**P101Mk2**

The P101 Mk 2 Hydraulic Robot Arm offers unrivalled value for money in the field of educational robots. Either as a self-contained system or linked to an external micro, the P101 Mk 2 gives a realistic simulation of industrial robots. The P101 Mk 2's robust construction makes it an excellent basis for experimentation and general robotics research.

Six-axis Robot System kit £1200 + VAT

**P102Mk2**

The two-speed Hydraulic Robot Arm is designed to provide "hands-on" experience in practical robotics courses. The Genesis P102 Mk 2 has most of the features of large industrial robots costing from 10 times the price.

The P102 Mk 2 is supplied with its own micro-processor control system and remote control box. Alternatively an external microcomputer can be used to control the robot via its RS232C interface or parallel port. Complete Six-axis Robot System kit £1625 + VAT

**MICROGRASP**

A real programmable robot for the price of a printer! MicroGrasp has four servo-controlled axes and an independent gripper. The robot can be connected to most popular computers via special Powertran adaptors.

Robot kit with power supply £215 + VAT

Universal interface board kit £57 + VAT

**POWERTRAN PLOTTER**

Three-colour precision plotting on an A3 plane. This plotter is one of the most versatile peripherals that can be bought. Exchange the pen carriage for a router or a scriber for computer-controlled etching or machining. Available for BBC "B" or RML 380Z.

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**HEBOT II**

With independent control of its two wheels, two-tone hooter, flashing "eyes", retractable pen and four-way collision detectors, Hebot provides an ideal introduction to computer control. Connects to most popular micros.

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Universal computer interface board kit £11 + VAT


Please send me the following kits

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- Name
- Address

To Powertran Cybernetics Limited, Portway Industrial Estate, Andover, Hampshire SP10 3PE

Please allow 21 days for delivery. Offers subject to availability. Prices apply to UK only, are exclusive of V.A.T. and correct at time of going to press. Overseas customers - please contact our Export Department.
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Proportional mains control up to 10A

DISC DRIVE PSU by J. R. W. Barnes                            18
Power for second BBC disc drive

MODULAR AUDIO POWER SYSTEM—Part 3 by M. Tooley BA and D. Whitfield MA MSc CEng MIEE  23
Power supply and test signal source

RUGBY CONTROLLED CLOCK—Part 1 by Stephen Ibbis              47
A receiver and decoder for the 'Rugby' time signal

POWER SUPPLY WATCHDOG by Tom Gaskell BA(Hons) CEng MIEE      58
An over and under voltage warning system

GENERAL FEATURES

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Part Seven: Binary full-adders. Index to the series

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An introduction to printer specifications plus a comprehensive buyer’s guide

PRINTER BUYER’S GUIDE                                          30
BBC MICRO FORUM by D. Whitfield MA MSc CEng MIEE
A scintillating cauldron of new ideas for BBC wizards

SEMICONDUCTOR CIRCUITS by Tom Gaskell BA(Hons) CEng MIEE       56
Programmable voltage detectors ICL8211CPA and ICL8212CPA

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Our May issue will be on sale Friday, April 4th, 1985 (see page 43)

This month's cover shows a digitised photograph, designed and created by Alex Kempkens, of a National Semiconductor 32-bit microprocessor. The Series 32000 Family from National includes the first commercially available 32-bit c.p.u.
### POLYSYRene Capacitors

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OPTO

- \( C 12 \) COMPUTER GRADE BASF CASSETTES
- \( Q L \) RGB MONITOR
- \( K A G A / T A M ) X K 810 \) Printer
- \( K A G A / T A M ) X K 810 \) Printer
- \( B R O T H E R H 1 R 5 \) Daisywheel Printer
- Centronics Printer CABLE for all the above printers/b interface with the BBC Micro

VOLTAGE REGULATORS

- DC: 5000/10000
- AC: 5000/10000
- 12V, 1A
- 24V, 1A
- 48V, 1A
- 60V, 1A
- 90V, 1A
- 120V, 1A
- 150V, 1A
- 180V, 1A
- 220V, 1A
- 250V, 1A
- 300V, 1A
- 400V, 1A
- 500V, 1A
- 600V, 1A
- 800V, 1A
- 1000V, 1A
- 1200V, 1A
- 1500V, 1A
- 1800V, 1A
- 2200V, 1A
- 2500V, 1A
- 3000V, 1A
- 4000V, 1A
- 5000V, 1A
- 6000V, 1A
- 8000V, 1A
- 10000V, 1A

DIC SOCKETS

- Low profile wrap
- High profile wrap
- 5 pin
- 8 pin
- 10 pin
- 12 pin
- 14 pin
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- 84 pin
- 86 pin
- 88 pin

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- Memory expansion kits
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Example Package: BBC Micro, with DFS Interface, Wordwise, Twin 400K TEC Disc Drives, 12” High Res monitor, Brother HR15 Daisywheel printer, Beebcalc & Database software on Disc, 10 M3 Discs, 500 sheets of paper, 4 way trays mailing slot, manuals and all cables.

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- Low Profile Professional
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- DISC DRIVES FOR BBC MICRO
- £29

- MITSUBISHI 5½" Slim line Disc Drives double sided, double density, track density 96 TPI, track to track access time 3msec.
- £29

- SINGLE MITSUBISHI Slim line - Cased with own PSU, DS/DD, 1 Megabyte (400K with BBC) £165

- TWIN MITSUBISHI Slim line - Cased with own PSU, DS/DD, 2 Megabytes (800K with BBC) £339

51½" Diskettes (Life Time Warranty)
- 10 M3 Diskettes S/S D/D £22

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- CD400 – EPSON Twin Cased with own PSU, DS, 40 track, 5½", 400K £299

- MITSUBISHI 5½" Slim line Disc Drives double sided, double density, track density 96 TPI, track to track access time 3msec.

- SINGLE MITSUBISHI Slim line – Cased with own PSU, DS/DD, 1 Megabyte (400K with BBC) £165

- TWIN MITSUBISHI Slim line – Cased with own PSU, DS/DD, 2 Megabytes (800K with BBC) £339

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- 10 M3 Diskettes S/S D/D £14

- 10 M3 Diskettes S/D D/S £22
ULTRA VIOLET BLACK LIGHT FLUORESCENT TUBES

24 V AC Ballast kits for either 4n, 8n or 12n tubes £5.50 + £5p £10.00 inc VAT.

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For 12n 4p, 12n, 13n tubes only £5.50 + £7.50 (£7.18 inc VAT).

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1. ESCAP precision Swiss-made remote motor, 6V DC geared 70/1 gear ratio, 6V DC - 16 r.p.m 3V - 8 r.p.m amazing power, no load current only 10ms approx. Size 3 x 2 1/2 cm. Equipment tested and guaranteed. ONLY £4.50 + 60p inc VAT £5.10 inc VAT.

