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Including Countdown and Points Arising

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Introduction and 8080 and 8085A Filesheet 1

between pages 40 and 41

OUR DECEMBER ISSUE WILL BE ON SALE FRIDAY, NOVEMBER 12th, 1982
(for details of contents see page 39)
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The ZX Spectrum incorporates all the proven features of the ZX81. But its new 16K BASIC ROM dramatically increases your computing power. You have access to a range of 8 colours for foreground, background and border, together with a sound generator and high-resolution graphics. You have the facility to support separate data files. You have a choice of storage capacities (governed by the amount of RAM). 16K of RAM (which you can upgrade later to 48K of RAM) or a massive 48K of RAM. Yet the price of the Spectrum 16K is an amazing £125! Even the popular 48K version costs only £175!

You may decide to begin with the 16K version. If so, you can still return it later for an upgrade. The cost? Around £60.

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There's no need to stop there. The ZX Printer—available now—is fully compatible with the ZX Spectrum. And later this year there will be Microdrives for massive amounts of extra on-line storage, plus an RS232/network interface board.

Key features of the Sinclair ZX Spectrum

- Full colour - 8 colours each for foreground, background and border, plus flashing and brightness-intensity control.
- Sound - BEEP command with variable pitch and duration.
- Massive RAM - 16K or 48K.
- Full-size moving-keyboard - all keys at normal typewriter pitch, with repeat facility on each key.
- High-resolution - 256 dots horizontally x 192 vertically, each individually addressable for true high-resolution graphics.
- ASCII character set - with upper- and lower-case characters.
- Teletext-compatible - user software can generate 40 characters per line or other settings.
- High speed LOAD & SAVE - 16K in 100 seconds via cassette, with VERIFY & MERGE for programs and separate data files.
- Sinclair 16K extended BASIC - incorporating unique 'one-touch' keyword entry, syntax check, and report codes.
RS232/network interface board

This interface, available later this year, will enable you to connect your ZX Spectrum to a whole host of printers, terminals and other computers. The potential is enormous. And the astonishingly low price of only £20 is possible only because the operating systems are already designed into the ROM.

The ZX Printer - available now

Designed exclusively for use with the Sinclair ZX range of computers, the printer offers ZX Spectrum owners the full ASCII character set — including lower-case characters and high-resolution graphics. A special feature is COPY which prints out exactly what is on the whole TV screen without the need for further instructions. Printing speed is 50 characters per second, with 32 characters per line and 9 lines per vertical inch. The ZX Printer connects to the rear of your ZX Spectrum. A roll of paper (65ft long and 4in wide) is supplied, along with full instructions. Further supplies of paper are available in packs of five rolls.

The ZX Microdrive - coming soon

The new Microdrives, designed especially for the ZX Spectrum, are set to change the face of personal computing. Each Microdrive is capable of holding up to 100K bytes using a single interchangeable microfloppy. The transfer rate is 16K bytes per second, with average access time of 3.5 seconds. And you'll be able to connect up to 8 ZX Microdrives to your ZX Spectrum. All the BASIC commands required for the Microdrives are included on the Spectrum.

A remarkable breakthrough at a remarkable price. The Microdrives are available later this year, for around £50.

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BY PHONE - Access, Barclaycard or Trustcard holders can call 01-200 0200 for personal attention 24 hours a day, every day. BY FREEPOST - use the no-stamp needed coupon below. You can pay by cheque, postal order, Access, Barclaycard or Trustcard. EITHER WAY — please allow up to 28 days for delivery. And there's a 14-day money-back option, of course. We want you to be satisfied beyond doubt — and we have no doubt that you will be.

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THE MULTI-PURPOSE TIMER HAS ARRIVED

Now you can run your central heating, lighting, full system and lots more without rewiring orprogramming the kit. At your selection it is designed to control 60-120mA loads and is perfect for pre-set times over a 7 day cycle, e.g. to control your central heating, lighting or anywhere else. Just connect it to your system programme and set it to run — it will do the rest.

FEATURES INCLUDE:
- 3.5" LED 12 hour display.
- Day of week and time in 24 hour clock.
- 4 level sensitivity: low, medium, high and OFF.
- Display flashing during power failure to conserve battery power.
- 14 programme time sets.
- Poweroff "Everyday" function enabling output to switch everyday.
- Non-volatile memory enabling output to remain switched on if power failure occurs.
- Brownout display when mains voltage falls below threshold.
- Switch control enabling output to be turned on or off at pre-set times over a 7 day cycle.
- 36 function keypad for programme entry.
- Programming instructions are printed on the base.

(Kit includes all components, PCB, assembly and programming instructions).

THE HOME CONTROL CENTRE

This new Remote Control Kit enables you to control up to 16 different appliances anywhere in the house from the comfort of your armchair. The transmitter comprises a mains powered receiver which accepts commands from up to two receivers, each with separate memory. Receivers are addressed by means of a 16-way push button switch and can be connected in series or parallel, enabling you to control up to 64 different appliances. The kit also includes a 10-way keyboard and a special IC which provides a unique code for each appliance. A further 24-hour clock function enables you to control your appliances at any time over a 24-hour period.

For a detailed booklet on the Multi-purpose Timer see page 11.

MINI KITS

MK6 THERMOCOUPLE/THERMISTOR THERMOMETER

Ideal for monitoring the temperature of a fire, oven or any other appliance. The MK6 has a sensitivity of 200mV for a full scale reading, allowing audio "beat" to be detected using a pre-set pot. Outputs are undirectional channel sequence with speed of sequence, speed of sequence change, being variable by means of potentiometers and displays: a maximum of four different combinations within the range of 0-0.01°C. The kit forms a 16 element LED display as a "digital" display. The kit includes all components to make a coded transmitter and only requires 4x1.5V MN batteries. An additional IC is required — details supplied.

MK5 TEMPERATURE CONTROLLER

This new design is based on the SL441 zero voltage switch. It incorporates a four figure display, a "duty free" power controller, and a relay enabling the system to be controlled by a thermostat. The kit contains all components except a 9V battery and is supplied with all necessary screws and wires. It is available in the following models:

MK12 16 -CHANNEL IR RECEIVER

Based on the SL441 zero voltage switch which is used to control the receiver. Receivers are addressed by means of a 16-way push button switch and can be connected in series or parallel, enabling you to control up to 64 different appliances. The kit also includes a 10-way keyboard and a special IC which provides a unique code for each appliance. A further 24-hour clock function enables you to control your appliances at any time over a 24-hour period.

MK11 10 -CHANNEL IR RECEIVER

Based on the SL441 zero voltage switch which is used to control the receiver. Receivers are addressed by means of a 10-way push button switch and can be connected in series or parallel, enabling you to control up to 32 different appliances. The kit also includes a 10-way keyboard and a special IC which provides a unique code for each appliance. A further 24-hour clock function enables you to control your appliances at any time over a 24-hour period.

THE SOFTY 2 EPROM PROGRAMMER

Overview: The SOFTY 2 is a simple yet versatile programmer for EPROMs, microcontrollers and other memory devices. It can program a wide range of devices, from small 4-bit microcontrollers to large 256Kbit flash memories. The SOFTY 2 uses a standard 28-pin DIP socket for programming, allowing you to program your device in-situ. The kit includes all components except the target device, which you will need to supply.

This is a kit for the SOFTY 2 EPROM programmer in stock at £169.
CRICKLEWOOD ELECTRONICS LTD

STOCKING PARTS OTHER STORES CANNOT REACH

SUPERIOR QUALITY CARBON FILM RESISTORS, the world wide choice. 3.9k 3p, 100k 1p, 50k 3p.

LOW NOISE

7W (IEC120) 1% T1 15p
7W (IEC120) 0.5% 20mV 15p
1W (IEC120) 0.1% 20mV 5p
2W (IEC120) 0.1% 20mV 15p
15W (IEC120) 0.1% 20mV 15p

METAL OXIDE RESISTORS

1% 100k 5p, 10k 2p, 5k 2p, 2.2k 20p, 1k 7p, 470 6p, 100 5p, 10k 4p, 1M 1.5p.

LOW OHM VALUE RESISTORS

3k 5p, 5.6k 5p, 10k 10p.

WIRE WOUND RESISTORS

3W 15k 2p, 5W 10k 20p, 1W 5k 2p, 2W 10k 20p, 10W 10k 15p.

LOW NOISE ROTARY POSTS

E Series 1-10k 5p, 1-1k 10p, 10-1k 1p, 1k-10k 5p.

Variable Capacitors

Forbi 1p 1k-470pf, Jasco 1k-56pf.

Low Voltage Stabilised

Metal Oxide.

ETCH RESIST TRANSFORMERS

1.9 Turns 1p, 500pf 2p.

Soldering Irons

Low Voltage Matsushita 15w 5.5V 100mA.

QF111 Quality Electro-lux by Matsushita 15w 5.5V 100mA.

Tantalum Beads

220pf 20p, 1nF 5p, 10nF 5p.

Auto Transformer 115v up to 240v 500w 12.00.

NOT TRANSFORMER RECEPTABLE

3-12V 6.00, 12-24V 12.00.

Tornado 30-350v 30w 20-200w 18.00.

Tankless

450w 300v 20.00.

High Voltage Electrolytics

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3.5kV 1000uF 1000w 30.00.

5.5kV 400uF 4000w 60.00.

8lKv 100uF 1000w 70.00.

4500 Volts 1000uF 2000w 120.00.

4500 Volts 500uF 4000w 200.00.

Aluminium Panels

18w x 84m x 46mm 25w 3.50.

40w x 123m x 46mm 50w 7.50.

40w x 246m x 46mm 160w 13.00.

Aluminium Boxers

4 x 4 x 151m, 6 x 6 x 3m, 6 x 6 x 6m, 6 x 6 x 12m, 7 x 7 x 6m, 7 x 7 x 7m, 7 x 7 x 12m, 7 x 7 x 18m, 8 x 8 x 6m, 8 x 8 x 12m, 8 x 8 x 18m, 8 x 8 x 24m, 9 x 9 x 6m, 9 x 9 x 12m, 9 x 9 x 18m.

Illuminating Capacitors

47uf 160v 50p, 1uf 160v 10p.

MINI FILM MILLIAR

10uf 50v 1p, 5uf 50v 5p.

Soldering Irons

15w 3.50, 20w 5.00.

Rainbow Ribbon Cable

30m 55p.

Aerial Cable

500m 6.50.

COAX CABLE 50ohm

100m 4.50.

Antenna Amplifiers

75ohm 20w 3.00.

Antennas

4500ohm, 5000ohm, 7000ohm.

12m Antennas

10m 4.00.

12m Antennas

10m 3.00.

THYRISTORS

Small Signal

Small Signal.

Small Signal.

Medium Duty

Medium Duty.

Large Duty

Large Duty.

Large Duty.
FIRST STEPS

The microprocessor has now been with us for many years although few have been used in projects for the hobbyist. Perhaps this is because their use has often been a more expensive solution than smaller chips in any given project, except perhaps the "hobby computer". Well, PE did its bit for computing with the publication of the Compukit UK101 design back in '78 and of course we have published various projects using dedicated micros. The PE Bandbox, Car Computer, Robots and Telectric being shining examples that are going strong on the retail market. However, the big breakthrough that microprocessors promised has been slow in coming to the hobbyist, until now!

This month we take the first of a series of steps to put that right. No, we are not going to expand our computer projects (even though the amazing Ultimum Interface system starts in this issue). What we hope to achieve is the use of micros to expand the range and sophistication of our projects without necessarily making them more expensive or more difficult to build.

We have decided that it's high time the micro is used as a "regular" component by the hobbyist and high time that hobbyists understand the devices more fully. With this in mind we are launching Micro-file in this issue. This file system will consist of a pull out section, in the centre of each issue, describing a wide range of microprocessors. The section can be extracted from the issue and filed for easy reference.

The first Micro-file consists of an introductory four page article, which will form the covers of the file, plus the first Datasheet and backup article on the 8080A/8085A. Each month we will present a Datasheet plus back up information on a different chip, so that over a period of about a year the sheets will form into a file packed with data on all the popular microprocessors. A file full of valuable information that will enable the hobbyist to choose and use microprocessor chips in dedicated applications.

CONTROL

In addition to Micro-file we are also proud to present the Microcontroller, which is not a project in the truest sense: the boards come ready built at an unbelievable price! What we have done is commission Mike Tooley and David Whitfield to unravel the intricacies of the unit and write a monitor program for it, so that the hardware can be used as a "universal controller".

What we want you to do is to let us know how you have applied the unit (maybe to a robot, central heating or overall house electrical management system etc.) so that we can interest others in doing something similar. To encourage readers to do this, Display Electronics (the Microcontroller suppliers) are running a competition for Microcontroller users and PE will publish any suitable winning entries — and pay for them of course! So here's your chance to obtain and use a micro system in a control application at a very low price and maybe reap a reward for your ideas.

We believe the time of the dedicated micro has now come for the hobbyist in a big way. We intend to provide the necessary information and more, exciting projects as the months go by.

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New Computer Systems

The Dragon 32 micro computer is just one of five new systems which have been launched this month. The others include the Micro 8 from the Japanese mainframe giant Fujitsu, the latest Colour Genie from Lowe Electronics and from two new companies, ORIC I and Jupiter Ace.

Based around the 6809E microprocessor the Dragon 32 has 32K of RAM, extended Microsoft basic, eight graphic pages from 512 text points to 49,152 points, nine colours and a five octave range for both music and speech synthesis. The unit is available from Dragon Data Ltd., Queensway, Swansea Industrial Estate, Swansea (0792 580651). Price £199.50 including VAT.

The Micro 8 from Fujitsu boasts no fewer than three microprocessors; two 6809's which handle 640 x 200, 8 colour dot high resolution graphics, 8 x 8 matric block graphics and a Z80A for use with CP/M based software. Other features of the system include a real time clock, 32K of Microsoft Basic, 128K of total memory and provision for bubble memory. The Micro 8 is available from Minichip Limited, Enterprise House, Terrace Road, Walton, Surrey (0932 242777). Price £895 excluding VAT.

Lowe Electronics have added another Genie to their range of home computers the Colour Genie has 16K RAM, 16K ROM, 16K basic ROM, a maximum of 16 colours, 160 x 96 high resolution graphic characters with 128 programmable graphic characters and 64 preset characters. The Colour Genie is priced at £199 including VAT, Lowe Electronics, Mallock, Derbyshire (0629 2430). Oric I from Oric Products has been designed by Tangerine Computer Systems and is produced in two versions, both have 16 colours, one has 16K of RAM and is priced at £99 including VAT whilst the other has 48K of RAM and is priced at £169 including VAT. Oric I uses Microsoft basic, has a sound generator chip covering six octaves and a display resolution of 24 rows x 40 characters.

The Jupiter Ace which has been designed by two ex-Sinclair men uses a specially adapted version of the compiled language FORTH. The unit has 8K of ROM and 3K of RAM a memory mapped 32 x 24 character display, a programmable sound generator and a fast cassette interface. Priced at £89.95 including VAT and p&p the Ace comes complete with a mains adapter, cassette and TV leads and a manual. Jupiter Cantab. 22 Foxhollow, Bar Hill, Cambridge.

POINTS ARISING . . .

AUDIO ANALYSER (August–October '81)
1. In Fig. 13, the orientation of the diode D1 is incorrect, and this component should be reversed. The circuit diagram is correct in this respect.

2. In Fig. 17, the component layout for the backplane, the orientation of C115 and C116 is incorrect. Both components should be reversed.

3. In Fig. 17, the component layout for the backplane, C114 is shown connected between rails 1 and 3 (the +7.5V supply), rather than between rails 1 and 2 (the +5V supply), as it should be connected.

4. In Fig. 29, the component layout for the microphone preamplifier, IC1 is shown incorrectly orientated, and should be rotated so that pin 1 is adjacent to C1. Also, the capacitor shown marked C7, and positioned near to IC1, should be marked C4.

5. In the parts list for the microphone preamplifier, C7 should be shown as 47µ 16V tantalum, and C8 as 4n7 disc ceramic.

MICROBUS (SEPT '82)
It is stated that the output of 0–255 corresponds to an analogue input of 0–5V; in this particular case this is not correct.

It can be seen from the circuit diagram that pins 7 and 8 of the ZN427 have been joined; this in effect brings into use the internal reference voltage of the chip which is 2.55V. The statement should therefore be “The output of 0–255 corresponds to an analogue input of 0–2.55V”.

COMBO AMPLIFIER (Aug.–Oct. '82)
A complete set of semiconductors is available for this project from Hart Electronic Kits Ltd., Penylan Mill, Oswestry, Shropshire SY10 9AF. Tel: 0691 2894.
BECKMAN DMM's

Beckman Instruments has introduced two handheld digital multimeters; the 3½ digit T100 and T110 models, both of which offer five d.c. voltage ranges from 200mV to 1000V, five a.c. voltage ranges from 200mV to 750V, six d.c. and a.c. current ranges from 200µA to 10A and six resistance ranges from 200 ohm to 20 Mohm.

Of special interest is the direct 10A current range which obviates the need for external shunts. The resistance ranges can be switched to either low power for measuring in electronic circuits without turning on diodes and transistor junctions, or to high power for measuring resistances in electrical circuits or out of circuit. Both instruments also feature a special range for testing diodes and transistors which provides an accurate measure of the forward voltage drop in the diode junctions.

Diodes and transistors can also be checked in or out of circuit. The T110 also incorporates a buzzer for continuity testing and circuit tracing.

A high 10 Mohm input impedance ensures that measurements are hardly affected by circuit loading, and effective RF shielding guards against external fields. Accuracies are guaranteed for one year, and eventual recalibration is very simple, as it only requires the adjustment of two potentiometers.

