the form AND,\( r \) where \( r \) is another register such as AND,\( C \). There should be an instruction such as AND,\( n \) where \( n \) is any number up to FF, and you may get AND(HL) and even AND(IX + d). Your CPU instruction set should show what AND instructions you can use. Whatever the instruction, everything is ANDed with register \( A \), the accumulator.

Assuming that register \( A \) holds FF and register \( B \) holds 0F, Fig. 19 shows what happens when the instruction AND,B is met. The explanation couldn’t be easier: if the bits in \( A \) and \( B \) are both 1 then that bit remains the same in register \( A \).

Check with your CPU instruction set, but an AND instruction will usually alter all of the flags, with the carry flag always being set. If, during the writing of your program, you are not sure of the status of the carry flag, then AND \( A \) or AND FF will always reset it for you. Another use for ANDing is to mask off certain bits, and this is worth an explanation.

In the first part of this series I made a passing mention to a refresh register which is used to ensure that data isn’t lost from RAM by the simple expedient of each address from time to time. What happens is that this register \( R \), starts off at zero and is incremented until it reaches 7F, it is then discharged and starts at zero again. So at any time register \( R \) will hold a number between 00 and 7F. The 280 set has an instruction ED 5F — LD \( A, R \) which, if used from time to time in a program, gives the effect of putting a random number in \( A \). If you want to make sure that this ‘random’ number doesn’t go above a certain number all you have to do is AND,\( x \) where \( x \) is your limit; note, however that if you chose an \( x \) that is not equal to 2\(^n\)-1, this operation will not return a truly random number (why?).

The refresh register is actually 8 bits but only the 7 lower bits are incremented automatically. The 8th bit can be set or reset by using the LD \( R, A \) — ED 4F which transfers the contents of the \( A \) register to the refresh register. The refresh register will then be incremented from that value but the MSB will stay in its current state.

![Register and instruction result AND B](image)

**Fig. 19 The result of the instruction AND B.**

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### TOROIDALS

The toroidal transformer is now accepted as the standard in industry, overtaking the obsolete laminated type. Industry has been quick to recognise the advantages toroidal offer in size, weight, lower radiated field and, thanks to I.L.P., PRICE.

Our large standard range is complemented by our SPECIAL DESIGN section which can offer prototype service within 7 DAYS together with a short lead time on quantity orders which can be programmed to your requirements with no price penalty.

<table>
<thead>
<tr>
<th>VA</th>
<th>Size</th>
<th>Core</th>
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<th>30 VA</th>
<th>50 VA</th>
<th>62 x 34mm</th>
<th>120 VA</th>
<th>220 VA</th>
<th>500 VA</th>
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<td>1010</td>
<td>510</td>
<td>1500</td>
<td>90 x 30mm</td>
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<td>1500</td>
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We don't bother with the bureaucracy for Tech Tips — all you do is send in your idea, stating clearly if you want an acknowledgement of receipt. It's possible for you to explain why the circuit is different, what it does and how it works, on a separate sheet and the circuit diagram, both sheets should carry your address, name and the circuit title. We'll let you know (within a month or so) if we want to use your Tech Tip.

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OOPS!

We have in the past published small corrections to projects on the letters page, and major corrections separately. From now on corrections will appear on this page, and will be repeated for several months just to increase our embarrassment. If a correction is too large to fit on here, we will publish it just once, but will note the facts of the correction does exist, and that copies of it can be obtained from us. Preferably you send in an SAE. But please request copies only if you really do need them; if this service is abused, we may be forced to withdraw it.

Telescope (August 1983)

We had a shower of annotation falling off our diagrams! On Fig. 5, IC14 was not labelled nor was Q2 (above R11), and there were two C23s — one should be IC22 and it doesn't matter which. In Fig. 5, IC12 was not labelled. Unfortuantely there was a mistake in the correction (blush): C14 is the 22µF on the —5V line.

Graphic Equalizer (August 1983)

D2 and D3 are shown the wrong way round in the power supply circuit diagram on page 20.

Universal EPROM Programmer (August 1983)

Corrections to this project are listed in the article "Universal EPROM Programmer Revised" which appeared in the January '84 issue.

Z80 Controller Computer (August 1983)

On the overlay, SW1 is the rectangle beside IC3, IC7, and IC8. IC6, C14, and IC1 on the overlay, IC3 and 7, and a link through has been missed — to the right of pin 18. IC11. Typewriter Interface (October 1983)

An update article on this project will appear in the March '84 issue.

Car Alarm (October 1983)

In the semiconductor section of the parts list, Q1, 2, 5, and 7 should be IC21LQ3 should be IC21L3 and Q4, 5 should be TIP30 or BD131. There was also another (unconsequential) silly but we bet you've already spotted that one!

Tech Tips (October 1983)

Ramp Ups. For Stepper Motors pin 1 of IC2 should be grounded, the Ramp Up and Ramp Down inputs accept negative, not positive, going pulses, and IC7 should be a 4011 rather than a 4001.

Active Loudspeaker (November 1983)

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<td>1000V</td>
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<th>Pin</th>
<th>8 pin</th>
<th>10 pin</th>
<th>12 pin</th>
<th>14 pin</th>
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<td>37 pin</td>
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