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COOLING or EXTRACTOR FAN

40W 700 CFM @ 1000 r.p.m. £7.50 + £1.00 inc VAT £8.50 inc VAT.

240V AC SOLENOID VALVE

Direct Action Air-operated 1/2" X 1/8" B.S.P. Male Connector. £18.00 + £2.00 inc VAT = £20.00 inc VAT.

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INPUT 230, 240v to 0 - 50/0 OUTPUT 0 - 250V, 0 - 50A Max.

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1kVA 10 AMP Max. £41.00
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5kVA 10 AMP Max. £111.00
8kVA 10 AMP Max. £175.00
10kVA 7 AMP Max. £208.00
15kVA 5 AMP Max. £275.00
25kVA 3 AMP Max. £630.00

3-PHASE VARIABLE VOLTAGE TRANSFORMERS

Dual input 200-280V to 300-415V Star connected

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5kVA Lamp with phase max. £117.10 + plus VAT
10kVA Lamp with phase max. £345.45 + plus VAT

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1750 G.P.M. 115/230V. Head, £55.00 + £1.75 inc VAT £56.75 inc VAT.

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Max 20 psi. One C.F.M approx. 240v A.C. £18.00 + £2.00 inc VAT £20.00 inc VAT.

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Why waste money? Build your own EPROM ERASURE KIT for a fraction of the price of a made up unit. Complete kit of parts less than £15. Complete kit of parts less than £15. Includes: 1 x 14-pin IC, safety microswitch, on/off switch and cabling. £5.50 CASE. Price £13.50 + £7.50 inc VAT (Total inc VAT £16.50) Inc VAT.

Warning: Tube used in this circuit is highly dangerous to the eyes. Unit must be fitted in suitable case.

SOLID STATE E.H.T. UNIT

Input 120V A.C. Approx. 15WV, Producing 100000 volt. Built in 10 sec timer. Easily modified for 20 sec, 30 sec, to continuous. Designed for X-ray, ionisation of gases etc. e.g. manufacturing, houses of power or electronics: e.g. spraying iron or aragon tubes etc. £5.00 + £4.00 inc VAT (Total inc VAT £9.00). £9.00 + £1.16 inc VAT £10.16 inc VAT. Suitable for +200 volts.

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AC GEARED MOTORS

D.C. MOTORS SMALL

MICROWAVES

REELS

SEEDS REED SWITCHES

SOLÉNÓIDS A.C. or D.C.

POWER FACTOR TIMEKERS

WIDE RANGE OF XENON TUBES

WRITE/PHONE IN YOUR ENQUIRIES

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MAGNIFYING LENS

Also

• Direct Conversion Receiver A high-performance design for the 3.5 and 14 MHz amateur bands.

• Amateur Bands Occupancy An analysis of activity on the 3.5 and 7 MHz bands.
VALUE PACKS

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While the computer boom appears to be over and a price battle under way, interest in our computer projects is showing a steady increase. We believe that many thousands of computers have been bought by people with little real interest in them and virtually no idea of what to do with them apart from play games. It is likely that many good computers will appear on the secondhand market quite soon; that some of the manufacturers will go out of business or move out of the computer marketplace and that as many as half the software houses will disappear during the next year.

With such a down-turn in the industry why are our readers more interested in 'computer projects'? Our projects either add extra facilities, abilities or aid in the understanding and testing of computer systems. It seems therefore that a significant number of hobby computer owners are what we might call 'serious' users. They are interested in getting past the game playing, giving their computer a more educational role or putting it to use in control applications.

PE readers want to know how the system functions, how to interface it, how to control mains loads or how to provide mechanical ability. Many of you already have the ability to write software of a high standard, to blow your own EPROMS and connect your c.p.u. to other peripherals.

With all this in mind we have developed PE to meet your needs and we have planned some interesting projects and features for future months. They are not all directly aimed at computer buffs, indeed we will still be retaining our strong interest and involvement in all other areas, but items like switched mode power supplies, logic analysers and even sound effects units are all related to the wider area of computers these days.

For those that want more information on micro-computer systems, without perhaps wanting to buy a home computer or even to ever use one, we are planning an excellent introduction series for later in the year. We will also be widening our horizons and hopefully yours in the area of low cost educational robotics. While many readers have shown considerable interest in robotics, the relatively high initial outlay has been a stumbling block. We have been working on ways to overcome this and a series of educational ideas and designs, coming soon, is the result. We also have a mobile robot project designed to be developed in 'easy' stages which will soon be manoeuvring into our pages.

BACK NUMBERS and BINDERS...

Copies of most of our recent issues are available from: Post Sales Department (Practical Electronics), IPC Magazines Ltd., Livington House, 25 Lavington Street, London SE1 0PF, at £1 each including Inland/Overseas p&p. When ordering please state title, month and/or issue required.

Binders for PE are available from the same address as back numbers at £5.50 each to UK or overseas addresses, including postage, packing and VAT.

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Copies of Practical Electronics are available by post, inland for £13, overseas for £14 per 12 issues, from: Practical Electronics, Subscription Department, IPC Magazines Ltd., Room 2816, King's Reach Tower, Stamford Street, London SE1 9LS. Cheques, postal orders and international money orders should be made payable to IPC Magazines Limited. Payment for subscriptions can also be made using a credit card.

Phone: Editorial Poole (0202) 671191

We regret that lengthy technical enquiries cannot be answered over the telephone.
Cambridge Microprocessor Systems has developed a 'second processor' that will really open up the outside world for BBC micro owners. Via the tube interface the CMS 6502 2nd processor is programmed using BBC Basic (or using any other BBC language ROM) then disconnected from the machine to run as the 'hub' of a completely separate microprocessor system suitable for an unlimited range of control applications with a large analogue or digital I/O capability.

Feasibly such systems as intelligent alarms, machine control, experimental and domestic monitoring, etc. can be developed.

Relatively inexperienced programmers can write, develop and test application programs in BBC Basic and run them in the target environment before transferring the program to the 2nd processor's EPROM.

The real time calendar clock provides time of day, month, and year, interval timing and alarm facilities, and can also be configured as non-volatile battery backed-up RAM (8k). In the event of power failure, correct operation of the clock circuitry is maintained and the on-board battery is automatically recharged from the 5V power supply. PROM decoding allows the memory map to be re-defined.

The 64-way bus connector allows the user direct access to a comprehensive range of interface boards, all are Eurocard size (100mm x 160mm) and a complete racking system is available. The CMS 6502 costs £229 inc. VAT and the tube interface board £90 inc. VAT. Contact: Cambridge Microprocessor Systems, 44a Honson Street, Cambridge, CB1 1NL (0223 324 141).

The Diamond Anvil

Take two diamonds, then squeeze them together with such incredible force so as to recreate the pressure levels at the centre of the earth. Using this method American scientists are reported to be close to a breakthrough in semiconductor technology.