All functions and ranges are selected with a single rotary switch and the 3½ digit l.c.d. features automatic decimal point positioning, polarity, overrange and low battery indication. The instruments will operate continuously for 200 hours from one standard 9V battery.

Satellite TV Receiver

When you arrive at Alexandra Pavilion for the Electronic Hobbies Fair, the first thing you will see is a Luxor satellite TV receiver dish like the one shown opposite. The system with its two metre dish will be set up to receive programmes from the Russian Ghorizant-3 satellite in geostationary position 53 degrees E. The dish will be linked to a Luxor receiver system and TV inside the Pavilion so that visitors can see the results; this is just one of the special exhibits that is being arranged.

The other photo below was taken during the third International Road Racing Show. It gives a good impression of the inside of the hall. What is not apparent from this photo are the facilities available; these include three bars, two buffets, comprehensive toilet facilities—including a disabled toilet, first aid room and a baby changing room. Of course all these are purpose built and virtually brand new. In addition there will be extra cafeteria facilities with an additional area of tables and chairs, so no one should want for anything.

The largest supplier of components to the hobbyist—Maplin Electronic Supplies Ltd.—had this to say about the Fair: "The show coming in November is the one we are all excited about, here at Maplin. It's the Electronic Hobbies Fair, a brand new show, that is going to be very different from anything you've ever seen before. As well as the usual electronic stands, there will be computers, model control, amateur radio, CB and practical hi-fi."

"But the big plus about this show is that the organisers have really gone to town to provide you with dozens of extra exciting things to see and do."

Maplin will be devoting part of their stand to a bank of Atari computers, each running a different piece of software, so visitors will be able to play with them or just stand and watch.

Electronic Hobbies Fair, Alexandra Pavilion, November 18th to 21st. For more details and a 50p off voucher, see page 75.

Keep watching PE for more details of the Fair; it will be the liveliest and most professionally organised event ever to be staged in this field.
A wide range of sound effects can be added to your ZX-81 with the ZON X-81 Sound Unit, now available form BI-PAK.

The unit is based on a three-channel plus-noise sound chip and is so designed that the pitches and volumes of the three channels and the overall attack/decay envelope can be controlled by simple BASIC statements. By this means, piano, organ, bells, orchestrions, lasers, explosions etc., can be simulated and easily added to existing programmes.

ZON X-81 is housed in a neat black plastic case with loudspeaker and manual volume control (in addition to programmed volume) and simply plugs in between the rear of the ZX-81 and its RAM pack and/or printer (if fitted). No dismantling, wiring, soldering, batteries, power supplies or leads are required.

An instruction booklet explains the operation of the unit and a number of example programmes of useful sounds is also included.

The ZON X-81 is available from: BI-PAK Semiconductors, P.O. Box 6, Ware, Herts. 0902 3442 and is priced at £25.95 including postage and VAT.

Namal Electronics have developed a speech synthesizer which can be directly connected to the ZX81 or the Spectrum. The synthesizer has a standard dictionary of about 600 words stored in an EPROM and the user can add to these by utilising the units 2K static RAM. The unit is programmed via the host computer, needing only two instructions per word.

Based on a phonetic speech synthesizer made by Votrax of Detroit the unit which measures 150 x 180 x 35mm comes complete with an integral loudspeaker, volume control and ribbon connector. There is also provision for driving an external loudspeaker or amplifier.

The Super Talker is priced at £49.95 for the ZX81 and £59.95 for the Spectrum (prices excluding VAT).

Namal Electronics, 25 Gwydir Street, Cambridge (0223 355404).

Readers may be interested to know that Premier Publications are intending to do for the Dragons what they have done for the UK101. They are already supplying Dragons, writing software and generally getting inside the unit in preparation for servicing and the design of various add on kits. This back up will no doubt add to the Dragons attraction.

Premier Publications, 208 Croydon Road, Anserley, London B20 7TT.

The assets of EDA-Sparkrite Limited, which went into voluntary receivership in July 1982, have been acquired by STADIUM LTD. Sparkrite manufacture electronic ignition, car security systems and in-car computers and is based in Walsall, West Midlands.

This change of ownership is a major turning point for Sparkrite after the difficult circumstances of the last few months.

Sparkrite (A Division of Stadium Ltd.), 82 Bath Street, Walsall WS1 3DE. 0922 614791.
Probably the fastest microcomputer in the universe
the **JUPITER ACE** only £89.95.

**Key Features**
- Revolutionary microcomputer language FORTH.
- Full-size moving-key keyboard.
- User-defined high-resolution graphics.
- Programmable sound generator.
- Floating point arithmetic.
- Fast cassette interface.
- Upper and lower case ascii character set.
- 24 x 32 character flicker-free display.

**The Jupiter Ace uses FORTH**

The Ace is set apart from all other personal computers on the market by its use of a revolutionary language called 'FORTH'. Some computer languages are easy for humans to understand, others are easy for computers; FORTH is most unusual in being both. Its underlying principles are so simple that it takes even a newcomer to computers only a few minutes to learn how to do calculations on the Ace, yet the very same principles are powerful enough to allow you to invent your own extensions to the language itself.

At the same time, the memory-saving coded form used to store your programs inside the Ace allows it to obey them very fast — typically in less than a tenth of the time it would take to do the same thing using a different language. Amongst other things, this makes the Ace ideal for games.

FORTH’s unique combination of speed, versatility and ease of programming has already made it a prime choice for professional applications as diverse as pub games and radio telescopes, and gained it an enthusiastic national user group. Now the Jupiter Ace can bring this addictive language into your own home.

**Designed by Jupiter Cantab**

Leading computer Designers Richard Altwasser and Steven Vickers have a reputation for pushing technology forwards. After playing the major role in creating the ZX Spectrum they formed Jupiter Cantab to develop their latest brainchild the Jupiter Ace.

**Technical Specification**

Hardware
- **Processor/Memory**: Z80A running at 3.25 MHz. 8K bytes ROM 3K bytes RAM.
- **Input**: 40 moving-key keyboard with auto-repeat on every key.
- **Output**: Memory-mapped 32 x 24 character display with high resolution user graphics. Output to drive normal UHF TV set on channel 36.
- **Sound**: Provided by internal loudspeaker.
- **Cassette**: Load Save & Verify at 1500 baud, separate data storage.

Software, FORTH
- **Data Structures**: Integer, Floating point and String data may be held as constants, variables or arrays with multiple dimensions and mixed data types.
- **Control Structures**: IF-THEN-ELSE, DO-LOOP, BEGIN-WHILE-REPEAT, BEGIN-UNTIL, all may be mixed and nested to any depth.
- **Operators**: Mathematical +, -, X, -. Logical AND, OR, NOT, XOR. Comparison <, >, =.
- **Program Editing**: FORTH words may be listed, edited and redefined. Comments are preserved when words are compiled.

**Order Form**

The Jupiter Ace is available only by mail order. Please allow up to 28 days for delivery.

Send cheque or postal order with the form to:

**JUPITER CANTAB**, 22 FOXHOLLOW, BAR HILL, CAMBRIDGE CB3 8EP

Please send me:

□ JUPITER ACE MICROCOMPUTER(S) @ £89.95.

Name. Mr/Mrs/Miss [ ]  
Address [ ]

**All inclusive Price**

For £89.95 you receive your Jupiter Ace, a mains adaptor, all the leads needed to connect to most cassette recorders and T.V.s (colour or black and white), a software catalogue and a manual.

The manual is a complete introduction to the world of personal computing and a course in FORTH programming on the Ace. Even if you are a complete newcomer to computers, the manual will guide you step by step from first principles to confident programming.

The price includes postage packing and V.A.T.
THE PE Microcontroller is an assembled project which is based around the 6800 micro.

Long term success for any product is usually assured if it is cost effective and if it can easily be adapted to meet any new requirements. The more adaptable the tool, the more successful and durable it is likely to be. Nature provides an example of a highly versatile tool in the human hand, which is capable of performing an extremely wide range of intricate tasks. It is, however, only with the advent of the microprocessor that the idea of the general purpose electronic controller has become a practical proposition. Such controllers still have a long way to go before they are able to rival the flexibility and ease of programming of the human hand. Programmable controllers are, nevertheless, now able to offer some significant advantages over the dedicated controllers of the last decade, and increasingly at prices which are acceptable to the home constructor.

This Microcontroller was originally designed to form the intelligent 'heart' of a mass produced commercial product. The basic design, however, followed conventional guidelines, and the final controller is a good example of a general purpose programmable controller. A wide range of control facilities are available within the basic controller, and users should have little difficulty in adapting it (often simply by writing a suitable control program) to a wide range of new applications. Practical applications will be discussed in later issues, together with details on how to program the 6800 microprocessor which is the CPU in the Microcontroller.

MICROCONTROLLERS

A microprocessor which is used to control a system (i.e. a microcontroller) must be capable of accepting input information, responding, and outputting appropriate signals to implement the required control action. A typical microcontroller arrangement is shown in the block diagram of Fig. 1.1. It can be seen from this figure that the input/output signals may require signal conditioning so that their forms and levels become compatible with the input/output interface elements. In many cases, however, no such conditioning is necessary, and indeed it is one of the aims of any general purpose microcontroller that the amount of conditioning circuitry is kept to a minimum. In the 6800 microprocessor family, interfacing is greatly simplified by the availability of a range of versatile and programmable interface adaptors, making the 6800 well suited to controller applications. The four parallel interface adaptors in the system can each provide up to 16 separately controllable input/output lines.

An important feature of any programmable controller is that its function may be changed by modifying its control program. Thus, in many situations, the age-old call of "Back to the drawing board", becomes "Back to the keyboard". This feature also allows the function of a controller to be modified during production without the need for any changes to be made to the hardware. This is one of the reasons that the use of erasable PROMS in early production units is
The applications for the Microcontroller are therefore limited only by the ingenuity and imagination of the user; the best application offered for the unit is the subject of a competition details of which are given at the end of this article.

**SYSTEM HARDWARE DESCRIPTION**

The Microcontroller is a 6800 microprocessor-based system which is ideally suited to programmed control in a wide variety of applications. A block schematic for the Microcontroller is shown in Fig. 1.2. This diagram shows the 6800 configured in a conventional fashion with an 8-bit data bus, 16-bit address bus, and a control bus. The arrangement supports the full 64Kbyte addressing range of the 6800, while leaving scope for further expansion.

The 6800 is designed to use programmable memory-mapped peripheral devices. The system has four programmable interface adaptors (PIAs), each of which has 16 individually programmable input/output lines. One of these PIAs is dedicated to the keyboard, the second drives the gas discharge display, and the remaining two are available for user applications. The capabilities of the PIA devices are discussed in greater detail in a subsequent section, and at length in a later issue.

The Microcontroller has 1024-bytes of RAM, which is provided with integral battery back-up to safeguard against program loss in the event of power failure. The board has facility for the inclusion of a 32-byte ROM, originally intended for “personalising” units. This ROM is unused in the basic system. Permanent memory is provided for storage of the monitor program (DISBUG) by a 2048-byte EPROM. The circuit configuration does, however, allow the use of up to 8196 bytes of permanent memory.

An address map for the system is shown in Fig. 1.3. The addresses shown are all given in hexadecimal notation; areas shown with dotted line boundaries are available for use, but are not utilised in the basic unit. Users should be aware that full address decoding is not always employed, and that some address images do occur.

Two crystal controlled clocks are incorporated in the Microcontroller. The first is the master system clock which provides the basic timing for the microprocessor and the buses. In addition, it incorporates facilities for synchronising the start-up and reset sequences. The second oscillator is a real time clock, operating at 1Hz, which is connected to the display PIA. This clock may be configured under program...
control to provide regular interrupts, which are essential for any time dependent applications.

Separate from the main Microcontroller board are the gas discharge display, keyboard, power supply and mains transformer. Peripheral equipment to be controlled is connected to the main board by a multi-way ribbon cable.

ARCHITECTURE OF THE 6800 FAMILY

The 6800 is an 8-bit microprocessor whose internal architecture is shown in Fig. 1.4. The device is supplied in a 40-pin d.i.l. package, and requires only a single +5 volt supply. The main processor requires a 2-phase non-overlapping clock to control its operation. The basic processor cycle time is one quarter of the oscillator's crystal frequency.

The CPU device includes an 8-bit bidirectional buffer for the data bus, and a 16-bit unidirectional address bus buffer. These buffers will each drive a single TTL load; each standard peripheral device imposes a significantly lower load.

The programming model, given in Fig. 1.5, shows the registers which are available to the user. Two general purpose 8-bit accumulator registers (rA and rB) are provided for arithmetic and logic operations. A 16-bit index register (In) is available for indexed addressing modes of many instructions. The 16-bit program counter (PC) is maintained automatically by the CPU, and holds the memory address of the next instruction to be executed. The 16-bit stack pointer (SP)
indicates the next free location on the push-down user stack. The stack pointer must be initialised by the user, but thereafter is maintained by the CPU. Finally, the condition code register (CCR) is used to indicate CPU and interrupt status. Only six bits of the CCR are used, the remaining two being permanently set HIGH.

Arithmetic and logic operations are performed by the arithmetic and logic unit (ALU). Operations may take one or two operands, depending on the instruction. Operands may be the contents of registers and/or memory locations. ALU operations set various bits within the CCR, depending on the instruction and the result of the operation.

The 6800 provides interrupt facilities for software interrupts, user interrupts, non-maskable interrupts and also for system reset. User interrupt requests may be masked under program control. The addresses of the interrupt service and reset service routines are defined as the top eight bytes of the 6800's memory. The Instruction decode and control unit handles interrupt requests, provides bus control signals and executes instructions. Details of programming the 6800 will be given next month.

The 6821 peripheral interface adaptor (PIA) provides a universal means of parallel interfacing to peripheral equipment. The PIA interface uses two 8-bit bidirectional buses and four control/interrupt lines. Internal architecture of the 6821 PIA. The CPU sets up the PIA's functional configuration under program control. The peripheral data lines, PA0 to PA7 and PB0 to PB7, can each be configured either as an input or as an output. Consequently, any combination of inputs and outputs is possible, up to the maximum of 16 lines. The four control/interrupt lines, CA1, CA2, CB1 and CB2, may also be configured to act in one of several modes for handshaking with peripheral equipment. All PIA peripheral data lines may drive up to two TTL loads, with CMOS drive capability on PA0 to PA7.

Internally, the 6821 contains two independent sections each comprising an output register, control register, and data direction register. Separate interrupt status control is provided, together with an interface buffer, for each group of eight peripheral lines. Data is transferred to the output registers during a CPU WRITE operation via the data bus buffers and input register. Where a particular peripheral line has been programmed as an output, data will be transferred to this line. Where a particular line has been programmed as an input, data will be transferred to the system data bus from this line during a CPU READ operation. Multiple chip select lines simplify the selection of a particular PIA where several have been used. Timing is provided by an ENABLE signal derived from the 6800. Part of the address bus is externally decoded to select the required PIA, and usually the two least significant address bits are used to select the appropriate register within the PIA.

**DISBUG MONITOR FACILITIES**

A program of instructions is required by the CPU in order to make any use of the hardware facilities offered by an intelligent controller. It is this feature which distinguishes between dedicated and programmable controllers. The function of a programmable controller may be changed simply by the installation of a different control program; this may be
accomplished in a number of ways. In mass production applications, programs are written on development systems and then stored in the permanent memory of the controller. The function of the Microcontroller, however, is user-defined and therefore facilities must be provided to enable the user to develop his own control programs. These facilities are provided by the DISBUG monitor program which resides in permanent memory, and thus cannot be over-written. User programs are stored in the RAM area, allowing them to be developed in a modular fashion.

The facilities provided by a monitor program should include the following:
1. An interface between the user and the system.
2. The means to input and modify programs.
3. The ability to control the execution of programs.
4. Debugging facilities.

The interface between the user and the system is provided by the keyboard and the display. The DISBUG monitor scans the keyboard for user commands, and uses the display to output results. The keyboard layout is shown in Fig. 1.7.

The keys are essentially divided into two major groups; numeric keys and command/control keys. The command/control keys are associated with five major groups of monitor functions:
1. Memory examine and change.
2. Register examine and change.
3. Setting of breakpoints.
4. Memory presets.
5. User program control.

The facilities offered are outlined below and will be examined in detail in a later issue.

**MEMORY EXAMINE AND CHANGE**

The contents of any memory location may be examined and (optionally) changed using the memory editor. This function is also used for entering programs into the user RAM area. The user may specify any address in the 6800 address space, i.e. 0000 to FFFF. Over-writing the DISBUG RAM area may have unforeseen consequences, although writing to ROM addresses will have no effect.

The memory editor is invoked by pressing the MEMORY key, and the numeric keys 0 to F are then used to specify the four-digit memory address to be examined. The contents may then be changed, if required, and the editor then exited, or the next/previous memory location examined. The CANCEL key allows the user to abandon any uncompleted memory change.

**REGISTER EXAMINE AND CHANGE**

The user may examine the contents of any of the 6800's registers after a breakpoint has been encountered. The REGISTER key is used to invoke the register editor, and changes may then be made before the program proceeds from the current breakpoint. Registers are displayed in a cyclic fashion, as shown in Fig. 1.8. The 16-bit registers are displayed in two stages, lower and upper bytes in turn. Other editing facilities are similar to those in the memory editor.

**MEMORY PRESETTING**

Areas of RAM may be present to user-defined values by using the preset editor. This facility is useful for initialising RAM to known values, e.g. all zeroes, filled with NOP instruction codes, etc. The preset editor is entered using the PRESET key, and pointers are then set up to indicate the bottom and top of the RAM area to be filled. The preset value is input, and this is then written to each location in the range specified, including the two extreme addresses.