Theoretically under these pressures (around 2.5 million atmospheres) hydrogen would be transformed into a metallic state that would be retained, even when normal conditions were resumed. Furthermore the resultant metal would possess superconductive properties, enabling the conduction of electricity at the speed of light, without generating any heat caused by resistance.

Present technology can only employ the superconductive properties of metals by operating them at extremely low temperatures which is proving to be prohibitively expensive. The machine being used by the researchers at the Carnegie Institution of Washington has been nicknamed the 'diamond anvil'; so far it has managed to maintain the enormous pressures for forty consecutive days.
Whether it’s Star Wars or Raiders of the Last Ark, or even home-recorded re-runs, they all have one thing in common—slowly but surely they cause the video tape head to wear.

It is unlikely that most of us will adhere to the service industry’s advice and replace our video heads ‘every two or three years (or 1000hrs)’. It is likely, however, that sooner or later the job will have to be done. To have this work done professionally could cost over £100.

Monolith Electronics have an option for those of us who might like to do the job ourselves, in the form of a video head replacement kit. It is not an understatement to say that this kit is very comprehensive as the following list of inclusions will prove.

The kit’s storage box contains a novel head-concentricity gauge for the alignment of Betamax heads to an accuracy of better than three hundredths of a millimetre, a straboscopic tacho disc which verifies the head speeds of VHS machines, a pair of handling gloves, a cross-head screwdriver, an anti-static cloth, cleaning fluid and shaped spatulas, replacement service labels, and last but not least a mains soldering iron with solder.

A step-by-step instructions and stock list of available heads is also provided, and customers can make use of the telephone advisory service. The VM–02 video head replacement and maintenance kit costs £22.45 inc VAT and p&p. The average cost of Monolith’s replacement heads are—VHS £41 and Betamax £53, prices inc VAT. For further details contact, Monolith Electronics Co. Ltd., 5–7 Church Street, Crewkerne, Somerset (0460 743210).

At exactly 8.17 a.m. on Monday 1st April the planet Pluto will pass directly behind the planet Jupiter, bringing about a strong, albeit momentary, increase in the combined gravitational pull. At the precise moment when the planets are in exact spacial alignment, a sense of elation can be felt. Indeed jumping into the air at this exact moment will bring about a real sensation of weightlessness. This phenomenon was originally discovered in 1899 when a Mr. V. S. Dilloss made an incredible high jump of 3-47 metres, a record incidentally that has never been broken.

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Please check dates before setting out, as we cannot guarantee the accuracy of the information presented below. Note: some exhibitions may be trade only. If you are organising any electrical/electronics, radio or scientific event, big or small, we shall be glad to include it here. Address details to Mike Abbott.

The Northern Computer Show April 16–18. Belle Vue, Manchester. K2
British Electronics Week (includes: All Electronics, Circuit Technology & Fibre Optics) April 30–May 2. Olympia. E
IFSSEC (fire/security) April 15–19. Earls Court, London. S
Cast (Cable & Satellite) April 16–18. NEC, Birmingham. F5
Communications April 23–25. Olympia. I
Photoworld April 23–May 6. Earls Court. I
**Power Control Interface**

**R.A. PENFOLD**

Simple on/off control using a computer is a relatively straightforward affair with a digital output being used to control the load by way of a relay, triac, or other power switching device. Proportional power control, where intermediate power levels as well as on and off are required, represents a more difficult proposition, especially where a mains powered load is concerned. The high voltages involved with the mains supply do not in themselves represent a real difficulty since high voltage semiconductor control devices are readily available at quite reasonable prices. However, proper isolation of the computer from the mains supply is an important factor and one which must be adequately taken care of. This is not just to ensure that the computer comes to no harm, but is also necessary to safeguard the user against an electric shock.

**POWER CONTROL**

The power controller circuit described here gives proportional control over a mains load, and with the specified triac which has a current rating of 10 amps (provided suitable heatsinking is used) the unit can handle loads of up to about 2 kilowatts or so. A triac-isolator (a form of opto-isolator device) ensures that the connections to the computer are properly isolated from the mains supply. As the unit is digitally controlled it does not give an infinite number of output power levels, but the use of an 8 bit input gives some 256 different power levels (including zero and maximum), and this should be more than adequate for the vast majority of practical applications. The simple method of power control used in the unit does preclude its use with some type of equipment, but it is suitable for use with a heating element, which was the principal application in mind when the interface was designed. The interface is ideal for use in a high quality computer based thermostat.

Normally thermostats use simple on/off switching of the heating element, but with a proportional set up, a more sophisticated approach is possible, with the heat from the element being adjusted to match the heat loss from the system. This gives better stabilisation than is possible using a simple on/off thermostat.

**SYSTEM OPERATION**

The block diagram of Fig. 1 shows the arrangement used in the power controller. A digital to analogue converter is fed from an 8-bit latching output of a computer. Several home computers, including the BBC model B, VIC-20, Commodore 64, and Memotech MTX500 have a user port which provides a suitable output. For use with some machines, such as the Sinclair Spectrum and ZX81, the unit would have to be driven via an add-on parallel port. The converter requires a precision reference voltage, and in this case the built-in 2.55 volt reference source of the converter chip is used.

The 0 to 2.55 volt output of the digital to analogue converter is used as the control voltage for a VCO. The latter has an output frequency that is roughly proportional to the control voltage, with no output when the control voltage is zero. The squarewave output of the VCO is processed by a simple highpass filter circuit to give a series of brief positive and negative pulses. The negative pulses trigger a monostable multivibrator. With maximum control voltage to the VCO the monostable is retriggered almost instantly as each pulse ends, so that there is no significant gap between the pulses.

**Photograph illustrating the Power Controller Interface**

![Photograph illustrating the Power Controller Interface](image-url)
Lower control voltages and frequencies give greater gaps between pulses, and with zero control voltage the monostable is not triggered at all.

TRIAC ISOLATOR

The positive output pulses from the monostable multivibrator operate a triac-isolator. This is similar to a conventional opto-isolator where an infra-red light emitting diode drives a phototransistor, but the phototransistor is replaced by a triac. The gate terminal of the triac is not externally accessible though. When the I.e.d. is not activated and the triac is in darkness, the device is switched off and passes only small leakage currents. If the I.e.d. is provided with a suitably high current it produces sufficient ‘light’ output to cause large leakage currents to flow in the triac. These currents produce a regenerative action that cause the device to conduct strongly, just as if it had been switched on in the normal way by a gate current. The triac remains in conduction for as long as the I.e.d. is activated, and like an ordinary triac, it will also remain in conduction until the current flow between the MT1 and MT2 terminals falls to a very low level (usually just a few milliamps).

The triac section of the triac-isolator has a current rating of only 100 milliamps, which represents just 24 watts with the 240 volt a.c. mains supply. This is obviously not sufficient for most power controller applications, but it is very easy to use the isolator to drive an ordinary triac having a much higher current rating so that high power loads can be controlled.

Fig. 2, shows the output waveforms of the controller at low, medium, and maximum output powers. The circuit actually functions in what is essentially the same way as an ordinary pulsed type power controller of the type that is commonly used for the control of small d.c. electric motors. The output waveform consists of bursts of a.c. signal rather than d.c. pulses, but the effect is much the same. At low output powers there is no output for the majority of the time, giving a low average output power. At medium power levels the power is switched on for about half the time, giving an average output power of about 50 per cent. At maximum output the current is switched on for virtually all the time. There are actually brief gaps in the signal, but these are too small to significantly reduce the output power, and for most practical purposes can be ignored.

There is a limitation to this system in that it can only work properly if the VCO has a fairly low maximum frequency so that the mains signal is chopped up into bursts of several half cycles. It will not give the desired result if a higher VCO frequency is used, since the circuit can not chop up each half mains half cycle. This would not work because of the hold-on characteristic of a triac, which causes it to remain in conduction until the current flow through the device falls to a low level. Once switched on the triac must therefore remain in conduction until virtually the end of each mains half cycle.

In most practical power controller applications the simple method of power control adopted here will operate perfectly well, but it is not suitable for all purposes. It will give good results if the unit is being used in something like a thermostat where a heating element is being controlled. Results are less likely to be satisfactory if a lamp was being controlled, since at medium and low powers there would certainly be very noticeable flickering of the lamp.

As is often the case, it would be possible to simplify the hardware at the expense of more complicated and difficult software. In this case it would be quite feasible to drive the triac isolator from a digital output of the computer, with the software being used to generate an output signal of suitable frequency and mark-space ratio.

For those who are more interested in hardware than in software the adopted approach has the obvious attraction of requiring very simple driving software with only one value to be written to the appropriate address in order to set the required output power. The alternative approach outlined above would make an interesting project for someone who is software orientated.
CIRCUIT OPERATION

The circuit is reasonably simple, as can be seen by referring to the circuit diagram which appears in Fig. 3.

IC1 is the digital to analogue converter, and this is a Ferranti ZN426E low current consumption type. This is a conventional converter having an R-2R resistor network and a bank of eight electronic switches. The integral 2.55 volt reference source requires load resistor R1 and decoupling capacitor C1. These are the only discrete components needed by the ZN426.

The VCO is the oscillator section of a CMOS 4046BE low power phase locked loop (IC2). The phase comparators and other sections of IC2 are not used in this circuit. C2, R4, and VR2 are the timing components for the oscillator. R2 couples the output of the digital to analogue converter to the control input of IC2, and VR1 with R3 are used to give a small positive bias to the control input. Without this bias all values from about 0 to 50 would give zero output from the VCO, and therefore from the controller as well. With the correct bias added the circuit gives greatly improved results with low values giving low output powers.

TIMING

The monostable multivibrator uses a 555 timer device, IC3 in the standard 555 monostable configuration. R6 and C4 are the timing components for the monostable, and these set the output pulse duration at approximately 500 milliseconds. IC3 is triggered by taking pin 2 to less than one third of the supply voltage. However, the trigger pulses must be very brief as the monostable is a retrigerable type, and long trigger pulses could result in the output pulses being extended.

R5 is used to bias the trigger input of IC3 to the positive supply rail, and C3 couples the output signal of IC2 to this input. IC2 has a squarewave output signal, but the highpass filtering provided by C3 and R5 modifies this to a short positive pulse on each rising edge of the squarewave, and a brief negative pulse on each trailing edge. These negative pulses provide a suitable trigger signal for IC3.

IC3 has more than adequate current drive to operate the i.e.d. in the triac-isolator, and R7 is in fact needed to provide current limiting here. The triac section of the isolator is used to trigger the main triac via R8 which limits the gate current to a safe level.

CONSTRUCTION

The component layout and full-size track pattern for the printed circuit board are shown in Fig. 4. Construction of the board does not present any real difficulties, but as the mains supply is involved it is obviously essential to take great care to avoid errors, and to thoroughly check the finished board.

If desired the interface could be constructed as a self-contained unit with the board fitted in a case with a multiway input socket and a mains outlet for the controlled equipment. Alternatively, it could be built into a larger system. This is something that must be varied to suit individual requirements. In either case the triac will need a heatsink if it is to control currents of more than about two amps, and for high currents of around six to eight amps a substantial heatsink (about 2.5°C per watt or better) with adequate ventilation would be needed. Bear in mind that the heat-tab of the triac connects to the MT2 terminal, and that the heatsink will therefore be connected to the mains supply unless it is properly insulated from the triac.

DRIVING THE UNIT

For use with the VIC-20, Commodore 64, and BBC model B computers the 8-bit input of the interface is fed from the eight data lines of the user port (PB0 to PB7). The O\(^V\) and 5V lines of the port are also connected to the interface. The two Commodore machines require a 2 by 12 way, 0.156 inch pitch edge connector, and as you are unlikely to be able to obtain a connector which has the appropriate polarising key, care must be taken to fit it to the computer the right way round. It is advisable to clearly label the top and bottom edges of the connector so that mistakes are avoided. Connections to the user port of the BBC model B computer are made by way of a 20 way IDC header socket. Connection details for the user ports of all three computers are provided in the relevant manuals.

Before data can be written to the interface the lines of the user port must be set as outputs. This is achieved by writing 255 to the appropriate address, as detailed below:

```
?&FE62=255 (BBC model B)
POKE 37138,255 (VIC-20)
POKE 56579,255 (CBM 64)
```

Data is then written to address &FE60 in the case of the BBC model B, 37136 for the VIC-20, and 56577 for the CBM 64.

The connections to the user port of the Memotech MTX-500/512 computers (the 20 pin d.i.l. i.e. socket on the printed circuit board) are made via a d.i.p. plug. Rather than PB0 to PB7 lines POTO to POT7 are used. These do not

---

The circuit requires a single 5 volt supply and has a current consumption of about 30 millamps or so. The user or expansion port of most computers is capable of supplying this.

---

![Fig. 4. The p.c.b. and component layout of the Power Controller Interface](image-url)
require any setting up software to set them as outputs, but the OTSTB line must be linked to the OV line in order to take the outputs into the active state. Data for the interface is sent from BASIC using the OUT instruction, and the user port is at address 7.

**ADJUSTMENT**

When setting up the interface ready for use it does not need to be connected to the mains supply, and in the interest of safety it is probably best not to do so. Write a value of 0 to the interface, and then adjust VR1 for the lowest resistance that does not produce oscillation from IC2 (i.e. set it as far in an anticlockwise direction as possible without oscillation occurring). An oscilloscope, audio amplifier, or a crystal earphone can be used to detect the output pulses at pin 4 of IC2.