**SETTING BREAKPOINTS**

Temporary halts or breakpoints are a useful aid to debugging user programs. They enable the programmer to split the program into convenient blocks so that each block may be tested separately. Breakpoints are set and reset using the breakpoint editor, which is entered by pressing the BREAKPOINT key. Up to four breakpoints may be set in the user program and, when a breakpoint is encountered, the user may examine the register contents using the register editor.

**USER PROGRAM CONTROL**

GO: The user program is started using the GO function key. After pressing GO, the user enters the start address from which program execution should commence. The ENTER key is used to initiate execution, or CANCEL may be used to abandon the function.

PROCEED: The user program may be caused to continue from a breakpoint using the proceed function. After PROCEED is pressed, ENTER restarts program execution, or CANCEL abandons the command.

RESTART: The RESTART key is used to re-initialise the DISBUG monitor program. The DISBUG RAM area is reset to its initial values, and the welcome message appears. The user RAM is unaffected by this function. A restart has the same effect as entering DISBUG at power-up, but without
SOFTWARE FACILITIES
 Various software aids are available within the DISBUG monitor program to assist the user in developing control programs. These aids are subroutines which may be called from RAM based code. The functions and interfaces for these routines will be described in a later issue.

CIRCUIT DESCRIPTION
 The circuit diagram for the Microcontroller is shown in two parts. The CPU, clocks, memory and the CPU side of the PIA's appear in Fig. 1.9. The keyboard, display, output drivers and the peripheral side of the PIA's are shown in Fig. 1.10.

When interfacing in control applications, the primary concern is with the logic shown in the second of these drawings. Applications programs, and the monitor program used to enter and control these programs, reside in the memory and are executed by the hardware shown in the first figure.

A discrete Colpitts crystal oscillator, formed by TR1 and associated components, provides the master timing signal. The crystal operates in series resonant mode to produce a signal at 3.579MHz. The oscillator output is taken from the collector of TR1 and applied to the clock generator, IC1. The clock generator provides the necessary non-overlapping two-phase clock, producing a CPU cycle frequency of 894.75kHz, i.e. at one quarter of the frequency of the master timing signal. Outputs are also provided for memory synchronisation, and for the system reset signal.

The 6800 CPU is arranged in a conventional small system configuration, with no additional bus buffers required. Memory address decoding is provided by IC6 and IC25a. The HALT and NMI interrupt request lines are unused, and are therefore held HIGH by R7 and R5, respectively. The IRQ user interrupt request line is connected to the four PIAs, any one of which may assert this line, thereby causing a user interrupt request.

The four PIAs, IC11, IC12, IC13 and IC14, are all connected to the full width of the CPU data bus. Also connected to the PIAs are the system RESET signal from the clock generator, and the CPU R/W signal. The address decoder, IC6, provides an active low chip select (CS) to a PIA when one of its register addresses is output by the CPU. Four of these chip select outputs from IC6 are connected to the appropriate CS2 pin on the four PIAs. The CS0 and CS1 pins on all PIAs are unused, and are connected to +5 volts via R39. The two least significant lines of the address bus (A0 and A1) are connected to the register select inputs (RS1 and RS0, respectively) on the PIAs. The correspondence between the address value and the PIA register selected is shown in Table 1. A0 and A1 have no effect on the PIAs unless the CS2 in the PIA in question is held LOW by the address decoder.

The 1Hz real time clock is provided by IC2. This device is a 24-stage frequency divider which incorporates a conven-
Fig. 1.9. Circuit diagram of the Microcontroller.
tional CMOS oscillator stage. A single inverting stage, biased into the linear region by R30, generates the fundamental clock at 4.194MHz. R32 reduces the crystal drive and improves the stability and accuracy of the oscillator. The oscillator output is set to standard logic levels by R33 and R34. The 1Hz output is applied to the CB1 line on the display PIA, IC12.

The RAM storage in the Microcontroller is provided by two 1024x4-bit very low power memory devices, IC8 and IC9. These are arranged to provide 1024 bytes of storage. The two RAM devices are de-selected whenever the main +5V supply is absent, thus preventing inadvertent memory corruption. The memory contents are retained by the on-board Ni-Cad battery supply, B1. This battery has a capacity of 90mA/h, and during normal operation it is trickle charged at a nominal 4mA rate by means of R10. Control logic devices IC7 and IC15 are also supplied from B1 during power failure.

The gas discharge display is connected to the display PIA, IC12, via three high voltage drivers, IC20, IC21 and IC22. Power failure.

The keyboard is connected as a matrix between the A and B halves of the keyboard PIA, IC11. The three-to-eight line simplifies the software scanning of the keys should all be labelled as shown in the diagram.

INTERCONNECTIONS
1) Check that the thin blue and white wires on the mains transformer primary are connected together via an insulated connector block.
2) Remove the spade and tag connectors from the yellow, red, and green/yellow thin primary wires, N.B. do not remove the 4-way connector socket from the secondary wires.
3) Connect a good quality 3-core mains lead to the mains transformer, via a mains fuse (1 amp) and double pole on/off switch, as follows:

<table>
<thead>
<tr>
<th>A1</th>
<th>A0</th>
<th>PIA Register Selected</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>PIA output register A</td>
</tr>
<tr>
<td>0</td>
<td>1</td>
<td>PIA output register B</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>PIA control register A</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>PIA control register B</td>
</tr>
</tbody>
</table>

The inclusion of a mains indicator neon, after the switch, is recommended.

4) Connect the mains transformer secondary lead to the power supply board by inserting the socket into the 4-pin connector labelled "D" via four 12V high current drivers, IC16 to IC19. The function of these PIA's is, of course, user definable.

5) The Power supply and Microcontroller boards should be linked together by mating the 11-way connectors marked "A" on the two boards.
6) Connect the 20-way ribbon cable from the display to plug "B" on the Microcontroller board, noting that the connectors are polarised.
7) Connect the 20-way ribbon cable from the keyboard to plug "C" on the Microcontroller board, again noting the polarisation of the connectors.
8) Connector "D" is utilised for interfacing the Microcontroller to the user's peripheral equipment.

HARDWARE MODIFICATIONS
To set up the Microcontroller the following steps should be carried out.
1) Obtain a good quality 24-pin D.I.L. socket and bend pins 18 and 21 outwards at right angles. Remove any PROMs which may be supplied fitted in IC3 and, on some units only, in IC26 positions.
2) Insert the modified D.I.L. socket into the existing holder for IC3, taking care to observe correct orientation.
3) Using a short length of tinned copper wire, connect pin 18 of the new socket to the OV rail; this is the wide p.c.b. track which runs on the top of the board between IC3 and IC5 (the 6800 CPU).
4) Using a 0.25W 1 kohm micro-structure resistor, connect pin 21 of the new socket to the +5V rail; this is the medium width p.c.b. track which runs on the top of the board between pin 24 of IC3 and one end of C4.
5) Insert the DISBUG monitor EPROM into the new socket in the IC3 position, taking care to observe correct orientation.
6) Turn the display board over. The display unit has pins which are numbered from 1 to 30, with pin 14 missing. Pin 1 is identified on the p.c.b. Connect a short length of insulated connecting wire between pin 7 (previously unused) and pin 22.
7) Remove the key tops marked "-" and "I" and replace them in the positions shown in Fig. 1.8. The key top which they replace should be relocated to fill the two gaps. The keys should all be labelled as shown in the diagram.

SWITCHING ON
1) Connect the mains supply, switch on and observe the DISBUG monitor "welcome" message on the display.
2) Should no display occur, check the voltages on connector "A" using a multimeter of 20 kohms/volt or better. Typical voltages expected are as follows:

| A1 | +5V
| A2 | +4.3V
| A3 | 0V
| A4 | +4.2V
| A5 | +3.8V
| A6 | 0V
| A7 | 0V
| A8 | +19V

Any significant deviation from these values should be investigated. Also check that the DISBUG monitor EPROM has been correctly inserted, and that the voltage on pin 18 is OV, and that the voltage on pin 21 is greater than +2V.

COMPETITION
The Microcontroller competition is being run by Display Electronics to find the most practical application for the system.

The winning entry, which will be considered for publication in PE, will receive £300 in cash or goods from Display Electronics to the value of £400.

Full details of the competition together with an entry form and a copy of the rules are available from Display Electronics.

PRICES
The complete Microcontroller system (excluding the case) is available for £32.95 plus VAT and p&p or separately at the following prices: main board £10.95, p.s.u. board £7.75, keyboard £5.50, display board £4.75, Disbug £6.25. All prices exclude VAT and p&p.

Display Electronics, 64-66 Mefford Road, Thornton Heath, Surrey 01-689 7702. The case is available from West Hyde Developments, Unit 8, Park Street Industrial Estate, Aylesbury, Bucks.

NEXT MONTH: P.S.U., DISBUG and 6800 programming.
Spy Scare

The Japanese are nothing if not single-minded. For centuries theirs was an isolated nation, having no truck with foreigners. In this century they became dedicated to military conquest. Frustrated in this attempt they turned to industrial and trade war, so far with conspicuous success. No other nation has so mobilised itself to the single purpose of industrial supremacy on a world scale when military conquest has failed. The nearest parallel is equally defeated West Germany whose own ‘economic miracle’ is now faltering.

Every company likes to know what its competitors are doing and planning. But it still came as something of a shock that allegations are made that Hitachi and Mitsubishi have both been conspiring to obtain the trade secrets of IBM. Both companies have been indicted in US courts. Hitachi is reported to have admitted paying large sums (some £250,000) for information but denied knowing it had been stolen. Mitsubishi is reputed to have denied unlawful conduct and will offer a vigorous defence against all charges.

Apparently the FBI set a trap by setting up a computer dealing company in Silicon Valley which looked genuine but was in fact bogus. Approaches were made to Japanese executives but confidential IBM documents could be provided—at a price. First contact, face-to-face, with an FBI undercover agent was, appropriately, in vice-city Las Vegas. The story, doubtless to be revealed more fully in court hearings, includes penetration of a building for photographic sessions and undercover payment in 100-dollar bills.

Whatever the outcome of these charges there is no question that they have opened another can of worms in the industry. For example it has re-opened the whole question of US technology leaking to other countries. One way of getting hold of a technology is by poaching engineering staff. A newly employed engineer should, in theory, betray the secrets of his former employer, but even if he doesn’t it is inevitable that ideas and techniques he has developed in his old job will be applied in his new employment. On a larger scale, another method is to buy a company outright or a big enough share to guarantee a place on the board. Examples are Philips buying Signetics and, more recently, Schlumberger’s purchase of Fairchild. Then there are numerous cross-licensing deals which give a technology exchange between companies and also across national boundaries.

What worries the Americans is that US advanced technology can reach the Soviet Union through channels over which they have little or no control. If, say, a French company has acquired US know-how through acquisition of an American company, it can be regarded equally as French know-how and would need to be very sensitive (e.g. military security) not to be sold openly in the French manner, or indirectly through a third country acceptable to the West but having close links with the East.

So far, foreign ownership of electronics companies in the United States is mainly European and Japanese. But now, according to one report, the People’s Republic of China has a half interest in a new Semicon-ductor factory now building. It is hardly likely that the Soviet Union would be allowed equal access. But an awful thought remains. What if they have already done so through nominees? If the FBI can dupe the Japanese, why not the Soviets the USA?

Fifth Generation

The immediate practical objective in the secrets probe at IBM was to come to the market with plug-for-plug compatible products to sell to IBM users. A longer term objective could well have been fifth generation computers which are planned to have a high order of artificial intelligence and in specialist applications are already being described as expert systems. They should be with us in the 1990s, if not earlier.

Such machines will need to be ‘friendly’ in the sense of being uncomplicated to use. Most of the hardware is available today but capable of further development. Voice entry, for example, rather than keyboard, and voice response with optional print-out. Assume a medical expert system. A GP may address it, describing a patient’s symptoms, and get an instant diagnosis and suggested course of treatment as if the GP is in conversation with a top consultant. Which, indeed, he or she would be because massive storage would house the accumulated experience and judgement of the best medical experts. The secret, as usual, will be in very advanced programming.

The snag lies in validation of the knowledge stored. In the medical example a mistake in programming could cost lives. And, of course, ‘experts’ are often proved wrong. The computer, with its phenomenal calculating power, programmed with the best economic models, has hardly been a success in management of our own and other nations’ economies.

Nonetheless, expert systems are on the way and the Japanese are investing a reported £200 million of government funds in a ten-year development programme plus possibly £500 million or more from Japanese industry. It all sounds very ambitious until we are reminded, as happened at a recent conference on the topic, that IBM spends as much in a year on R&D as the whole Japanese ten-year programme.

Anyway, it would be foolish to ignore progress and although it would be difficult to match the level of investment of the Japanese or the Americans, there is no doubt that British engineers and companies will be involved in expert systems. On the commercial front Racal have been first to announce an Expert Systems Division which will initially concentrate on oilfield exploration requirements and later expanded to such applications as medicine, finance, energy and defence.

The new breed of super programmers generating artificial intelligence also have a new name to distinguish them from run-of-the-mill hacks. They are to be knowledge engineers.
THE alarming rate at which personal computers have been introduced over the last couple of years may demonstrate a healthy growth market, but it doesn’t help those who already took the plunge and are now left with a less capable machine. It matters little when you bought your computer, it is almost bound to be superseded by the next model in the range, and you are left with little or no support, and just like hi-fi five years ago, the only way out is to cut your losses and upgrade to one of the newer machines.

THE ULTIMUM!
The ULTIMUM has been designed to allow almost any 8 bit computer to be expanded into a much more flexible system. It is modular, which makes custom systems possible, and it offers features which should whet the most megalomaniac appetite.

The ULTIMUM itself is a seven slot expansion board which connects to your computer via a 40 way ribbon cable. A purpose built case is available which will house a power supply, man enough to handle a fully expanded system.

Over the coming months, we shall be introducing several daughter cards. Below is a brief summary of the range:

- A 16/64 KByte RAM card with paging.
- A ROM/RAM/Battery back-up card allowing up to 20 Kbytes of RAM/ROM combinations.
- A EPROM programmer with emulation facilities.
- An intelligent floppy disk controller card, with its own processor allowing full control of disks from BASIC or M/C.
- A port card with RS-232c, parallel and Centronics interfaces.
- An analogue card with A>D and D>A capability.
- A sound board providing up to nine voices, all independently programmable.
- A speech card.
- A terminal card which provides 80 column output and a keyboard interface.
- A second processor card based on the 6809, for speed. This card can share the other cards on the ULTIMUM.
- A prototype board, with pads and power tracks, for your own additions.

THE MOTHERBOARD
We begin with the motherboard. Fig. 1.1 gives the circuit diagram. IC1 to IC4 provide the full buffering of the data and address lines. Two basic bus standards are supported, the 65xx/68xx series and the Z80. These differ in their timing requirements and IC11 and IC12 (along with a few links) enable you to select either.

ICs 5,6,7,9 and 10 provide an on-board port, which makes paging and handshaking possible. This facility is not essential but makes the addition of large amounts of memory (256 Kbytes uses 4 slots) possible. The buffered signals are connected to each of the seven slots. IC8 is used to control the selection of the data buffer by collecting the select signals from the daughter cards. Cards can be moved around freely once set up, as all address decoding is done off the mother board.

There are three 40 ways d.i.l. sockets which enable you to connect to your computer from the side or from the back. The board is well decoupled, with diodes to prevent rails from crossing over on switch on/off. The slots themselves make use of two-part connectors, which although a little more expensive, do ensure reliable, knock resistant connection to the daughter cards.

Interfaces are in preparation for the following machines: Acorn Atom, Apple II, Atari, Commodore PET, Research Machines RML 380Z, Superboard, Spectrum, Superbrain, S100 Bus, UK101, Video Genie, ZX81.
Fig. 1.1. Circuit diagram of the Motherboard. Tracks to the seven edge connectors are shown copper-side for convenience, although geometrically edge connector 1 would then be on the right-hand side. These tracks are cut to accommodate the bus required. The edge connectors actually have 32 pins in each row, but the top-numbered ones are n.c. and therefore not shown.

THE UNIVERSAL INTERFACE
ASSEMBLY

You will need a fine tipped soldering iron. Referring to the component layout of Fig. 1.3 install the i.c. sockets first, then the discrete components and finally the connectors. The backplane connections are close together and you must be careful to avoid shorting the tracks. Put the i.c.s in last, checking orientation carefully.

The connection to your computer will, of course, vary from model to model. A manual is provided with the kit of parts (see constructors' note) which tells you how to interface with most machines. As a general guide, Table 1.1 gives the standard connection to Z80 based systems and Table 1.2 is for the 6502/6800 microprocessor family. These tables also describe how to set up the various links for each type.

TESTING THE 8255

The best way of testing that the board is wired correctly is to address the 8255 port i.c. The 8255 can be mapped to any 256 byte boundary by setting d.i.l. switches 1 to 8. Find an unused space and select it as shown in Table 1.3. The 8255 resets on power-on to its all input state. A setup routine (written in BASIC) is given in Table 1.4, which makes all the lines outputs, and then flips them from 1 to 0 approximately twice a second. You can observe this by looking on the port pins as laid out in Fig. 1.1. If nothing happens, check that you have set up the correct address and check your connections. If you use a multi-meter to check the outputs, make sure that it has an impedance of 5Kohms/volt or greater. Once the 8255 is working you can be fairly sure that any other faults are minor, and unlikely to damage the daughter cards.

COMPONENTS...