Next write 255 to the interface, and use a multimeter set to a low voltage range (about 6 or 10 volts f.s.d.) to monitor the output voltage at pin 3 of IC3. With VR2 set fully clockwise there should be only a fairly low voltage present, but adjusting VR2 in an anticlockwise direction should result in the voltage rising. Adjusting VR2 too far will cause the voltage to suddenly drop to about half its peak level. VR2 should then be backed off slightly to reinstate the peak reading. After repeating this procedure a couple of times the unit is ready for use.

---

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We conclude our series on Sequential Logic Techniques with a brief look at binary full-adders. This topic was first introduced in our earlier series (Introduction to Digital Electronics) which described the characteristics and basic gate arrangements of both half and full-adders. As with most popular gate arrangements, the TTL chip designer has come to our aid with d.i.l. packaged devices which provide the complete function of a full-adder. We shall examine one such device which can be readily cascaded to cope with binary words of any desired length.

**THE 74283 BINARY FULL-ADDER**

The 74283 is a high speed 4-bit binary full-adder with internal carry 'look-ahead', the pin connections and internal logic of which are respectively shown in Figs. 7.1 and 7.2.

The 74283 accepts two 4-bit binary words (A1 to A4 and B1 to B4) and a carry input (Cin). The sum of the two 4-bit words is combined with the carry input and presented as four sum outputs (Σ1 to Σ4) and a carry output (Cout). This arrangement permits cascading of the device.

We shall begin our investigation of the 74283 with the simple full-adder shown in Fig. 7.3. This arrangement uses only three inputs; A1, B1 and Cin. The 'sum' output appears as Σ1 whilst the 'carry' output appears as Σ2.

The 74283 should be inserted into socket E of the Logic Tutor (taking care to align pin-1 with E1) and the following links should then be made:

- E1 to D3 (D3 shows the state of Σ1)
- E4 to D4 (D4 shows the state of Σ2)
- E5 to S1 (A1 input)
- E6 to S2 (B1 input)
- E7 to S3 (carry input)
- E8 to OV (common)
- E16 to +5V (supply)

(a total of 7 links)

---

**Fig. 7.1. Pin connections for the 74283**

**Fig. 7.2. Internal logic of the 74283**
Fig. 7.3. Simple full-adder arrangement using the 74283

Logic Tutor switches S1, S2 and S3 should all be initially adjusted to produce logic 0 inputs on A1, B1 and Cin. In this condition D3 and D4 should both be extinguished showing that the 'sum' and 'carry' outputs are both at logic 0. Now depress, and hold down, momentary action switch, S1. This produces a logic 1 at the A1 input. D4 will then become illuminated whilst D3 should remain extinguished showing that the 'sum' is 1 whilst the 'carry' is 0.

S1 should now be released and S2 held down to produce logic 0 and logic 1 on the A1 and B1 inputs respectively. This should again produce 'sum' and 'carry' outputs of 1 and 0 respectively.

S2 should now be released whilst latching action switch S3 should be depressed. This produces a logic 1 on the carry input whilst the A1 and B1 inputs remain at logic 0. D4 will become illuminated whilst D3 should remain extinguished, again indicating 'sum' and 'carry' outputs of 1 and 0 respectively.

S3 should now be depressed a second time so that the carry input reverts to logic 0. S1 and S2 should now be held down to produce logic 1 on both A1 and B1. D4 should become extinguished whilst D3 should become illuminated. This shows a 'sum' output of 0 and a 'carry' output of 1.

S3 should now be depressed a third time in order to produce a logic 1 carry input. Now depress first S1 and then S2. Notice that both of these input conditions result in a 'sum' output of 0 and a 'carry' output of 1.

Finally, hold down both S1 and S2 to produce a logic 1 on all three inputs, A1, B1 and Cin. In this condition D3 and D4 will both be illuminated indicating that both the 'sum' and 'carry' outputs have become logic 1. The results of the investigation are summarised in Table 7.1.

Having shown how the 74283 can be used as a simple full-adder let's extend the arrangement to provide a fourth input derived from the remaining unused Logic Tutor switch, S4. Make the following extra connections: E3 to S4 (A2 input)
E13 to D2 (D2 shows the state of Σ3)

This modified arrangement is shown in Fig. 7.4. and uses E1 and E3 to respectively denote the least (LSB) and the most (MSB) significant bits of the sum.

All four Logic Tutor switches should initially be adjusted for logic 0 inputs. D2 and D4 will be extinguished but D3 will have become illuminated to indicate a result of '010'. Clearly we must have forgotten something!

Unused inputs of TTL devices normally float 'high' thus, with the B1 input left unconnected, the B1 input receives a logic 1. We shall therefore need to 'hard-wire' this input to logic 0 using the following additional link: E2 to logic 0

All three output indicators should now be extinguished showing that the sum is '000'. Readers should experiment with all possible input combinations (there are sixteen of them!) and confirm that the arrangement conforms to the truth table that is shown in Table 7.2. It should be noted that the A2 and A1 inputs are the MSB and LSB of the two-bit number generated by S4 and S1 respectively, and that the remaining switches, S2 and S3, generate single bit inputs. For clarity, the equivalent decimal sum is also shown in the truth table with the leftmost digit corresponding to the two-bit A input.

A SIMPLE ADDING MACHINE

We shall conclude with an extension of the previous arrangement which forms a simple 'adding machine' and incorporates several of the techniques and devices introduced in the series. This simple arrangement accepts a 4 binary input (derived from the Logic

### Table 7.1. Truth table for the simple full-adder of Fig. 7.3

<table>
<thead>
<tr>
<th>INPUTS</th>
<th>OUTPUTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1 (S1)</td>
<td>B1 (S2)</td>
</tr>
<tr>
<td>0 0 0</td>
<td>0 0 0</td>
</tr>
<tr>
<td>0 0 1</td>
<td>0 0 1</td>
</tr>
<tr>
<td>0 1 0</td>
<td>0 1 0</td>
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<tr>
<td>0 1 1</td>
<td>0 1 1</td>
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<td>1 0 0</td>
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<tr>
<td>1 0 1</td>
<td>1 0 1</td>
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<tr>
<td>1 1 0</td>
<td>1 1 0</td>
</tr>
<tr>
<td>1 1 1</td>
<td>1 1 1</td>
</tr>
</tbody>
</table>

### Table 7.2. Truth table for the arrangement shown in Fig. 7.4

<table>
<thead>
<tr>
<th>INPUTS</th>
<th>OUTPUTS</th>
<th>SUM</th>
</tr>
</thead>
<tbody>
<tr>
<td>A2 (S4)</td>
<td>A1 (S1)</td>
<td>B1 (S2)</td>
</tr>
<tr>
<td>0 0 0</td>
<td>0 0 0</td>
<td>0 0 0</td>
</tr>
<tr>
<td>0 0 1</td>
<td>0 0 1</td>
<td>0 0 1</td>
</tr>
<tr>
<td>0 1 0</td>
<td>0 1 0</td>
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<td>1 1 0</td>
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</tr>
<tr>
<td>1 1 1</td>
<td>1 1 1</td>
<td>1 1 1</td>
</tr>
</tbody>
</table>

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Tutor switches) and displays the resulting sum on a seven segment l.e.d. display.