ULTIMUM MOTHERBOARD

Resistors
R1-R11 3k3 (11 off)
R11 47k
All resistors are 1/4W 5%

Capacitors
C1, C6 47µ/16V axial elect. (12 off)
C2-C5 4µ7/63V axial elect. (4 off)
C7-C24 100n disc ceramic (18 off)

Diodes
D1-D5 1N5402 (5 off)

Integrated Circuits
IC1, IC2, IC4 81LS95 (3 off)
IC3 74LS245 (8T245)
IC5 8255
IC6, IC7 74LS85 (2 off)
IC8, IC9 74LS30 (2 off)
IC10 74LS04
IC11 74LS14
IC12, IC13 74LS32 (2 off)

Miscellaneous
14 pin d.i.l. sockets (6 off)
16 ... (4 off)
20 ... (4 off)
40 ... (2 off)
S1-S4, S5-S8 4 way d.p.s.t. d.i.l. switch (2 off)
EC1, EC2 2 x 32 'A+C' DIN Euro Socket (straight pin) (2 off)
TB1, TB2 4 way p.c.b. terminal block (2 off)

Optional Extras
EC3-7 2 x 32 'A+C' DIN Euro Socket (straight pin) (5 off)
40 pin d.i.l. socket (2 off)

TABLE 1.1. 40 WAY CONNECTIONS TO Z80 SYSTEMS

1 INT 40 MREQ
2 NMI 39 RST
3 NC 38 HALT
4 D0 37 NC
5 D1 36 D4
6 D2 35 D5
7 D3 34 D6
8 IORQ 33 D7
9 GND 32 NC
10 NC 31 CLOCK
11 NC 30 RD
12 A2 29 WR
13 A1 28 RFSH
14 A0 27 A15
15 A3 26 A14
16 A4 25 A13
17 A5 24 A12
18 A6 23 A11
19 A7 22 A10
20 AB 21 A9

TABLE 1.2. 40 WAY CONNECTIONS TO 68/65xx SYSTEMS

1 IRQ 46 NC
2 NMI 39 RST
3 NC 38 NC
4 D0 37 RDY
5 D1 36 D4
6 D2 35 D5
7 D3 34 D6
8 NC 33 D7
9 GND 32 R/W
10 NC 31 Q2
11 NC 30 NC
12 A2 29 NC
13 A1 28 NC
14 A0 27 A15
15 A3 26 A14
16 A4 25 A13
17 A5 24 A12
18 A6 23 A11
19 A7 22 A10
20 AB 21 A9

NC Means No Connection
Dn is Data bus
An is Address bus
TABLE 1.3.
SETTING THE 8255 ADDRESS SPACE

<table>
<thead>
<tr>
<th>Link/snowith</th>
<th>Mapped to . . . (hex)</th>
</tr>
</thead>
<tbody>
<tr>
<td>87654321</td>
<td>0000</td>
</tr>
<tr>
<td>00000000</td>
<td>0100</td>
</tr>
<tr>
<td>00000010</td>
<td>0200</td>
</tr>
<tr>
<td>00000011</td>
<td>0300</td>
</tr>
<tr>
<td>... in 100 hex increments</td>
<td>1000</td>
</tr>
<tr>
<td>00010000</td>
<td>1100</td>
</tr>
<tr>
<td>00010010</td>
<td>1200</td>
</tr>
<tr>
<td>... in 100 hex increments</td>
<td>2000</td>
</tr>
<tr>
<td>00100000</td>
<td>3000</td>
</tr>
<tr>
<td>... etc.</td>
<td>FF00</td>
</tr>
</tbody>
</table>

Link
- 1 means link to Vcc
- 0 means link to GND

Switch
- 1 means ON
- 0 means OFF

Although the kit of parts will include d.i.l. switches for the setting up of address lines A8 to A15, we feel it is worthwhile pointing out the existence of an earlier option which the p.c.b. will accommodate. This is the use of prewired d.i.l. header plugs instead of switches, which can be changed quickly for different addressing. The tamper-proof nature of this option may be preferred.

The remaining links (refer to Fig. 1.3) should be wired as follows:

**LINK 9**  
- Link A-B for Z80 systems (allows reset from host computer)
- Link B-C for 65/68 systems (gives on-board reset)

**LINK 10 (R/W, WR strapping link)**  
- Link A-B for 65/68 systems (gives R/W to R/W)
- Link A-C for Z80 systems (gives WR to R/W)

**LINK 11**  
- Link open for Z80 systems
- Link closed for 65/68 systems

---

**Table 1.4.**

<table>
<thead>
<tr>
<th>P</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td>POKE</td>
<td>128</td>
</tr>
<tr>
<td>POKE</td>
<td>0</td>
</tr>
<tr>
<td>POKE</td>
<td>1,0</td>
</tr>
<tr>
<td>POKE</td>
<td>2,0</td>
</tr>
<tr>
<td>GOSUB</td>
<td>120</td>
</tr>
<tr>
<td>POKE</td>
<td>255</td>
</tr>
<tr>
<td>POKE</td>
<td>1,255</td>
</tr>
<tr>
<td>POKE</td>
<td>2,255</td>
</tr>
<tr>
<td>GOSUB</td>
<td>120</td>
</tr>
<tr>
<td>GOTO</td>
<td>30</td>
</tr>
<tr>
<td>FOR T = 1 TO 250 (Approx 1 s delay)</td>
<td></td>
</tr>
<tr>
<td>NEXT T</td>
<td></td>
</tr>
<tr>
<td>RETURN</td>
<td></td>
</tr>
</tbody>
</table>

---

**ULTIMUM**

The ultimate motherboard?

---

**Fig. 1.2. Ultimum links, and methods of linking.**

(a) Using linked header plugs which can be swapped. (b) Using d.i.l. switches.
THE POWER SUPPLY

A special power supply has been designed for the ULTIMUM, which provides power rails for additions such as the disk drive and the EPROM programmer. The power supply will fit inside the ULTIMUM case or may be mounted separately.

The design of the power supply is given in Fig. 1.4. This is a standard design using current limiting, thermally protected i.c. regulators. The component layout is given in Fig. 1.5. Please observe the usual precautions when wiring mains equipment. How to fit the assembled unit into its housing is covered in a comprehensive manual (see constructors' note), available with the kit of parts, but construction of the power supply p.c.b. assembly is very straightforward. Follow the overlay given (Fig. 1.5) and the instructions below, being careful to note the polarity of components where appropriate. The construction sequence is as follows:

1) Fit p.c.b. pins in points A-G,M,I,J,K,N,O,P.
2) Fit diodes D1-D4.
3) Fit REC1 and heatsink—bolt heatsink to bridge REC1 and then mount this assembly to p.c.b.
4) Fit bridge rectifier REC2.
5) Fit R1—leave 5mm clearance between resistor and p.c.b. to allow heat flow around resistor.
6) Fit smoothing capacitors C1 and C2. Note that the dummy tag is used only to provide greater stability.
7) Fit smoothing capacitors C14,C7,C11,C8.
8) Fit ceramic capacitors C15,C6,C13,C10.
9) Fit capacitors C7,C12,C3.
10) Fit zener diode D5.
11) Fit IC5, IC2, IC4, IC3—note that the metal tabs stand towards the ceramic capacitors.

Fig. 1.4. PSU circuit diagram

Fig. 1.5. PSU component layout (copyright Watford Electronics)
### COMPONENTS . . .

#### MULTIRAIL POWER SUPPLY

<table>
<thead>
<tr>
<th>Resistors</th>
<th>Capacitors</th>
<th>Discrete Semiconductors</th>
</tr>
</thead>
<tbody>
<tr>
<td>R1 10 or 12Ω 5W</td>
<td>C1, C2 4700μ/25V tag elect. (2 off)</td>
<td>D1-D4 1N5401 (4 off)</td>
</tr>
<tr>
<td>R2 3300 ½W</td>
<td>C3 4µ/7/16V axial elect.</td>
<td>D5 6V8 1W3 Zener</td>
</tr>
<tr>
<td></td>
<td>C4 220n polyester radial</td>
<td>D6 0·2 in. i.e.d.</td>
</tr>
<tr>
<td></td>
<td>C5, C9, C12 10µ/16V axial elect. (2 off)</td>
<td>REC1 6A/100V bridge rect.</td>
</tr>
<tr>
<td></td>
<td>C6, C10, C13, C15 100n disc ceramic (4 off)</td>
<td>REC2 1A/100V bridge rect.</td>
</tr>
<tr>
<td></td>
<td>C7, C11 2200μ/25V radial elect. (2 off)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>C8 1000µ/16V radial elect.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>C14 470µ/50V radial elect.</td>
<td></td>
</tr>
</tbody>
</table>

#### Integrated Circuits
- IC1 78H05 +5V/5A reg.
- IC2 7812 +12V/1A reg.
- IC3 7905 -5V/1A reg.
- IC4 7812 -12V/1A reg.
- IC5 7818 +18V/1A reg.

#### Miscellaneous
- T1 Multitap transformer (0-15, 0-15, 0-30, 0-30, 0-9, 0-9@5A)
- S1 2 pole 2 way sub min. toggle (mains)
- FS1 20mm 1A A/S fuse plus 20mm panel fuse holder
- P.c.b. Watford PSU board
- 8BA stand-offs, nuts & screws for mounting p.c.b. (4 off each)
- Heatsink Type TV4
- Insulating kit TO3
- 5A 3-core mains cable 2 metres
- Grommet for above
- 4BA ¾ in. bolts, and nuts (5 off each)
- Solder tag (2 off)

**CONSTRUCTORS’ NOTE**

Kits for the ULTIMUM are available from Watford Electronics (see advertisers’ index). A limited number of ready-built units will be available. Please send SAE for price list of boards now available.

---

**Because the system has so many applications, we feel sure, that people will want to exchange ideas. If this is the case, a users group will be formed to provide support for existing and future machines.**

---

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STYLOCHORD

This is a stylus operated two octave keyboard with only one tuning preset and eight individual voices made up of four square and four triangular waves over a range of six octaves. It includes two stylii, each controlling four voices to enable the playing of two notes at a time and a switched option for one stylus to play one or both waveforms.

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4 PAGE PULLOUT

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Micrograsp, an ultra low cost electric robot. Even with full servo control and a universal computer interface board the price is under £200.
SALYUT 6 AND COSMOS 1,267

The Soviet Space control ended the 58 month mission of this composite unit on July the 29th, 1982. Cosmos 1,267 was docked automatically with Salyut 6 for a mission of scientific experiments and another of the Russian feasibility studies dealing with permanently manned units in orbit. Up till the time that the composite unit was commanded to destruct itself into the Pacific Ocean, it had logged some 676 days of manned operations. These were in short and long periods. The short duration involved 11 crews and the long durations 5 crews. The reason given for the termination of the missions was that the programme had been completed and the consumable items such as the fuel for the control systems was near the planned exhaustion level. The total number of launches of Soviet vehicles since Sputnik 1 on October the 4th, 1957, has now reached more than 1,500.

The American authorities seem to have been somewhat worried as to whether some of these manned missions were in fact concerned with anti-satellite homing vehicles as a defensive activity against American satellites. It seems out of keeping with the manner of space research that so much worthwhile work in the cause of science for the benefit of mankind should be marred by wrong attitudes and suspicious undercurrents. Nothing but benefit can come from co-operation, now especially as so many independent countries are active in space technology.

LOOKING BELOW THE SURFACE OF THE LAND

The Shuttle imaging radar has shown that it is possible to provide adequate data of conditions and the character of sub-surface terrain. While it is, of course, possible for radar to 'see' below the surface, the imaging has always been regarded as useless. Now, after the data being analysed from the second Shuttle mission is considered, there are already plans for expeditions to the Sahara. Interest has extended to the re-examination of previous passes over arid areas. The JPL data is to be opened up for this purpose. Some of the Landsat data, like the multispectral scan over the Sahara, shows mostly sand but also a hint of rough terrain below the sand. These, however, were over the 'hyperarid' areas where rainfall comes every 30-50 years. Here, the very fine sand allowed the radar to penetrate. Generally, however, there is no clear indication that there are reliable visual formations that could be reported. However, the radar pictures returned by the second shuttle flight provides ample evidence that very considerable detail can be seen. The varied techniques growing in experience and skill show remarkable conditions. As an example, some of the evidence points to formations which must be at least 35 million years old. Under the sand are to be seen large, wide and dry river valleys extending for hundreds of miles. Indeed, some of the valleys resemble very closely the present Nile valley. Other conclusions that have been drawn indicate that there are extensive fault lines and rugged terrain; also there can be seen alluvial valleys and terraces. The expeditions to make direct examination of these areas will be putting a new look on archaeology, for now they will be looking not at recent but at remote periods of time. It is not surprising that renewed interest in the planet Mars is taking place. The arid surface of Mars could yield a great deal of information if the new imaging techniques are an orbiter's, for now they could be possible to examine the terrain of Mars beneath the polar caps. These new techniques are already regarded as a great scientific advance and new missions for the shuttle are already being planned. It should also be proper that the person who first suggested that this subsurface imaging capability existed should be rewarded. The Geological Survey and the JPL view this a major discovery and award the credit to the guest investigator Carol S. Breed with the Astrogeology Branch.

However, while past history is a clue to the future, there are intensive matters of interest for the present. The ebb and flow of terrestrial changes on the crust of the Earth indicates periods of wet conditions and savanna growth and periods of arid conditions. Geological features now to be examined below the surface will enable assessments to be made as to the possibility of man's oil and coal recovery. Knowledge of places where possible human habitation may have been in existence as long ago as 200,000 years, offers evidence of the conditions then. So the priorities are already being set for future shuttle missions. Two special radar missions for radar surveys will have the benefit of the new techniques from the Geological SIR-B.

SIR-B radar is an improved and upgraded version of the initial imaging system and will be flown on the shuttle in 1984. This mission will use the same aerial, that is the L-band, but with the capability of variable incidence angle ranging from 15 to 65 deg. This will facilitate the assessment of the effects on the imaging content. The shuttle 1987 to 1988 missions will use a radar system that will have the facility of variable incidence and also variable polarisation. This experiment skill will

At the Jet Propulsion Laboratory a study is being made for a radar sounder mission to try to penetrate the polar icecaps. This will be possible because water ice is transparent to the radar energy. Studies of the surface effects indicated that a great deal of surface information is to be obtained. Large ice patterns on the ocean surfaces were seen. In one section of the Aegan Sea is thought that gravity waves had not been detected, or at least the effect of such waves.

In enthusiast about the imaging system it would be churlish not to deal with progress that is now being made with Landsat-D. The USA were intending to double the cost of the service of the distribution of data. These charges were $5 to $10 for a single coloured picture, and $200 for a length of binary tape which the purchaser had to process. Some countries have set up their own land stations, paying the USA annual fees for the right to interpret the data. They were able to sell their own data as they wished. Now with the new techniques the scene becomes almost a rescue. Landsat-D, which was launched in last July, carries the new cameras with much improved data acquisition and an improvement of nearly five to one with the new Thematic mapping. This is a far more efficient system and takes pictures both in the visible spectrum and in the infra-red. Areas of 1,000 square metres can be analysed, which adds to the detail that can be "seen". There are particular advantages in this for small areas and plantation study. Two teams are co-operating with NASA in Britain. These are the National Environment Council in Swindon and at Reading University. They will be doing this before the Landsat-D comes into official service next year.

There is a second improvement also available for this vehicle. It will be the first to use new communications satellites to be launched by NASA in January, 1983. It is called the Data Relay Satellite and will orbit 36,000 km above the Earth and will be in the Western Hemisphere. The signals will be received from the Landsat-D and bounced down to the Goddard Spaceflight Center. This means that it will not be necessary for them to operate a large number of base stations to receive data. This will reduce operation costs considerably.

BRITAIN SHARES THE SPACE TELESCOPE WORK

British Aerospace will be delivering solar panels to NASA for the Space Telescope in September, 1983. The Bristol plant of British Aerospace are constructing what must be the largest solar panels so far destined for operation in space. The area of the panels are some 33 square metres. They are, in fact, so large that it is difficult to test the arrays in the Earth's gravity. Some 48,000 silicon cells will produce about 5-7 kilowatts of direct current.

The design of the panels is rather special. As the vehicle will have to be carried in the shuttle cargo bay, a compact package must be made. The solar panels will be wound around drums 20 centimetres in diameter. When the spacecraft is unloaded into orbit the two giant panels will unroll. The height at which the Telescope will orbit is comparatively low, only a few hundred kilometres.

These solar panels are likely to be the forerunners of still larger arrays. This will be necessary because powers of 100kW will be required by the 1990's, and by the end of the century of the order of megawatts. The value of the contract to British Aerospace is worth some 11 million pounds.
WE HAVE all been touched by the far reaching effects of the microprocessor revolu-
tion in our day to day lives, and there will soon be few households which do not
have a microprocessor tucked away somewhere, in a TV game, a home computer, a
washing machine or even a door bell!

Of course, as electronics enthusiasts, we have a special interest in the potential of
the microprocessor, but although most of us are itching for a "piece of the action" it
has *not* been easy to decide quite what we are supposed to do with this marvellous
innovation. At the moment, even for electronic hobbyists, the main way "in" is to buy a
basic home computer such as the Sinclair ZX81. But I suspect that for some this has
been a frustrating experience. The problem is that using a home computer and
programming it in BASIC is not necessarily a suitable replacement for the smell of
solder flux and the burned fingers which we all enjoyed so much! Almost ten years
since the first microprocessor appeared, it now seems that microprocessors are for
software hobbyists and are much too complicated for us to use in the replacement of
the transistors, gates, and pink wire with which we have been traditionally associated.

This situation cannot be allowed to continue. Microprocessors are crying out for the
attentions of our soldering irons, and it is our contention that the use of these useful
devices is not as difficult as it may appear at first sight. The problem we face is in the
nature of an information explosion. We are surrounded by a bewildering array of
microprocessor chips, support chips, memory chips and software, all apparently very
complicated. If we want to build a simple system such as a music generator or a central
heating controller, which chip do we choose? Is it powerful enough? Has it got the
right features? Can we program it? Will it be obsolete next month? All questions not
easy to answer, and enough to put us off the idea and return to building "traditional"
projects or even turn our hand to writing a program to find all the prime numbers bet-
ween 1 and 1000.