The circuit of the 'adding machine' is shown in Fig. 7.5. The binary output from the 74283 adder, IC1, is fed to a 7447 seven segment decoder, IC2. Since only three bits are used, the fourth input to the 7447 must be wired to logic 0. The seven active low outputs of IC2 are connected to the display by means of a series resistor network comprising seven 150 ohm resistors contained within a single d.i.l. package. Where readers have difficulty in obtaining such a device, seven discrete 0.25W 150 ohm resistors may be substituted. These should be connected from B1 to B16, B2 to B15, B3 to B14, and so on, ending with B7 to B10. The pin-outs and characteristics of the 7447 and seven segment d.i.l. indicator were described in Parts One and Two and thus will not be repeated here.

The 74283 should be left in socket E of the Logic Tutor and the remaining devices inserted as follows: the 7447 in socket A, the 150 ohm d.i.l. resistor network in socket B, and the seven segment common anode l.e.d. indicator in socket C. The usual convention for connecting these devices should be observed.

The following links are required:

A1 to E1
A2 to E13
A6 to logic O
A7 to E4

A8 to OV (common)
A9 to B5
A10 to B4
A11 to B3
A12 to B2
A13 to B1
A14 to B7
A15 to B6
A16 to +5V (supply)
B10 to C13
B11 to C2
B12 to C7
B13 to C10
B14 to C12
B15 to C15
B16 to C1
C16 to +5V (common anode supply)
E2 to logic O

(A total of 28 links)

Readers should confirm that the 'adding machine' produces a decimal indication of the sum of the two-bit number generated by switches S4 and S1, and the two one-bit numbers generated by switches S2 and S3.

This concludes our series on Sequential Logic Techniques. Readers wishing to progress further will, no doubt, be interested to learn that we shall be returning in the autumn with a new series designed to provide an introduction to microprocessor systems.

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Fig. 7.5. The simple adding machine

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O V E R 9 , 0 0 0 S T O R E S & D E A L E R S H I P S W O R L D W I D E
THE advantages of using a disc drive over a cassette recorder have been covered in great depth elsewhere and are well known. To obtain full benefit from the BBC computer a disc drive is essential. The cheapest, and the most popular solution is to add a single drive and power this from the computer's internal power supply. Whilst this arrangement is satisfactory under most circumstances, the addition of a second drive and or a large number of sideways ROMs may result in the power supply being overloaded.

The unit described here is intended to provide the power for the extra disc drive. There is nothing particularly special about the power supply and constructors may find other uses for it. The prototype was made as a stand-alone unit but it may also be built inside a suitable disc drive housing.

REQUIREMENTS

The majority of disc drives require two power supply voltages, five volts for the logic integrated circuits and 12 volts for the various motors. The load on the five volt output is reasonably constant but, the load on the 12 volt output varies considerably depending whether the drive is idle or running. The output current required will also vary depending on the make and vintage of the drives. According to the label on the bottom of the BBC micro, 1-25A is available for the operation of external equipment. So as to allow a margin of safety this unit has been designed to provide 2A at each output.

 Provision has been made so that the current limit can be reduced by changing the value of a resistor. The output voltages are variable by 10% either side of their nominal value.

CIRCUIT DESCRIPTION

The complete circuit diagram of the unit is shown in Fig. 1. The circuit can be split into two sections, the five volt output and the 12 volt output. These two sections are very similar in their mode of operation but there are some important differences.

Regular readers of PE will be surprised by the absence of three terminal regulator integrated circuits. While these can be used to provide simple regulated power supplies, those with high output current capability are relatively expensive and only the very expensive ones have facilities for being able to adjust the output voltage and current limit setting. The discrete arrangement as used here tends to offer better thermal stability. The reason for this, is that the series pass transistor dissipates a large amount of power raising the chip's temperature. In this discrete design the voltage reference and the pass transistor are in thermal isolation.

CIRCUIT OPERATION

The control circuits used in both outputs are examples of classic feedback systems. The differences arise because in the five volt case, the required output voltage is less than the reference voltage, and in the 12 volt case the output is greater than the reference. Both regulators are based on the LM723 i.c.

The mains transformer, T1 has two output windings; a nine volt winding for the five volt supply and a 16 volt winding for the 12 volt output. The two bridge rectifiers, D1–D4 and D5–D8 convert the a.c. to d.c., and smoothing is provided by C1 and C2.

Consider the 12 volt output first. TR1 and TR2 are connected in the Darlington configuration and are used as an emitter follower. An emitter follower provides current gain only, i.e. the output voltage is the same as the input voltage minus (2 x Vfhe). This is used to boost the output capability of the control i.c. Resistors R4 and R5 together with the preset potentiometer VR2 form a voltage divider and feed a percentage of the output voltage to the inverting input of the error amplifier.

VR2 allows the output voltage of the power supply to be adjusted to cope with small variations in the reference voltage. The non-inverting input is connected to the voltage reference output of IC1. This configuration provides negative feedback resulting in the output of the power supply being held constant for varying load conditions. The capacitor C3 provides frequency compensation for the error amplifier.

SHORT CIRCUIT PROTECTION

A constant current type of short circuit protection is implemented. R6 is used as a shunt to sense the output current. When the voltage across this resistor equals 0-7 volts the control i.c. reduces its output voltage to keep the constant current. Since V = IR it is possible to select the maximum current by a suitable choice of R6.

\[ R6 = \frac{0.7}{I_{\text{output max}}} \]

In the prototype the maximum output current was set to 3A. As with all linear regulators, short circuiting the output will cause the dissipation in the series pass transistor to rise. This will lead to the junction temperature of the transistor rising
and may lead to its eventual destruction. Whilst the power supply will withstand short term overloads it is not recommended that power supply is shorted for long periods.

Operation of the five volt output is very similar. The power supply for the control i.c. is derived from C1, this enables the five volt output to operate with a lower input to output voltage difference and leads to higher efficiency.

Constructors' note:
T1—Mains transformer 9 volt and 16 volt secondaries on 50 V/A Core. (Available from Samsons Electronics Ltd., 9-10 Chapel Street, Marylebone Road, London NW1. Note that this transformer has been specially designed.