But all is not lost! The editorial team of *Practical Electronics* is determined that the
electronic aspects of using microprocessors should not be delegated for ever to the
professionals, and we are therefore launching the MICRO-FILE series to help reduce the
confusion surrounding these powerful components. The series is an attempt to lay bare
the essential characteristics of the most popular processors so that the interested may
keep up to date, and the dedicated project designers can choose the correct processor
for their needs. Those who already have microprocessors in personal computers or
other units will also find the series useful if they wish to delve into the innards of their
machine to interface with it, repair it, or even just understand it.
There are currently about 40 different available microprocessor designs, although obviously not all of these can claim to be "winners". Even this daunting figure does not tell the whole story by any means. Many of the 40 basic chip designs come in several different versions which bumps the total up considerably, and nearly all the "popular" devices are produced by several manufacturers either by second sourcing under licence, or as functional copies which may not operate like the original in all respects. Add to this the fact that most micro based systems require additional family support chips to facilitate interfacing and the seeds of confusion have sprouted to form a forest!

Because of the kaleidoscopic nature of applications for the versatile microprocessor, it is not easy to create pigeon holes into which the various chips and their uses can be slotted, but some attempt has to be made to simplify things. Perhaps the best way to start is to split the spectrum of micro applications in two, with "data processors" on the one hand and "controllers" on the other. Data processors generally operate "off-line" under human supervision and require large programs usually written in a high level language such as BASIC. These systems require large arrays of read write memory and generally have at least one operator console. Personal computers are one example of a data processor application, word processors are another.

Controllers usually operate alone to control or monitor some process automatically and generally use smaller ROM based fixed programs which are usually written in assembly language machine code. For controller applications speed is often important, and transducers are required to sense the state of the process and to generate appropriate outputs. Burglar alarms, TV games and central heating systems are examples of applications where microprocessors are used as controllers.

CHOOSING A CHIP

Many microprocessor chips have special advantages which suit them either to data processor or to controller applications, but it is also true that many others are general purpose in nature.

Those best suited to data processing will have a word length of at least 8 bits and will have an address bus wide enough to access at least 64K words of memory. Their instruction sets should offer a rich variety of addressing modes and a family of interface devices should also be available. There is a very definite trend towards 16 bit processors with address ranges of 1 megabyte or more for most data processing tasks. These devices are at least as powerful as the minicomputers which they will soon replace, but the design of a hardware and software system to take advantage of their power is, unfortunately, a daunting prospect for the non-professional.

Microprocessors optimised for controller applications may have any word length from 4 bits upwards and should ideally be as self-contained as possible, even to the extent of being true "single chip" devices which pack RAM ROM and interface lines into a single package. Controller instruction sets should be compact and offer fast access to I/O and timing functions. Simple, on chip interrupt prioritisation is also an advantage, as is the availability of a multifunction peripheral chip family. Generally speaking, microprocessors which are optimised for control applications are simpler to design with in both hardware and software terms.

The author's view is that if your main interest lies in the data processing or personal computer field, then it is difficult to compete with the many ready-made offerings from Sinclair, Acorn, Commodore, Tandy, Apple, and a host of other suppliers. The main problem here is that the microprocessor is really only the tip of the iceberg in D.P. applications with software being the most important factor. It has been said, for example, that to make proper use of the new data processing orientated iAPX 432 microprocessor from Intel, the typical user will need to invest as much as ten man-years in software creation, even using a high level language!

If you wish to use a microprocessor to control things however, then hardware ingenuity is still very important and the required software can usually be created in weeks even when using machine code and without the benefit of expensive development systems. The message is clear. If your ambitions lie in designing a 16 bit personal computer with twin floppies, a megabyte of RAM and a Pascal compiler, then a stony road lies ahead! If, however, you wish to control your central heating or build a fuel consumption computer for your car, then pick a suitably simple control processor and have a go; you could have a lot of fun!
THE OBSOLESCENCE PROBLEM

One thorny problem for any budding designer is the very rapid progress in microprocessor technology which produces better, faster, and more complex devices at a breakneck pace. There is therefore the ever-present spectre of starting a project and then finding that before it is finished a new device has emerged which would do the job better and at a lower cost. This is especially true in the data processing field where development periods tend to be longer.

To avoid the worst of this problem, it is obviously necessary to choose a device which is not about to be superseded. Beware the bargain offer of a wheelbarrow full of National SC/MPs or Intel 8008s for a "Tenner!" At the same time it is necessary to choose a device which has been in play for a sufficiently long period to establish its popularity and which can therefore be expected to have good support and a long life. You can expect the manufacturers to develop their success with popular chips by bringing out improved versions, and this can be an advantage because your "learning" investment can be put to good use on future projects using the enhanced devices when they are available. It is also necessary to remember that, say, a central heating controller may be required to operate for 20 years or more while the lifetime of the majority of microprocessors can be expected to be less than ten years—so remember to buy a spare!

SUPPORT DEVICES

If there were any such thing as a typical microprocessor system then in addition to the processor device itself we could expect to find RAM and ROM memory, a parallel I/O port, a serial I/O port, and at least one "special" device such as a disc controller, a maths chip, or an analogue to digital converter. Support devices are available to fill all these requirements and many more besides, and these have to be given serious consideration since they contribute almost as much as the processor itself to the success of any project.

Support devices can be part of a particular microprocessor "family" and these often have special features to simplify their use with that family. Also available are many general-purpose devices which can be interfaced to most processors with the addition of a small amount of external logic. All have their part to play. The trend in support devices is towards complex and powerful chips which give a considerable boost to the basic performance of any processor by unloading from it a lot of the system "chores" which it would otherwise have to perform for itself. Prime examples here are the maths processor chips which give systems easy access to floating point arithmetic and high level math functions such as square roots and sines which would normally have to be provided by software routines. Many support devices rival the microprocessors which they serve in chip complexity, and so it is important not to underestimate the task of learning how to initialise and program these devices to perform the required function. Some support chips even have user manuals as thick as those of their attendant microprocessor!

MICRO-FILE FORMAT

Having set the scene, and perhaps frightened, but hopefully inspired many readers, we can now return to how the MICRO-FILE series has been designed to help!

To make any kind of objective assessment of a number of microprocessor devices it is normally necessary to purchase the relevant manuals, and these are not cheap. Having purchased the manuals, a period of intensive study is required to sort out the important characteristics and to come to any conclusion. Remember too, that the manuals are written by the manufacturer and are therefore unlikely to point out any shortcomings!

MICRO-FILE builds up month by month to provide a complete quick reference guide to the more popular microprocessors. Each MICRO-FILE entry consists of a quick reference fact sheet, designed for easy filing, and explanatory text which provides further information and application data. The sheets can be removed from the magazine and placed in a binder for filing.

This introductory article can form the binding "covers". At present there are plans to include about twelve of the most popular processors, but this may be extended later if necessary. So if you collect the whole series it will form a 48 page (or more) reference book on microprocessors plus this "cover" section.

The first FILESH EET considers the Intel 8080A and its successor the 8085A, two of the most popular processors so far, with the 8080A often considered to be the processor which really started the microprocessor revolution.

The reference fact sheet is intended to provide all the essential information about a processor or a processor family, including general background details, register arrangement, instruction set and software, system schematics, performance data, pin connections and basic support chip information. Using these sheets it will be possible to compare processors and to choose the best one for a particular application. Readers not interested in go-it-alone projects can use the sheets to assess the potential power of readily built systems using a particular processor, to help with system trouble shooting and interfacing, or simply to improve their knowledge of the subject.

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Send to: The Exhibition Manager, Electronic Hobbies Fair, IPC Exhibitions Ltd., Surrey House, 1 Throwley Way, Sutton, Surrey SM1 40Q.
THE Intel 8080 8 bit NMOS microprocessor first appeared in 1973 as a successor to the more limited 8008 PMOS device. The 8080A was the first microprocessor to capture the imagination of designers and was a fundamental cog in the microprocessor revolution generating annual sales of over 2 million devices per year in its heyday. The success of this chip resulted in the spawning of two, more powerful successors, the Z80 from Zilog which had an enhanced instruction set but basically the same bus configuration, and the 8085A from Intel which had basically the same instruction set but a new multiplexed bus structure. Both of the newcomers appeared in 1977 and have now replaced the 8080A for all new applications with the Z80 being most popular for data processing and the 8085 being more successful as a controller.

In order to squeeze the maximum performance from the NMOS technology available in the early 1970s the 8080A was designed to use three supply rails of +5, -5 and +12 volts and had to have technology available in the early 1970s the 8080A was designed and the 8085 being more successful as a controller. Two additional support chips to provide clock generation and bus to use three supply rails of +5, -5 and +12 volts and had to have technology available in the early 1970s the 8080A was designed and the 8085 being more successful as a controller. Both of the newcomers appeared in 1977 and have now replaced the 8080A for all new applications with the Z80 being most popular for data processing and the 8085 being more successful as a controller.

As mentioned above, the 8080/8085 instruction set is rather “messy” due to the somewhat specialised nature of the large register array, but this does make these devices very powerful considering their small chip areas. The 78 basic instructions of the 8080 are used to move data between registers, between a register and memory, between a register and an I/O port, and to carry out arithmetic and logical operations. Instructions are also included to perform conditional and unconditional jumps and to control processor operation. Two additional 8085A instructions, RIM and SIM, are ingeniously used to provide access to, and control over, the extra serial I/O and interrupt features not present on the 8080.

A comprehensive array of arithmetic and logical operations are provided including 8 and 16 bit binary addition, 8 bit binary subtraction, binary coded decimal (BCD) arithmetic on packed BCD values, logical operations such as AND, OR, XOR and Compare, and a range of accumulator shifts and carry flag modifiers. One item missing from this group is the ability to set, test, and reset, individual accumulator bits which is a very useful feature for control applications. These operations can be performed by shifting the relevant bit into the carry flip-flop or by using logic instructions, however.

Four addressing modes are used as follows:—Direct, in which a memory address is specified as part of the instruction; Register, in which a register or register pair is specified; Register Indirect, in which the instruction specifies a register pair which itself contains a memory address; and Immediate, in which the instruction contains not a reference to a data area but the actual data itself. One particularly useful feature of the instruction set is the provision of a group of eight Restart instructions which cause an immediate jump to fixed vectors in low memory. These instructions use only a single byte and are used for hardware interrupt service or as software interrupts. Access to the separate I/O/ADDRESS space of 256 inputs and 256 output ports is provided by means of the instructions IN and OUT which are fast because they are only 2 bytes long. The separate I/O ADDRESS space is useful because it does not encroach on main memory, but it is still possible to use memory mapping for I/O ports if required for a simple system not needing the full 64K memory address range.
GENERAL
The 8080A was the first of the mid-range NMOS 8 bit processors and is certainly the most widely used. It has a good general purpose architecture and is very well supported with both hardware and software. The 8085A, however, is an improved version of the 8080A but needs only a 5V supply and has many additional features such as on-chip clock, serial I/O and four new interrupt lines. Extra pins for these functions have been made available by multiplexing the low order address bits with the data bus. A complete 8085A system with 2K bytes of ROM, 256 bytes of RAM, timer and 38 I/O lines can be built with just three 40 pin chips by utilising the 8355 (ROM/10) and the 8155 (RAM/10 timer) combination devices.

REGISTERS: The 8080/8085 has 8 8-bit general purpose registers. Six of these can be addressed as the three lsb bits BC, DE, HL. 

INSTRUCTION SET AND SOFTWARE
The 8080A has 78 basic instructions and the 8085 has two more, RIM and SIM which support the additional interrupts and serial I/O. One, two and three byte instructions are used and Direct Register Index and Relative addressing modes are available. Full binary and BCD arithmetic is possible on 8 bit bytes, and some 16 bit arithmetic is possible using the HL pair as an accumulator. A separate address space is available for 1/0 using the IN and OUT instructions. Very well supported with software including very good basics and the CPM operating system.

BENCHMARKS
ADD REGISTER TO ACCUM: 2.4M 1.42M
OUTPUT ACCUMULATOR TO PORT: 5.6M 3.2M
MOVE FROM MEMORY TO MEMORY: 8M 5.12M

MANUFACTURERS
ORIGINATOR - INTEL
2nd Sources - SIEMENS, AMD, NEC.
8080A - NATIONAL, SIGNETICS, HITACHI
2nd Sources - AMD, SIEMENS, NEC
8085A

SUPPORT CHIPS
8080A Needs 8254 and 8256 and has a large family of support devices including: 8235 (UART), 8255A (Parallel I/O), 8253 (Timer), 8255 (Interrupt Control), 8257 (SMA)
8085A has two special combination 16/32 memory chips 8355 and 8155 in addition to above devices.
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<tr>
<td><strong>MOVE, LOAD, AND STORE</strong></td>
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<tr>
<td>MOV B, I, D</td>
<td>Move register to register</td>
<td>0 1 0 0 0 0 0 0</td>
<td>1 1 1 1 1 1 1 1</td>
<td>9/18</td>
</tr>
<tr>
<td>MOV M, r</td>
<td>Move register to memory</td>
<td>0 1 0 0 0 0 0 0</td>
<td>1 1 1 1 1 1 1 1</td>
<td>9/18</td>
</tr>
<tr>
<td>MVI r</td>
<td>Move immediate register</td>
<td>0 0 0 0 0 0 0 0</td>
<td>0 0 0 0 0 0 0 0</td>
<td>0</td>
</tr>
<tr>
<td>MVI M</td>
<td>Move immediate memory</td>
<td>0 0 1 1 1 1 1 1</td>
<td>0 0 0 0 0 0 0 0</td>
<td>0</td>
</tr>
<tr>
<td>LXI B</td>
<td>Load immediate register</td>
<td>0 0 0 0 0 0 0 0</td>
<td>1 1 1 1 1 1 1 1</td>
<td>9/18</td>
</tr>
<tr>
<td>LXI D</td>
<td>Load immediate register</td>
<td>0 0 0 0 0 0 0 0</td>
<td>1 1 1 1 1 1 1 1</td>
<td>9/18</td>
</tr>
<tr>
<td>LXI H</td>
<td>Load immediate register</td>
<td>0 0 0 0 0 0 0 0</td>
<td>1 1 1 1 1 1 1 1</td>
<td>9/18</td>
</tr>
<tr>
<td>LXI SP</td>
<td>Load immediate stack pointer</td>
<td>0 0 0 0 0 0 0 0</td>
<td>1 1 1 1 1 1 1 1</td>
<td>9/18</td>
</tr>
<tr>
<td>STAB B</td>
<td>Store A indirect</td>
<td>0 0 0 0 0 0 0 0</td>
<td>1 1 1 1 1 1 1 1</td>
<td>9/18</td>
</tr>
<tr>
<td>STAD B</td>
<td>Store A direct</td>
<td>0 0 0 0 0 0 0 0</td>
<td>1 1 1 1 1 1 1 1</td>
<td>9/18</td>
</tr>
<tr>
<td>LOAD B</td>
<td>Load A indirect</td>
<td>0 0 0 0 0 0 0 0</td>
<td>1 1 1 1 1 1 1 1</td>
<td>9/18</td>
</tr>
<tr>
<td>LOAD D</td>
<td>Load A direct</td>
<td>0 0 0 0 0 0 0 0</td>
<td>1 1 1 1 1 1 1 1</td>
<td>9/18</td>
</tr>
<tr>
<td>STA</td>
<td>Store A direct</td>
<td>0 0 0 0 0 0 0 0</td>
<td>1 1 1 1 1 1 1 1</td>
<td>9/18</td>
</tr>
<tr>
<td>STAC</td>
<td>Store B direct</td>
<td>0 0 0 0 0 0 0 0</td>
<td>1 1 1 1 1 1 1 1</td>
<td>9/18</td>
</tr>
<tr>
<td>SHLD</td>
<td>Store H &amp; L direct</td>
<td>0 0 0 0 0 0 0 0</td>
<td>1 1 1 1 1 1 1 1</td>
<td>9/18</td>
</tr>
<tr>
<td>SHLD</td>
<td>Store L &amp; H direct</td>
<td>0 0 0 0 0 0 0 0</td>
<td>1 1 1 1 1 1 1 1</td>
<td>9/18</td>
</tr>
<tr>
<td>XCHG</td>
<td>Exchange D &amp; E, H &amp; L Registers</td>
<td>1 1 1 1 0 0 0 0</td>
<td>1 1 1 1 1 1 1 1</td>
<td>9/18</td>
</tr>
<tr>
<td><strong>STACK OPS</strong></td>
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<tr>
<td>PUSH B</td>
<td>Push register Pair B &amp; C on stack</td>
<td>1 1 0 0 0 0 0 0</td>
<td>1 1 1 1 1 1 1 1</td>
<td>9/18</td>
</tr>
<tr>
<td>PUSH D</td>
<td>Push register Pair D &amp; E on stack</td>
<td>1 1 0 0 0 0 0 0</td>
<td>1 1 1 1 1 1 1 1</td>
<td>9/18</td>
</tr>
<tr>
<td>PUSH H</td>
<td>Push register Pair H &amp; L on stack</td>
<td>1 1 0 0 0 0 0 0</td>
<td>1 1 1 1 1 1 1 1</td>
<td>9/18</td>
</tr>
<tr>
<td>PUSH SW</td>
<td>Push &amp; Flags on stack</td>
<td>1 1 1 1 1 1 1 1</td>
<td>1 1 1 1 1 1 1 1</td>
<td>9/18</td>
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<tr>
<td>POP B</td>
<td>Pop register Pair B &amp; C off stack</td>
<td>1 1 0 0 0 0 0 0</td>
<td>1 1 1 1 1 1 1 1</td>
<td>9/18</td>
</tr>
<tr>
<td>POP D</td>
<td>Pop register Pair D &amp; E off stack</td>
<td>1 1 0 0 0 0 0 0</td>
<td>1 1 1 1 1 1 1 1</td>
<td>9/18</td>
</tr>
<tr>
<td>POP H</td>
<td>Pop register Pair H &amp; L off stack</td>
<td>1 1 0 0 0 0 0 0</td>
<td>1 1 1 1 1 1 1 1</td>
<td>9/18</td>
</tr>
<tr>
<td>POP SW</td>
<td>Pop &amp; Flags off stack</td>
<td>1 1 1 1 0 0 0 0</td>
<td>1 1 1 1 1 1 1 1</td>
<td>9/18</td>
</tr>
<tr>
<td><strong>XTHL</strong></td>
<td>Exchange top of stack, H &amp; L</td>
<td>1 1 1 1 1 1 1 1</td>
<td>1 1 1 1 1 1 1 1</td>
<td>9/18</td>
</tr>
<tr>
<td><strong>SPLH</strong></td>
<td>H &amp; L to stack pointer</td>
<td>1 1 1 1 1 1 1 1</td>
<td>1 1 1 1 1 1 1 1</td>
<td>9/18</td>
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<tr>
<td><strong>JUMP</strong></td>
<td></td>
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<tr>
<td>JMP</td>
<td>Jump unconditional</td>
<td>1 1 0 0 0 0 0 0</td>
<td>1 1 1 1 1 1 1 1</td>
<td>9/18</td>
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<tr>
<td>JC</td>
<td>Jump on carry</td>
<td>1 1 0 1 0 0 0 0</td>
<td>1 1 1 1 1 1 1 1</td>
<td>9/18</td>
</tr>
<tr>
<td>JNC</td>
<td>Jump on no carry</td>
<td>1 1 0 1 0 0 0 0</td>
<td>1 1 1 1 1 1 1 1</td>
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<tr>
<td>JZ</td>
<td>Jump on zero</td>
<td>1 1 0 0 0 0 0 0</td>
<td>1 1 1 1 1 1 1 1</td>
<td>9/18</td>
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<tr>
<td>JNZ</td>
<td>Jump on no zero</td>
<td>1 1 0 0 0 0 0 0</td>
<td>1 1 1 1 1 1 1 1</td>
<td>9/18</td>
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<tr>
<td>JP</td>
<td>Jump on positive</td>
<td>1 1 1 1 0 0 0 0</td>
<td>1 1 1 1 1 1 1 1</td>
<td>9/18</td>
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<tr>
<td>JM</td>
<td>Jump on minus</td>
<td>1 1 1 1 0 0 0 0</td>
<td>1 1 1 1 1 1 1 1</td>
<td>9/18</td>
</tr>
<tr>
<td>JPE</td>
<td>Jump on parity even</td>
<td>1 1 0 1 0 0 0 0</td>
<td>1 1 1 1 1 1 1 1</td>
<td>9/18</td>
</tr>
<tr>
<td>JPO</td>
<td>Jump on parity odd</td>
<td>1 1 0 1 0 0 0 0</td>
<td>1 1 1 1 1 1 1 1</td>
<td>9/18</td>
</tr>
<tr>
<td><strong>PCHL</strong></td>
<td>H &amp; L to program counter</td>
<td>1 1 1 1 1 1 1 1</td>
<td>1 1 1 1 1 1 1 1</td>
<td>9/18</td>
</tr>
</tbody>
</table>

**ADD**

| ADD r | Add register to A | 1 1 0 0 0 0 0 0 | 1 1 1 1 1 1 1 1 | 9/18 |
| ADD r | Add register to A with carry | 1 1 0 0 0 0 0 0 | 1 1 1 1 1 1 1 1 | 9/18 |
| ADD M | Add memory to A | 1 1 0 0 0 0 0 0 | 1 1 1 1 1 1 1 1 | 9/18 |
| ADD M | Add memory to A with carry | 1 1 0 0 0 0 0 0 | 1 1 1 1 1 1 1 1 | 9/18 |
| **SUBTRACT** | | | | |
| SUB r | Subtract register from A | 1 0 0 0 0 0 0 0 | 1 1 1 1 1 1 1 1 | 9/18 |
| SBB r | Subtract register from A with borrow | 1 0 0 0 0 0 0 0 | 1 1 1 1 1 1 1 1 | 9/18 |
| SUB M | Subtract memory from A | 1 0 0 0 0 0 0 0 | 1 1 1 1 1 1 1 1 | 9/18 |
| SBB M | Subtract memory from A with borrow | 1 0 0 0 0 0 0 0 | 1 1 1 1 1 1 1 1 | 9/18 |
| **SUBTRACT** | | | | |
| SUB r | Subtract register from A | 1 0 0 0 1 1 1 1 | 1 1 1 1 1 1 1 1 | 9/18 |
| SUB r | Subtract register from A with borrow | 1 0 0 0 1 1 1 1 | 1 1 1 1 1 1 1 1 | 9/18 |
SOFTWARE

The 8080/8085 family is probably better supported in software than any of the other microprocessors. There is so much software available that it would be quite impossible to list it all. The key to 8080/8085 software is the CP/M disc operating system produced available that it would be quite impossible to list it all. The key to

SOFTWARE

structures of the 8080A and 80854 are virtually identical. The 8085A provides a special signal, ALE, to cause the such as the UART, need a non-multiplexed bus and this can be including general purpose ROM and RAM chips, and interface chips that they can work directly from the 8085 bus. Other devices in-

special purpose 8085A interface chips, the 8155 RAM/I0/TIMER have an associated control line output (RD and WR respectively).

have an associated control line output (RD and WR respectively). An additional control line I0/M informs bus users whether the cycle applies to a memory or an I/O device. The main difference between the two processors is the multiplexed bus structure of the 8085A where the eight low order address bits (AO-A7) share the same pins as the data bus and are therefore labelled ADO-AD7. The special purpose 8085A interface chips, the 8155 RAM/TIMER and the 8355 ROM/I0, have internal demultiplexing circuitry so that they can work directly from the 8085 bus. Other devices including general purpose ROM and RAM chips, and interface chips such as the UART, need a non-multiplexed bus and this can be easily achieved by using an external 8 bit latch such as the 74LS373. The 8085A provides a special signal, ALE, to cause the low address data to be latched. With this latch in use, the bus structures of the 8080A and 8085A are virtually identical.

The most versatile interrupt line, INT on the 8080A and INTR on the 8085A can cause a vector to any location in memory with the use of external hardware to force a CALL (Jump to subroutine) instruction on to the bus. This three byte instruction is best generated by the 8259A interrupt controller which will provide separate interrupt vectors for up to eight interrupts. A much simpler scheme can also be used to generate single byte RESTART instructions instead, but of course these vector to fixed locations in low memory. In addition to this general purpose interrupt, the 8085A has four additional fixed vector interrupt lines which do not need any external hardware support. These inputs, RST 5.5, RST 6.5, RST 7.5 and TRAP, cause the processor to vector to locations in low memory positioned between the RESTART vectors which remain available. The TRAP interrupt puts right one criticism of the 8080A by providing a non-maskable interrupt which cannot be ignored. This is useful for important occurrences such as power failure. One major strength of the 8080A/8085A family is the very wide range of directly compatible interface devices available. In addition to the 8259A Interrupt controller there is the 8251A Universal Synchronous/Asynchronous Receiver/Transmitter (USART), the 8255A Programmable Parallel Interface (PPI), the 8271 Floppy Disc Controller, the 8278 Programmable Keyboard Interface and many, many more, including devices made for this family by other manufacturers such as N.E.C. Both processors are compatible with a wide range of standard memory components including static and dynamic RAM, ROM, EPROM, and EEPROM.

APPLICATIONS

Unless you are an existing 8080A fan, there would seem to be little point in using this processor for new applications since both the Z80 and the 8085A are actually cheaper and, of course, more powerful. The 8085A still has a part to play in controller applications which can make good use of its extra Interrupts, Serial I/O lines, and the useful 8155A peripheral device, but it is really best suited to applications which are too "big" for one of the single chip processors like the 8748, but not so big that they need one of the newer 16 bit devices. For data processing applications the Zilog Z80 is probably a better choice. Perhaps the main obstacle to using the 8085A in home projects is the inability to use the 8355A masked ROM and I/O device and the consequent need to use a standard EPROM such as the 2716 which therefore makes the use of a bus demultiplexer latch necessary.

8085A/8085A-2

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>LOGICAL</td>
<td></td>
<td>D₀, D₁, D₂, D₃, D₄</td>
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<tr>
<td>ANA</td>
<td>And register with A</td>
<td>1 0 1 0 0 S S S S</td>
<td>4</td>
</tr>
<tr>
<td>XRA</td>
<td>Exclusive Or register</td>
<td>1 0 1 0 1 S S S S</td>
<td>4</td>
</tr>
<tr>
<td>ORA</td>
<td>Or register with A</td>
<td>1 0 1 1 0 S S S S</td>
<td>4</td>
</tr>
<tr>
<td>CMP</td>
<td>Compare register with A</td>
<td>1 0 1 1 1 S S S S</td>
<td>4</td>
</tr>
<tr>
<td>ANA M</td>
<td>And memory with A</td>
<td>1 0 1 0 1 1 1 0</td>
<td>7</td>
</tr>
<tr>
<td>XRA M</td>
<td>Exclusive Or memory</td>
<td>1 0 1 0 1 1 1 0</td>
<td>7</td>
</tr>
<tr>
<td>ORA M</td>
<td>Or memory with A</td>
<td>1 0 1 1 1 1 1 0</td>
<td>7</td>
</tr>
<tr>
<td>ANI</td>
<td>And immediate with A</td>
<td>1 1 1 1 0 1 1 1</td>
<td>7</td>
</tr>
<tr>
<td>XRI</td>
<td>Exclusive Or immediate</td>
<td>1 1 1 1 1 1 1 1</td>
<td>7</td>
</tr>
</tbody>
</table>

NOTES: 1. D0D or SSS: B=000, C=001, D=010, E=011, H=100, L=101, Memory 110, A=111
2. Two possible cycle times, (6/12) indicate instruction cycles dependent on condition flags.

All mnemonics copyright Intel Corporation 1977

INTERFACING

The 8080A and 8085A interface to both memory and I/O devices by means of READ and WRITE machine cycles which each have an associated control line output (RD and WR respectively). An additional control line I0/M informs bus users whether the cycle applies to a memory or an I/O device. The main difference between the two processors is the multiplexed bus structure of the 8085A where the eight low order address bits (AO-A7) share the same pins as the data bus and are therefore labelled ADO-AD7. The special purpose 8085A interface chips, the 8155 RAM/TIMER and the 8355 ROM/I0 have internal demultiplexing circuitry so that they can work directly from the 8085 bus. Other devices including general purpose ROM and RAM chips, and interface chips such as the UART, need a non-multiplexed bus and this can be easily achieved by using an external 8 bit latch such as the 74LS373. The 8085A provides a special signal, ALE, to cause the low address data to be latched. With this latch in use, the bus structures of the 8080A and 8085A are virtually identical.

1/4
BY NOW you will no doubt have found the 6 Ty-It cable ties attached to the front of this issue. Just in case you don’t know what to do with them (I) here are a few suggestions, some buying information and details of other related products. Even if you don’t build any of our projects the ties will be useful in a number of other applications.

Many of the devices in current use which have been designed for the specific purpose of securing electrical cables employ plastics, either wholly, or as a covering for stronger materials such as stainless steel or aluminium. Our free Ty-It ties are made of nylon and are from the Hellermann Insuloid range.

Broadly, the range can be divided into harnessing ties, with the cables only tied to one another, and fixing ties which hold single cables or bundles of wires to chassis, cabinet, machine or cable tray. A third class provides a solid anchorage for a flexible lead—say into a domestic appliance—sometimes with the added feature of a block terminal.

Ties and fastenings which were once pieces of string and insulated staples, are now almost exclusively produced as plastic mouldings. Some flat metal types are made in stainless steel or aluminium, but these are normally plastic covered. Nylon 66 is a commonly used standard material with a high tensile strength. For outside use where weather resistance is needed there is a special 2 per cent carbon black grade and there is also a heat stabilised grade which extends the life at 150 degrees C.

STANDARD TIES

The Ty-It ties are made in tough, flexible nylon 66. They are offered in various lengths and with alternative types of fixing heads. The size range covers 2.5mm to 7.6mm strap width with lengths from 120 to 540mm. Note that the length can be extended in an emergency by joining ties.

It is in the field of flexible ties that the greatest variety of designs is found, simply because of the infinite variety of applications such as TV receivers, business machines, motor cars, commercial vehicles, machine tools, switchgear and telecommunications, each of which can present different problems of accessibility, the concealment of fastenings and the panel material or chassis wall.

There is a variety of mounting bases or cradles designed for fixing to panels and walls before anchoring down the loom, these being arranged to accept standard nylon ties. Rivet fixing is possible for releasable and permanent ties where corrosion-proof anchorage and a sealed hole are sought. A bolted-on version is available for restricted spaces and there is a further version which lifts the loom clear of the panel surface and is recommended for tropical and high humidity conditions.

Quickly installed and very convenient is an adhesive base cradle, which also takes a standard tie. The adhesive should be checked in the case of high temperature installations.

CLIPS

Successor to the insulated staple perhaps and useful for domestic appliances, radio and automotive work are moulded PVC clips. Screwed down or self-adhesive (Stiki-Clips) versions are made for single core cables, pairs or flat twin cables. These clips save time in securing cables and harnesses particularly where fixing holes are impractical.

APPLICATIONS

For every cable and every situation there is a potential tying and fixing problem, but one that has probably been solved before and its solution entered into the standard repertoire of the tie maker. Sometimes cable routing has to be chosen to suit available fixing methods—for instance to avoid having to drill holes that will appear on external surfaces—but even this problem is now disappearing with the adoption of self-adhesive devices.

Cable ties have many other uses outside the original field of electrical wiring. The securing of large or heavy components to a p.c.b. and the fixing of light pneumatic or fluidic tubing are obvious ones, but in virtually any application where a piece of tape or string can be used a cable tie will probably do it better. With this wide range of fasteners the only limitation is the ingenuity of the designer in choosing and applying the right one.

Ty-It ties and Stiki-Clips are available from stores throughout the country. For further details contact Hellermann Insuloid, Sharston Works, Leeston Road, Wythenshawe, Manchester M22 4RH. Tel 061-988 5415-8.

Ty-It Releasable Ties, available in 140mm and 250mm sizes; Ty-It Non-Releasable Ties, available in 100mm, 150mm and 200mm sizes; Stiki-Clips for 6mm, 13mm and 18mm maximum overall diameter.
A compact multimeter with digital read-out

This compact multimeter features twenty-one ranges with six functions. L.c.d. read-out gives excellent readability with extended battery life. The complete instrument calibration is by one multi-turn trimming potentiometer.

BOARD DESCRIPTIONS
The instrument comprises of two printed circuit boards. The display unit is a self-contained panel meter with l.c.d. readout, which measures voltages within the range 0–200mV. It displays the magnitude and polarity of the applied voltage. The other board contains the conditioning circuitry to change all inputs into a voltage output in range 0–200mV.

PANEL METER MODULE
The heart of the meter is the 7126 i.c. which is a complete dual-slope integration analogue to digital convertor. It consumes typically only 50µA and drives the l.c.d. directly. Components R25 and C6 determine the integrator time constant, and C7 reduces the susceptibility to noise of the auto-zero circuit. The l.c.d. has an auto-zero feature which gives a zero reading when the analogue input is zero volts.

An input filter is formed by R27 and C8 and assists with overload protection. The frequency of the internal oscillator is determined by C10 and R28 and provides typically three samples per second. The module has a full scale reading of 199.9mV. IC3 is a high stability reference and a potential divider is formed across this so that VR1 can be adjusted to produce a Vref of 100mV. A low-battery detection circuit is included to provide advance warning of battery failure directly on the display.

A potential divider is formed across the supply by R31 and R33 and when the supply voltage falls below a threshold level, the collector of TR1 goes high. EX-OR gate IC4a then acts as an inverter to provide the required drive signal for the LO BAT warning. EX-OR gate IC4b output may be used to drive the decimal points.

CONDITIONING BOARD
The circuit diagram of the multimeter is shown in Fig. 1. Switch S3 selects d.c. or a.c. functions whilst connecting the battery to the appropriate circuitry via S3c and S3d. When the switch is in the centre ‘off’ position, S3a and S3b route the input to voltage, current, resistance or diode check stages.

For the measurement of the d.c. voltage an input attenuator is formed by resistors R1 to R5 which are high stability metal film types. The attenuator settings ensure that each input range is reduced to 200mV full scale for input to the module. The input impedance of the multimeter is the standard value of 10 megohms and ensures that negligible current is drawn from the voltage source.

When a current range is selected, S2b selects one of four shunt resistors R6 to R9, each of which should develop 200mV with full scale current input. The value of R9 is chosen to allow for the effect of switch resistance. A series chain configuration could have been used for current sensing but the low value resistors required could be difficult to obtain.

A fuse protects against excessive input currents and diodes D1 and D2 protect the instrument from connection of high input voltages.