Because the desired output voltage is lower than the voltage reference a different configuration is employed. R1, R2 and VR1 act as a voltage divider on the reference voltage, the output of which is fed to the non-inverting input of the error amplifier. VR1 allows fine adjustment of the five volt output. The output voltage of the power supply is fed back via R3 to the inverting input of the error amplifier. The output of the control i.c. is boosted by the Darlington consisting of TR3 and TR4.

Current limiting is provided by R9 in an identical way to the 12 volt output, and the two i.e.d.s and their limiting resistors give an indication that the outputs are on.

**Components...**

<table>
<thead>
<tr>
<th>Resistors</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>R1</td>
<td>1k2</td>
</tr>
<tr>
<td>R2</td>
<td>4k7</td>
</tr>
<tr>
<td>R3</td>
<td>1k5</td>
</tr>
<tr>
<td>R4</td>
<td>2k2</td>
</tr>
<tr>
<td>R5</td>
<td>3k3</td>
</tr>
<tr>
<td>R6, R8</td>
<td>0Ω2 2.3 watt WW(2 off)</td>
</tr>
<tr>
<td>R7</td>
<td>1K 0.5 watt carbon</td>
</tr>
<tr>
<td>R9</td>
<td>270 0.5 watt carbon</td>
</tr>
<tr>
<td>All resistors</td>
<td>±5% unless stated otherwise</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Potentiometers</th>
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</tr>
</thead>
<tbody>
<tr>
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<td>1k sub. min. pre-set pot. (2 off)</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Capacitors</th>
<th></th>
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<tbody>
<tr>
<td>C1, C2</td>
<td>4700µ 25 volt elect. axial (2 off)</td>
</tr>
<tr>
<td>C3, C4</td>
<td>470p disc ceramic (2 off)</td>
</tr>
<tr>
<td>C5, C6</td>
<td>10µ 25 volt elect. radial (2 off)</td>
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</table>

<table>
<thead>
<tr>
<th>Semiconductors</th>
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<tbody>
<tr>
<td>D1–D8</td>
<td>IN5402 (8 off)</td>
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<tr>
<td>D9–D10</td>
<td>0.2 inch i.e.d.s with panel mounting clips (2 off)</td>
</tr>
<tr>
<td>TR1, TR3</td>
<td>BC107 silicon npn (2 off)</td>
</tr>
<tr>
<td>TR2, TR4</td>
<td>TIP3055 silicon npn plastic power transistors (2 off)</td>
</tr>
<tr>
<td>IC1, IC2</td>
<td>LM723 voltage regulator i.c.s (2 off)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Miscellaneous</th>
<th></th>
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</thead>
<tbody>
<tr>
<td>S1</td>
<td>d.p.s.t. rotary mains switch</td>
</tr>
<tr>
<td>SK1–SK3</td>
<td>Binding posts colour to suit (3 off)</td>
</tr>
<tr>
<td>T1 Transformer</td>
<td>9V and 16V secondaries</td>
</tr>
<tr>
<td>Verobox</td>
<td></td>
</tr>
<tr>
<td>P.c.b. PE 504-02</td>
<td>Knob for S1</td>
</tr>
<tr>
<td>Heatsink</td>
<td></td>
</tr>
<tr>
<td>Fixing screws</td>
<td></td>
</tr>
<tr>
<td>Captive grommet</td>
<td></td>
</tr>
<tr>
<td>Connecting wire</td>
<td></td>
</tr>
<tr>
<td>Insulating kits for TR2, TR4 (2 off)</td>
<td></td>
</tr>
</tbody>
</table>
CONSTRUCTION

With the exception of the mains transformer all the components are mounted on a single p.c.b. and front panel. The printed circuit board track layout is shown in Fig. 2. The design can be transferred to the circuit board by any of the usual methods and subsequently etched and drilled.

To allow some of the components to be mounted some of the holes may need to be enlarged. The normal practice of constructing circuit boards should be followed. The Veropins if used should be fitted first, then the wire links and the smaller components. It will assist if the bulky electrolytic capacitors are left till last. Care should be taken to ensure that all the polarised components such as capacitors and diodes are correctly orientated. Constructors are advised to use sockets for the two i.c.s.

The prototype was built in a Verobox and before the transformer can be bolted in position, it is essential to remove some of the internal mouldings. This can be done with a large twist drill and then any remaining plastic should be removed using a sharp knife.

ADJUSTMENT

Before the power supply is connected to a disc drive it is essential to test it and adjust the output voltage. Connect an accurate volt meter to the five volt output and turn the unit on. The meter should read approximately five volts, adjust VR1 until the output is exactly five volts, switch off. Set the meter to a range greater than three amps d.c. and connect this across the output and turn the unit on. If all is well the meter should read about 3A.

Repeat for the 12 volt output, but this time set the voltage with VR2.
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In the series thus far we have assumed that all of the ancillary modules described have derived their d.c. supplies from an associated power amplifier module. Whilst this arrangement is convenient when pre-amplifier and power amplifier modules are assembled together within a common external enclosure, it is less attractive when the power amplifier module is remotely located.

A somewhat simpler, and far more flexible solution is that of including a 'local' power supply within the pre-amplifier enclosure, thus obviating the need to provide three additional conductors in order to convey the positive and negative supply rails and common earth.

Such a supply need only be capable of delivering a few tens of milliamps from symmetrical output voltage rails of between 15V and 30V. Furthermore, there is no need for electronic regulation of the d.c. output voltage as shunt Zener stabilisation is incorporated within each ancillary module.

The complete circuit diagram of the power supply module is shown in Fig. 1. This relatively straightforward arrangement is capable of supplying up to five parallel connected ancillary modules and employs a mains transformer, T1, having either two series connected 12V windings or a single centre tapped secondary of nominally 24V. In either case, a conventional plastic encapsulated bridge rectifier, REC1, is employed.

The power supply is built on a single sided p.c.b. measuring approximately 65mm x 155mm (i.e. identical in size to all other modules). The component overlay is shown in Fig 2.

Components should be assembled on the p.c.b. in the following sequence: terminal pins, transformer, resistors, capacitors, and bridge rectifier. As always, care should be taken to ensure the correct orientation of the polarised components (including the bridge rectifier).

When the p.c.b. wiring is complete, the underside of the board should be carefully checked for solder bridges and dry joints whereas the component side should be examined paying particular attention to the correct placement and orientation of components.

Although the power supply will normally be mounted in the same enclosure as that used for the pre-amplifier module (see last month) some constructors may prefer to use a separate enclosure. In such cases the authors strongly recommend the inclusion of the mains transformer to the nearest mains socket. However, for those who are determined to eliminate the use of power leads, the legs of the transformer can be connected to the mains supply as shown in Fig. 1.