### Specification

<table>
<thead>
<tr>
<th>Function</th>
<th>F.s.d.</th>
<th>Resolution</th>
<th>Accuracy</th>
<th>Protection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volts</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(d.c.)</td>
<td>2V</td>
<td>1mV</td>
<td>1% ± 1 digit</td>
<td>500V for one</td>
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<tr>
<td></td>
<td>20V</td>
<td>10mV</td>
<td>1% ± 1 digit minute</td>
<td></td>
</tr>
<tr>
<td></td>
<td>200V</td>
<td>100mV</td>
<td>1% ± 1 digit</td>
<td></td>
</tr>
<tr>
<td></td>
<td>500V</td>
<td>1V</td>
<td>1% ± 1 digit</td>
<td></td>
</tr>
<tr>
<td>Current</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(d.c.)</td>
<td>2mA</td>
<td>1µA</td>
<td>1% ± 1 digit 1A/250V</td>
<td></td>
</tr>
<tr>
<td></td>
<td>20mA</td>
<td>10µA</td>
<td>1% ± 1 digit</td>
<td></td>
</tr>
<tr>
<td></td>
<td>200mA</td>
<td>100µA</td>
<td>3% ± 1 digit</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2A</td>
<td>1mA</td>
<td>5% ± 1 digit</td>
<td></td>
</tr>
<tr>
<td>Volts</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(d.c.)</td>
<td>2V</td>
<td>1mV</td>
<td>2% ± 5 digit 500V for one</td>
<td></td>
</tr>
<tr>
<td></td>
<td>20V</td>
<td>10mV</td>
<td>2% ± 5 digit minute</td>
<td></td>
</tr>
<tr>
<td></td>
<td>200V</td>
<td>100mV</td>
<td>2% ± 5 digit</td>
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<tr>
<td></td>
<td>500V</td>
<td>1V</td>
<td>2% ± 5 digit</td>
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<tr>
<td>Current</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(d.c.)</td>
<td>2mA</td>
<td>1µA</td>
<td>2% ± 5 digit 1A/250V</td>
<td></td>
</tr>
<tr>
<td></td>
<td>20mA</td>
<td>10µA</td>
<td>2% ± 5 digit</td>
<td></td>
</tr>
<tr>
<td></td>
<td>200mA</td>
<td>100µA</td>
<td>4% ± 5 digit</td>
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<td>1% ± 1 digit 260V r.m.s.</td>
<td></td>
<td></td>
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<tr>
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<td>10</td>
<td>1% ± 1 digit</td>
<td></td>
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<td>2M</td>
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<td>1% ± 1 digit</td>
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<td></td>
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<tr>
<td>Diode Test</td>
<td>2V</td>
<td>1mV</td>
<td>1% ± 1 digit 260V r.m.s.</td>
<td></td>
</tr>
</tbody>
</table>
Fig. 1. Circuit of the conditioning board

Fig. 2. Circuit of the display board
A.C. VOLTAGE AND CURRENT RANGES
When S3a selects a.c. functions, the output from either the voltage attenuator or current shunts is fed through C1 to remove any d.c. component.

The operational amplifier IC1 is a TL061 connected as a precision rectifier. The j.f.e.t. input results in high input impedance and the supply consumption is only 250µA. Diodes D3 and D4 rectify the alternating input and the positive component is sampled by R13 and filtered by R15 and C5.

The circuit is mean sensing and calibrated to indicate the r.m.s. value of sine wave inputs by establishing the correct gain of the amplifier stage. The gain is set by R14 and R16 and use of the values indicated will eliminate the need for calibration. Alternatively, a 10k potentiometer could be substituted for R10.

RESISTANCE RANGES
In order to minimise the components required for resistance measurement and eliminate the need for calibration adjustment, a ratiometric method is employed.

For all other multimeter functions, the voltage reference within the module is employed and the 100mV output is connected to the module reference inputs via S1c and S1d. All inputs to the module are thus compared against the reference voltage. For resistance measurement the supply voltage is applied across the reference resistor Rr and the unknown resistor Rx. The voltage developed across each resistor is dependent upon the ratio of the two resistors and the value of the unknown resistor may be read directly using the equation Reading = 1000 Rx/Rr.

Metal film resistors R20 to R23 are used as references. It would have been possible to use the resistors from the voltage attenuator but the resistors required are in reverse order to those for the voltage ranges, resulting in the decimal
points on the display being incorrectly positioned. Additional switch sections would be required to provide correct decimal point location and to isolate R5 from circuit common.

Resistance measurements should not be made on live circuits but protection against the application of high input voltage is provided. Thermistor TH1 has a nominal value of 1k at room temperature and diode D7 will turn on at approximately 6.8V to shunt the applied voltage. When D7 draws current through TH1 the thermistor temperature rises and due to the positive temperature coefficient the resistance increases so limiting the input current.

**DIODE TEST**

When a silicon diode is forward-biased into conduction the voltage drop across the device is approximately 0.6V. The 200mV full scale of the module is however too low to measure this voltage drop. When S1 selects the 'Diode Test' function, biasing from the battery is available via D6 and R18. When the applied diode is forward-biased the voltage drop will be attenuated by a factor of 10 by R24 and R19 to bring it within the measurement range of the module. If the 2V range is selected the decimal point will be correctly positioned on the display for direct readout of the diode voltage.

If the applied diode is open-circuit or reverse-biased it will not conduct and the display will be over-range. If the diode is short-circuit the display will read zero. Because of the accuracy of measurement available close matching of transistor Vbe can be carried out.

The diode test should not be made on live circuits but diode D6 will protect the instrument from the application of high negative input voltages which would otherwise be shunted onto the supply by D5. Positive input voltages are held off by D5 and safely attenuated by R24 and R19.

**CONDITIONING MODULE**

Components should be checked against the component list and assembly commenced by soldering the through-board pins in place. As assembly proceeds, the solder pads on the top surface of the p.c.b. should be soldered to ensure circuit continuity.

Solder the resistors and capacitors in place, followed by VR1, TR1 and the i.c.s. As the I.C.D. is required to sit over IC1 and capacitors, these components should be arranged tight to the p.c.b. The display should be carefully positioned and all components soldered in place.

**TESTING**

The DPM is a self-contained instrument and may be tested and calibrated before connection to conditioning modules if required.

**CONSTRUCTION**

A plated-through-hole p.c.b. is used for the digital precision multimeter to simplify assembly. Soldering of components is required only on the underside of the printed circuit board. Link LA should be inserted first. Resistors and capacitors should be positioned followed by VR1, TR1 and the i.c.s. As the I.C.D. is required to sit over IC1 and capacitors, these components should be arranged tight to the p.c.b.

Fig. 5. Module connections for measuring a floating voltage source with 200mV full scale and autopolarity indication implemented.

Fig. 6. Double sided p.c.b. and component layout for the display board.
The display should be 0.00 and the voltage between Input 1 and battery should be connected. With the input switch to 20V d.c. the case is fitted and after checking all the soldering the battery of known accuracy. Calibration may also be carried out by comparison with a known 0.00. With a 100mV source connected between IN HI and IN LO the display shows approximately 600mV with a silicon diode or 300mV with a germanium diode. The diode test function should be checked with a known diode and the reading should be approximately 600mV with a silicon diode or 300mV with a germanium diode.

PRACTICAL Electronics Sep. '77 to date. E.T.I. April '78 to June '81. Everyday Electronics Feb. '76 to Aug. '77 offers. Mr. A. Pettitt, 2 Caburn View, Frize, Nr. Lewes, Sussex, Tel: Glynde 492. WANTED push pull output transformer to match N78 valves for HMV car radio model 4200, Mr. G. W. Nickolds, 15 Cambridge Rd., Lee-on-Solent, Hants. Tel: 550963.

AVO Model 8 MKIII small crack on case but fully operational. Mounted in 19 inch rack. £395. A. Gifford, Little Pundells, Bartley, Southampton SO4 2LN. Tel: 042 127 2392 (Evenings).

Fig. 5 demonstrates how the instrument may be connected to measure a floating voltage source in the 0–200mV range with the DPM powered from a 9V battery. The voltage between COM and V+ should be approximately 2.8V and the case is fitted and after checking all the soldering the display should be 0.00 and the voltage between Input 1 and battery should be connected. With the input switch to 20V d.c. the display should be 0-00 and the voltage between Input LO and battery positive should be approximately 2-8V. The voltage between pins 5 and 6 of the module should be 100mV. Apply a 10V input and adjust VR1 until the display reads 10.00. Switch to 20mA d.c. and check the reading with a 10mA source connected. Switch to 20k range and check that with the input open circuit the display shows a value in the most significant digit with the other three digits suppressed, which is the over-range indication. Connect a standard 10k resistor and check the reading.

With the instrument switched to 20V d.c. apply a 10V a.c. source and check the display.

The diode test function should be checked with a known diode and the reading should be approximately 600mV with a silicon diode or 300mV with a germanium diode.

Bazaar

WANTED ultrasonic cleaner, small size suitable for small components, must be good condition. Reasonable price. G. A. Chapell, 'Audeneche', Arrochar, Dunbartonshire.

TOKUDEN eight inch twin cone speakers. Eight ohms, seven watts max. unused £7 the pair. N. Norton, Arrochar, Dunbartonshire.

WANTED coil winder, hand or motor driven for software £165 o.n.o. Brian Andrews, 77 Valentia Hse., Valley Grove, Charlton S.E.7. Phone after 4.00 p.m. Ian Lavender, 288 Stourbridge Road, Holly Hall, Dudley, West Midlands.

P.E. STRING ENSEMBLE, only needs wiring up. Complete £90 ono. Pair of 38 radio sets—offers. L. Fletcher, 21 Shakespeare Avenue, Andover, Hants SP10 3DR. Tel: Andover 65368.
Practical Electronics

American CB market for the development of the PLL over may be trimmed to this frequency. The reference frequency may be reduced to not more than two.

This device has been utilised in the following circuitry and is capable of producing the required frequencies for receiving and transmitting 27MHz FM CB signals. The circuitry is very versatile indeed and has a multiplicity of inputs/outputs that may be combined with crystal controlled portables (such as the PE Ranger), FM communications receivers and FM transceivers operating in the 26MHz to 28MHz band.

The solution is a great deal more straightforward than employing the synthesiser techniques adopted by some companies which may use up to three separate i.c.s plus two or three different crystals.

The LC7137 is a 20-pin CMOS i.c. that forms a single crystal PLL system. It may be programmed via a 6-bit BCD input using an encoded switch or BCD logic. The receive local oscillator is generated directly with a 10-695MHz (low) IF offset; however, this may be mixed with the 10-24MHz crystal frequency to produce the local oscillator output with a 455kHz (low) IF offset. The transmit frequency is generated at half the output frequency. This is because the maximum input frequency of the programmable divider is 20MHz and at this lower frequency the modulation characteristics are more linear.

AT LAST after a five month long wait the Sanyo LC7137 PLL synthesiser has become generally available in the UK. (No explanation by Sanyo or their distributors for this delay, although one may hazard a guess.)

Phase-Lock-Loop frequency synthesiser have become standard in all 40 channel CBs and communications receivers. These techniques have eliminated the use of separate crystals for every channel. The actual concept stems from as early as the 1930s but until it became available in an i.c. its use was not generally cost effective. Many of the earlier PLL devices were of the analog type, but the advanced types such as the LC7137 and its hierarchy are digital in operation. We must thank the American CB market for the development of the PLL over the last ten years. The first generation synthesisers employed as many as nine i.c.s; however, the availability of LSI (Large Scale Integration) devices over the last few years has reduced the number to not more than two.

HAVE YOU HAD YOUR PLL?

Phase-Lock-Loop frequency synthesiser have become standard in all 40 channel CBs and communications receivers. These techniques have eliminated the use of separate crystals for every channel. The actual concept stems from as early as the 1930s but until it became available in an i.c. its use was not generally cost effective. Many of the earlier PLL devices were of the analog type, but the advanced types such as the LC7137 and its hierarchy are digital in operation. We must thank the American CB market for the development of the PLL over the last ten years. The first generation synthesisers employed as many as nine i.c.s; however, the availability of LSI (Large Scale Integration) devices over the last few years has reduced the number to not more than two.

IT'S ALL DONE WITH FREQUENCY

Fig. 1 shows the equivalent block diagram and external components. The important features are an on-board crystal oscillator, reference divider, programmable divider with associated ROM decoding logic and phase detector.

The reference frequency of 5kHz (5-000226kHz) is derived from the 10-2405MHz crystal frequency by dividing down by 2048. In practice a standard 10-24MHz crystal may be trimmed to this frequency. The reference frequency is not exactly 5kHz since the programmable divider uses only 4 decades to achieve the UK 27MHz CB specifications with the 1.25kHz "offset" however, the final frequencies are well within the tolerances and this error will not affect the transceiver performance.

The internal memory decodes this data and changes the divisor ratio depending on the channel and if RX or TX is required. The ratio of the RX to TX divisor values is due to the RX frequencies being generated with the 10-695MHz IF offset and the TX frequencies being generated at half the output frequency.

For example, channel 20, RX frequency = 27-79125MHz - 10-695MHz = 27-79125MHz/2

TX frequency = 27-79125MHz/2

Ratio of actual divisor ratio = 3419/2779

These ratios are not exactly correct as described earlier; however, this error is very small indeed and does not significantly change the receive frequency.

The programmable divider thus divides down the input frequency to approximately 5kHz. This is then compared with the 5kHz reference signal in the phase detector. This, as with most of the other internal circuitry, is achieved digitally. In this application the phase detector has three possible conditions of its output circuit, i.e. it provides three states to the following circuit, the loop filter. These are, an off state, a negative going state and a positive going state. When the loop is locked, i.e. the VCO is running at the correct frequency and the divided down input frequency and reference frequency are exactly in phase, the detector is in the off state and no error signals are generated. When the divided down input frequency lags behind the reference frequency the detector’s output pulses are negative going, and when it leads the reference frequency the output pulses are positive going.

These output pulses are inverted and amplified in an active integrator stage between the detector and VCO to provide the proper direction of bias change on the varicap diode controlling the VCO.

40 CHANNELS FOR ALL
Fig. 1. Equivalent circuit block diagram

<table>
<thead>
<tr>
<th>Channel</th>
<th>Program Code</th>
<th>RX (T/R = 1)</th>
<th>TX (T/R = 0)</th>
</tr>
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<tr>
<td>CH</td>
<td>Frequency</td>
<td>D&lt;sub&gt;1&lt;/sub&gt;, D&lt;sub&gt;2&lt;/sub&gt;, D&lt;sub&gt;3&lt;/sub&gt;, D&lt;sub&gt;4&lt;/sub&gt;, D&lt;sub&gt;5&lt;/sub&gt;, D&lt;sub&gt;6&lt;/sub&gt;, D&lt;sub&gt;7&lt;/sub&gt;, D&lt;sub&gt;8&lt;/sub&gt;</td>
<td>VCO Freq.</td>
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<td>3459</td>
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Fig. 2a. 40 Channel CB Synthesiser circuit diagram. Diode D6 should be shown directly in the output from pin 20 of IC1 (anode towards pin 20, cathode towards R35/TR9). C20 may need to be 47pF

Fig. 2b. Tx x 2 multiplier (TR4) and r.f. amplifier (TR5)

Fig. 2c. Mixer (TR6) and i.f. amplifier (TR7)
A loop filter follows this stage in order to smooth the phase detector output so that a d.c. voltage can be fed to the varicap diode. Thus, as the VCO frequency drifts slightly, the phase detector will sense this and will counteract this change by subsequently changing the bias on the varicap diode.

**OPERATION**

The VCO comprises TR1 (see Fig. 2) which is biased in such a way as to oscillate at a frequency determined by the equivalent series load inductance and capacitance present between the base and emitter connections. This comprises C1, L1 and the series loading of C3 and C2 with D1 and D2. The frequency is changed by altering the bias on D2, the varicap diode. This semiconductor device exhibits the property of changing capacitance when the reverse bias voltage is altered. The varicap diode is chosen to have a high Q, low reverse leakage and linear characteristics. The series capacitors C2 and C3 alter the relative effects of the varicap on the oscillator frequency. The output of the VCO is fed from L1 via C6 to a buffer amplifier TR3, and then into the PLL i.c. The loop output of the i.c. is amplified and then fed via R1 to a final filter comprising R2 and C7. The d.c. bias is then fed to D2.

On TX the VCO changes from approximately 17MHz to 13.5MHz, half the final TX output frequency. To achieve optimum linearity and keep the VCO and PLL locked the VCO frequency is pulled down to this range by switching in VC1 and C8 by turning on TR2.

The modulation input, which only requires to deviate the VCO frequency by a few kHz, is fed via C10 and R9 to D1. Note the different value of series capacitance, C2 compared to that of C3, required to tune the VCO over the complete band. The buffered output of the VCO is fed via C13 or C21 to the RX mixer section and TX RF driver section. To prevent any interference the TX circuitry is only powered up during transmit. TR8 and TR9 are used to switch the supply to the TX circuitry and change the logic on pin 20 of IC1, the RX/TX select. This input is TTL and CMOS compatible.

Transistor TR4 forms a frequency doubler circuit where the collector is tuned to 27MHz by L2 and C22. The output, rich in harmonics, is fed to a further amplifier stage consisting of TR5. The output of this stage is also tuned to 27MHz by L3 and C30.

TR6, a dual gate f.e.t., is employed in the receive circuitry to mix the VCO output with the 10-24MHz reference signal to produce the local oscillator output with a 455kHz IF offset. This section of the circuit may be omitted if an IF frequency of 10-695MHz is to be used. Again, as with the previous circuitry, the loads are tuned to remove as many harmonics and unwanted mixer products as possible. TR7 forms a buffer amplifier producing roughly 0.5V to 0.8V of RF signal.

The BCD channel coding is formed by two up-down counters, IC3, a BCD type and IC4 a binary type. The reason that IC4 is binary and not BCD coded is that as only the two LSBs of the counter are utilised no special reset lines are necessary to reset the counters from 39 to 00 on the up count and vice-versa on the down count. IC7 converts the BCD signal, 0000 0000 to 0100 0000 so that channel 40 is displayed corresponding to the BCD code 0000 0000. Refer to Table 1 for coding. The up-down select and clock pulses are produced by IC2, a quad two input NAND gate. Two gates form a pulse generator with a duty cycle determined by R42, R43 and D5. The other two gates form an enabling circuit which allows the pulses to clock the counters and select up or down. On power-up the counters are preset with the BCD number corresponding to channel 14. IC5 and IC6 decode the BCD signals and drive the 7-segment displays.
DANGER 240Vac

Fig. 3b. Printed circuit layout (actual size)
COMPONENTS...

Integrated Circuits
- IC1: LC7137
- IC2: 4011
- IC3: 4510
- IC4: 4516
- IC5, IC6: 4511 (2 off)
- IC7: 4078

Crystal
- XL1: 10-24MHz

Variable Capacitors
- VC1: 2-20p
- VC2: 3-30p

Potentiometers
- VR1: 10k

Inductors
- L1: XXNSK4612
- L2–L5: XXNSK3335 (4 off)

Transistors & Diodes
- D1, D2: BB109 (2 off)
- D3: BV2 400mW
- REC1: W005
- D4–D6: 1N4148 (3 off)
- TR1, TR3, TR4: BF274 (3 off)
- TR2: BC237
- TR5: BC548
- TR6: 40673
- TR7: 2N3819
- TR8: BC307
- TR9: BC237

Resistors
- R1, R4, R34, R35: 4.7k (4 off)
- R2, R43: 22k (2 off)
- R3, R9, R13: 10k (3 off)
- R5: 2.7k
- R6, R18, R22, R24, R30, R33: 4.7k (6 off)
- R7: 220k
- R8, R10, R20, R21, R25, R26, R28, R39, R31, R37, R38, R41, R44: 100k (13 off)
- R11, R14, R39, R40, R42: 2.2k (6 off)
- R12: 47k
- R15: 150k
- R16, R36: 1k (2 off)
- R17: 68
- R19: 220
- R23, R27, R32: 330 (3 off)
- R45–R58: 470 (14 off)
- R59: 150

Capacitors
- C1, C8: 22p (2 off)
- C2: 5.6p
- C3, C47: 56p (2 off)
- C4: 220p
- C5, C37: 150p (2 off)
- C6, C12, C13, C20, C21, C22, C32, C33, C39, C7, C14, C9, C15–C18, C23–25, C27–29, C34–36, C38, C40, C41: 33p (9 off)
- C10: 15n (2 off)
- C11, C26, C31: 22μf (17 off)
- C19: 1n (3 off)
- C30: 10μf
- C42: 100p
- C43, C44: 100n (2 off)
- C45, C46: 10μf (2 off)

Potentiometers
- VR1: 10k

Inductors
- L1: XXNSK4612
- L2–L5: XXNSK3335 (4 off)

Transistors & Diodes
- D1, D2: BB109 (2 off)
- D3: BV2 400mW
- REC1: W005
- D4–D6: 1N4148 (3 off)
- TR1, TR3, TR4: BF274 (3 off)
- TR2: BC237
- TR5: BC548
- TR6: 40673
- TR7: 2N3819
- TR8: BC307
- TR9: BC237

Resistors
- R1, R4, R34, R35: 4.7k (4 off)
- R2, R43: 22k (2 off)
- R3, R9, R13: 10k (3 off)
- R5: 2.7k
- R6, R18, R22, R24, R30, R33: 4.7k (6 off)
- R7: 220k
- R8, R10, R20, R21, R25, R26, R28, R39, R31, R37, R38, R41, R44: 100k (13 off)
- R11, R14, R39, R40, R42: 2.2k (6 off)
- R12: 47k
- R15: 150k
- R16, R36: 1k (2 off)
- R17: 68
- R19: 220
- R23, R27, R32: 330 (3 off)
- R45–R58: 470 (14 off)
- R59: 150

Capacitors
- C1, C8: 22p (2 off)
- C2: 5.6p
- C3, C47: 56p (2 off)
- C4: 220p
- C5, C37: 150p (2 off)
- C6, C12, C13, C20, C21, C22, C32, C33, C39, C7, C14, C9, C15–C18, C23–25, C27–29, C34–36, C38, C40, C41: 33p (9 off)
- C10: 15n (2 off)
- C11, C26, C31: 22μf (17 off)
- C19: 1n (3 off)
- C30: 10μf
- C42: 100p
- C43, C44: 100n (2 off)
- C45, C46: 10μf (2 off)

Miscellaneous
- T1: 12V 3VA p.c.b. mounting transformer
- Toggle switch spst
- Push button switch
- Push button switch
- LED display FND 500 (2 off)
- P.c.b.
- Case
- Mains socket
- Mains lead
- Fuse 20mm 1A
- Fuse holders
- 50 ohm coax
- BNC sockets (2 off)

Constructor's Note
LC7137 may be purchased from Anglia Components Ltd, Burdett Road, Wisbech, Cambs PE13 2PS (Tel 0945 63281) for the sum of £8.74 inc VAT and p/p.
T1, the case and the mains connector/lead may be purchased from Modus Systems Ltd, Park Drive, Baldock, Herts SG7 6EW (Tel 0462 894848) for the sum of £0.79, £1.99 and £1.35 respectively. VAT and 35p p/p should be added to each order.

ADAPTATION
The circuitry shown may be used in conjunction with several different types of equipment as discussed in the introduction. IF frequencies should be injected into the appropriate mixer section of the receiver. The higher 10-695 MHz IF frequency should always be used if possible to give the highest value of image rejection. Note that any existing inputs to the receiver's mixer should be inhibited or spurious outputs will cause serious interference.

On TX the input waveform should preferably be from a speech processor, i.e. amplitude and band limited to prevent over modulation and non-linearity distortion. The TX output should be connected to the pre-amplifier stage of the transmitter, which should be tunable to 27MHz.

The circuitry may also be connected to the PE Ranger. The modulating input should be connected to test point j, the output of the speech processor. To facilitate 40 channels,
one of the 6 channel selections in the Ranger must be inhibited, i.e. the TX and RX crystals shorted or switched out of circuit to prevent interference. The two RF connections to the synthesiser board from TR3 (base) and IC101 (pin 1) should be via 50 ohm screened coax terminated with BNC or other suitable miniature RF connectors at the cases. The TX/RX sense is connected to test point h.

TESTING AND ALIGNMENT
The unit is fairly simple to align. After it has been constructed and fully checked it should be powered up with a 9V to 12V supply. The channel display should indicate channel 14. If not, the load inputs to IC3 and IC4 (pins 3, 4, 12, 13) and the preset enable lines (pins 1) should be checked. On depressing the up or down switch the display should toggle at a reasonable rate. If not check IC2 and associated components. Assuming this is all correct check with the aid of an oscilloscope that the VCO and reference oscillators are working (TR3 collector and IC1 pin 12). With S1 in the off position, i.e. RX selected, measure the d.c. voltage at TP1 and adjust the core of L1 to produce a range of approximately 2V to 3V from channel 1 to 40. If the voltage at TP1 is either high or low continuously then check the BCD code input to IC1 and the associated components of IC1 and the VCO. Switch S1 on, i.e. TX selected, and adjust VC1 to produce the same voltage range at TP1 from channel 1 to 40. Repeat the alignment again and re-adjust L1 if necessary. With S1 off tune L4 and L5 for maximum local oscillator output. Re-tune when connected to a receiver for maximum receiver sensitivity. With S1 selected and a 50 ohm dummy load on the output socket tune L2 and L3 for maximum RF output, with least visible harmonic content. With a frequency counter connected to the Tx RF output, and with Tx selected, adjust VC2 to give the correct channel frequency (as shown in Table 1) to five places over the whole range. VR1 should now be adjusted to give adequate audio modulation. This is best checked with the use of a FM CB monitor or CB rig. Remember that over-modulation (≤±2.5kHz) will not only cause distortion on some FM receivers and/or cross channel interference, but is a contravention of the Home Office regulations.

Due to the nature of this circuitry, the author cannot accept any responsibility whatsoever for the specifications of any system that may be used in conjunction with the described article.
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INMOS WINNER

Inmos, the world-class semiconductor memory manufacturer set up and largely funded by the British Government, is continuing to expand its share of the memory market by introducing new devices which are, quite simply, better than those produced by either the American or the Japanese competition. This is a deliberate policy designed to allow Inmos to join the memory race as a market leader without the need to make vast quantities of the common-garden memory components already supplied by all the longer established manufacturers such as Texas, Motorola, Intel, N.E.C. and others. One day Inmos expect to compete directly in those markets too, and already they have a new product designed to allow Inmos to join the design centre in Bristol and their first production unit in Colorado, but for the moment Inmos are concentrating on the premium memory market where profits are higher and quantities lower. After success with their high speed 16K static parts, Inmos have now released their long awaited 64K dynamic, and it does seem to have been worth the wait! Their brand new IMS26000, organised as 64Kx1-bit, is the fastest dynamic RAM available anywhere, and it offers features which show it to be a second generation approach to the 64K DRAM design problem.

Most important in the long run may be the CAS before RAS refresh feature which has the effect of releasing a package pin so that upwards compatibility with the next generation 256K devices is possible. To get a 64K memory into a 16 pin package the 16-bit address is multiplexed as two 8-bit bytes strobed by the Row Address Strobe RAS, and the Column Address Strobe CAS. Normally RAS follows CAS and these signals are produced by an external dynamic RAM controller chip which also has the job of issuing a sequence of refresh cycles which interleave with normal memory cycles to prevent the capacitor storage cells from "forgetting." The refresh addresses are generated by an on-chip counter activated via pin 1 which unfortunately will be needed for A8 in the 256K chip when it appears. To keep pin 1 spare, Inmos detect the use of CAS before RAS to signify a refresh cycle, since this sequence is not used during a normal read or write access. The result is that circuit boards can be laid out now for 64K chips with a drop-in upgrade to 256K possible later.

Another IMS26000 innovation is "nibble mode" which allows the already fast 100 nanosecond access time of the chip to be reduced to 65 nanoseconds by a sequential four bit "nibbles". This feature is made possible by the internal memory organisation which actually gains access to four bits at a time even though only one of the four available is selected for output. With the IMS26000, a sequence of four CAS pulses will allow all four bits to be shifted out at high speed if required.

ROM THAT THINKS IT'S A RAM

After the EPROM, which had to be erased with UV light, came the EEPROM which can be erased and reprogrammed electrically by the application of high voltage pulses. EEPROMs are still cheaper than EPROMs; also, having to have high voltages and programming components on the circuit board is an inconvenience, and so the apparently more convenient EEPROM devices are nowhere as near as popular as their EPROM predecessors. If, as is likely, the cost advantage of the EEPROM is maintained in the future, the EEPROM will never replace it for normal program memory use and will be restricted only to those applications where the rewriting of non-volatile memory data is an especially desirable feature in itself.

Even if the price advantage of EPROMs cannot be removed, it is at least possible to overcome the technical disadvantages of the EEPROM technology as Xicor have demonstrated with a pair of new devices coded X2816A and X2804A. The great advantage of these two devices is that they do not require either the high voltages or the special programming circuits needed by the previous EEPROMs, and this makes them especially easy to use. In fact, these new chips appear to the rest of the system like RAM chips, and are actually pin compatible with byte-wide RAMs such as the Mostek 4802, with the main difference being that you can remove the power supply from the EEPROM without disturbing the stored data!

The X2816A and the X2804A can be read just like RAM chips, in 300 nanoseconds. Writing new data takes much longer at 10 milliseconds, but the "spanner" which might otherwise throw into the works of RAM compatibility is avoided by having address and data latches within the package. The system carries out a normal (fast) write cycle, but this is stretched internally by the EEPROMs to provide the required 10 milliseconds. The only restriction placed on the system is that the software should not try to program another location until at least 10 milliseconds has elapsed, although during the pause other systems actions can take place as required.

Now if you lay out your microprocessor board to take 24 or 28 pin memory sockets it is possible to decide later whether you plug in a static RAM (for short term data storage), an EPROM (to contain the program) or an EEPROM (for long term but alterable data). All three options will work from a single 5 volt supply and will not require special programming or refresh circuitry.

The Xicor X2816A has a 2Kx8 format and the X2804A provides 512x8.

NATURAL VOICE

According to information theory, you need to take at least two samples during the period of the shortest frequency when attempting to encode analogue signals digitally. For speech, this means a sampling rate of about 8kHz, so if we assume 8 bits per sample, the circuit board can carry up to 110 speech signals. If you have used the "Speak and Spell" learning aid, you will be rightly impressed by the great benefits that digitised speech encoding. Fortunately, ways have been found to encode speech with fewer bits by the elimination of the redundant information which speech signals contain. By this means, the size of the store required can be reduced by a factor of about one hundred. Linear Predictive Coding (LPC) is one such encoding technique which was championed by Texas Instruments and used, for example, in their "Speak and Spell" learning aid. If you have used the "Speak and Spell" you will be rightly impressed by the great benefits that digitised speech encoding brings, but you may also be less than happy about the clarity of the speech.

A new device from AMI Microsystems which uses a modified LPC technique, is claimed to provide a higher quality speech signal than has hitherto been possible with ordinary LPC. The manufacturers call their new speech technique "Natural Voice" and are currently making it available on two chips, the S4610 which has an internal 8K ROM for 17 seconds of speech, and the S3620 which can use an external 128K ROM (the S3630) to give up to 110 seconds. Apart from the promised advantages of the "Natural Voice" technique which I haven't been able to sample yet, the thing which appeals to me is AMI's "one-chip" approach to speech synthesis. The S3610 for example has an internal 30 milliwatt audio amplifier and needs only two capacitors and a cheap crystal to add speech to any instrument or toy. No doubt these chips will soon be available with a standard vocabulary so that we can all have a go. The chips are made in CMOS, run from a single 5 to 8 volt supply, and have a great deal to say for themselves.

R.W. Coles
TESTING

The input channels are relatively simple circuits; only 4 op amps are used to perform the amplification and tone control functions. Inject a 1Vpp sinewave into the line input, select LINE operation. The output signal seen at the SEND jack can be varied from 0.3Vpp to 18Vpp (with FLAT selected) by rotating the GAIN control pot. Now select the MIC mode and inject a 10mVpp signal into the MIC jack. The signal seen on the send jack should be variable over a range of 63mV to 6.3Vpp. In all cases the output signal should be free from distortion and clipping. Note that the LEVEL DETECTOR i.e.d. should come on and stay on when the SEND level exceeds +4dBm (3.5Vpp). The noise performance of the input amplifier can be measured, but only if you have the use of the equipment shown in Fig. 10. The procedure is as follows. Remove all inputs and select MIC operation and maximum gain. Also select FLAT operation and measure the noise voltage at the SEND jack. The theoretical input noise is 1.46µVr.m.s. which when multiplied by the MIC gain of 56dB results in an output noise voltage of 0.9mV r.m.s. If the input noise is significantly bigger than this then check that the gain is actually 56dB. Wrong resistor values may give you a high preamplifier gain, and hence more apparent noise. Also IC1 may be more noisy than other devices. It is not uncommon to select the input op amp for low noise operation. If noise is a problem then check for dry joints or other microphonic faults. When using the MIC input at full gain you will hear the preamplifier noise, this is not a fault. The important parameter in all audio equipment is the signal to noise ratio and not the absolute noise level. If the microphone input signal level is 1.46mV r.m.s. then the signal to noise ratio will be 60dB, which is not very much worse than most semi-professional tape recorders. A microphone signal level of 1.46mV r.m.s. is quite a small signal level. In cases like this the best advice is to move the microphone nearer to the object being recorded.

TONE CONTROLS

The tone controls can be tested either with test equipment or by listening to pre-recorded music through them. Inject a sinewave source into the LINE input, set S2 to EQ and monitor the signal at the SEND jack. The frequency response can be plotted out by varying the sinewave frequency and recording the gain changes. These responses should conform to those shown in Fig. 2 last month. However, no one would want laboriously to plot the frequency responses of 18 tone control units using this method! The best method for determining a circuit's frequency response is to inject a swept sinewave and to monitor the output waveform on an oscilloscope. However, if you do not have access to this equipment, then a listening test is quite adequate. Note that the TONE CONTROL section actually provides gain and so it is possible to amplify the system noise. If any of the controls
Fig. 1. Printed circuit board design for the Input Channel of the Mixer. The board is shown in two sections and should be joined along the X-X axis.
Fig. 2. Printed circuit board design for the Output Channel. The board is shown in two sections and should be joined along the X-X axis.
Fig. 3. Printed circuit board design for the Auxiliary Channel. The board is shown in two sections and should be joined along the X-X axis.
Fig. 4. Component layout for the Input Channel

Fig. 5. Component layout for the Output Channel

Fig. 6. Component layout for the Auxiliary Channel
operate at the wrong frequency or produce a wrong gain change then check the circuit for correct component values. All the pots and switches in the input channel should be almost noiseless and clickless when operated. If this is not the case then check the circuit for correct components or mechanically faulty pots.

The input channels consume about 15mA from each rail rising to nearly 30mA when the LEVEL i.e.d. comes on. All the op amps should have very little d.c. offset on their outputs. Typically the offset will be ±10mV. Larger offsets may well cause crackle when control pots are rotated. The two integrators in the MIDDLE tone control may have larger offsets but this will not degrade the performance.
Input Channel with the front panel layout shown in (a)

Output Channel with the front panel layout shown in (b)

Auxiliary Channel with the front panel layout shown in (c)

NEXT MONTH: P.S.U. construction and using the Mixing Desk.

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November 1982

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