Fig. 1. Circuit diagram of the power supply module

**COMPONENTS . . .**

**POWER SUPPLY**

<table>
<thead>
<tr>
<th>Resistors</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>R1</td>
<td>1k5 0.25W 5%</td>
</tr>
<tr>
<td>R2, R3</td>
<td>390 0.6W 5% (2 off)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Capacitors</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1, C2</td>
<td>470µ 50V p.c. electrolytic (2 off)</td>
</tr>
<tr>
<td>C3, C4</td>
<td>1000µ 16V p.c. electrolytic (2 off)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Semiconductors</th>
<th>Component</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>REC1</td>
<td>50V 1A bridge rectifier</td>
<td></td>
</tr>
<tr>
<td>D1</td>
<td>Red l.e.d.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Miscellaneous</th>
<th>Component</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>P.c.b.</td>
<td>Terminal pins (8 required)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>T1 3VA mains transformer with 2 x 120V primaries and 2 x 12V secondaries each rated at 120mA</td>
<td></td>
</tr>
<tr>
<td></td>
<td>D.p.s.t. mains switch</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mains connector</td>
<td></td>
</tr>
</tbody>
</table>
recommend the use of a small diecast box, being both neat and robust. Ventilation of such an enclosure will not normally be required.

**TEST SIGNAL SOURCE**

This final ancillary module generates a sinusoidal signal of reasonable purity at a frequency of approximately 1kHz. It thus not only provides a means of testing the complete power amplifier system but also enables a realistic measurement of the r.m.s. output power when used in conjunction with the test load described previously.

![Component layout of the power supply module](image1.png)

**Fig. 2.** Component layout of the power supply module

The test signal source is based on a 741 operational amplifier and its complete circuit diagram is shown in Fig. 3. The oscillator uses a simple Wien bridge network, R1, C1 and R2 C2, with negative feedback amplitude control provided by means of R3 and LP1. This arrangement ensures reasonable purity without the need to use a more expensive thermistor device in the feedback network.

With the component values shown, the frequency of

**COMPONENTS . . .**

**TEST SIGNAL SOURCE**

**Resistors**
- R1, R2 1k5 (2 off)
- R3 47
- R4, R5 1k 0-5W (2 off)
- VR1 1k horizontal mounting min. skeleton pre-set

Unless otherwise stated, all fixed resistors are 0-25W 5%

**Capacitors**
- C1, C2 100n polyester (2 off)
- C3 10μ 16V p.c. electrolytic
- C4, C5 100μ 16V p.c. electrolytic (2 off)

**Semiconductors**
- IC1 741
- D1, D2 BZY88 C9V1 (2 off)

**Miscellaneous**
- P.c.b.
- Terminal pins (5 required)
- LP1 6V 60mA wire ended pilot lamp
- 8-pin low profile d.i.l. socket

![Complete circuit diagram of the test signal source](image2.png)

**Fig. 3.** Circuit diagram of the test signal source

Pre-amplifier
The photograph shown above is of the test signal source p.c.b. whilst the power supply p.c.b. is shown on the right.

operation is approximately 1kHz. If desired, however, constructors may readily change the frequency of oscillation by altering the values of R1, R2 and C1, C2. The frequency of oscillation is given by:

\[
f = \frac{159}{C \times R} \text{ (kHz)}
\]

Where \( C = C1 = C2 \) (expressed in \( \mu \)F) and \( R = R1 = R2 \) (expressed in kohm).

Adjustment of the output voltage level is provided by means of VR1. With this control in mid-position, the output voltage produced will be of the order of 1V pk-pk. As mentioned previously, simple Zener diode shunt regulators, D1 and D2, are provided to stabilise the incoming positive and negative supply rails.

The test signal source is again built using a single sided p.c.b. measuring approximately 65mm x 115mm. The component overlay is shown in Fig. 4. Components should be assembled on the p.c.b. in the following sequence; terminal pins, i.e. holder, resistors, capacitors, diodes, variable resistor and filament lamp. This latter component should be secured to the p.c.b. using a small drop of epoxy resin based adhesive.

When complete, the p.c.b. should be carefully checked for solder bridges, dry joints, and correct orientation of all polarised components. The test signal source may be tested by simply connecting its output to the input of any of the other modules and listening for a signal output from the system. If available, an oscilloscope may be used both to confirm that the output waveform is sinusoidal and to accurately set the level of the output signal.

In a practical system the output of the test signal source may either be made available at a standard jack or d.i.n. connector so that it may be 'patched' into the system when required or may be switched directly to any of the inputs of the pre-amplifier/line driver or pre-amplifier-mixer modules described last month.
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- 10 x 8 division display
- Component comparator
- DC source outputs
- Measures 210H x 280W x 450D (mm), weight 8kg (approx.)
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Any of these three items would be an invaluable addition to the test gear used by an amateur or professional engineer. Each unit is supplied with an input lead, instruction manual and a free copy of "Getting The Best From Your Scope". Additional probes and accessories are also available.

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★ Triggering to 20MHz
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DARK RINGS
Using a C.C.D. (Charge Coupled Device) on the 100-inch reflector at the Las Campanas Observatory, in Chile, the American astronomers Richard Terrile and Bradford Smith have succeeded in imaging the rings of Uranus, together with all five known satellites (Miranda, Ariel, Umbriel, Titania and Oberon). Infra-red images have been obtained by D. A. Allen and J. Crawford from the Siding Spring Observatory in New South Wales, but this is the first record of them at visual wavelengths.

The rings are quite unlike those of Saturn; instead of being bright and icy, they are made up of material which is as dark as coal dust.

Meanwhile, occultation observations by F. Vilas and L. Elicer at the Cerro Tololo Observatory, also in Chile, give the first indications that the outermost giant planet, Neptune, may also have a dark ring. Previously no signs of a Neptunian ring had been found, and it had been thought that none might exist because of the presence of Triton, a large satellite with retrograde motion. The Chilean observations are far from conclusive, but they are certainly very interesting.

Russia's two Vega probes to Halley's Comet are now on their way, first to rendezvous with Venus and then to encounter the comet in March 1986—at about the same time as the Japanese Planet A, and shortly before the European probe, Giotto, is scheduled to pass right into the heart of the comet on March 13, 1986.

HORSE SENSE
There has been an interesting suggestion with respect to the famous Horse's Head Nebula in Orion, which is spectacular when photographed and really does give the impression of a knight's head in chess—though it is hard to see visually (with my 15-inch reflector I always find it an excessively difficult object). B. Reipurth of Denmark and P. Bouchet of France suggest that it may be an embryo Bok Globule.

These Globules, named in honour of the late Bart J. Bok (who first drew attention to them) are formed when strong radiation from very hot stars strips away all but the compact centres of large interstellar clouds, and are believed to form into stars of rather low mass.

In the case of the Horse's Head, the radiating star is Sigma Orionis. Reipurth and Bouchet believe that eventually the Horse's Head will emerge from the surrounding nebulosity and become typically spherical in form, though obviously the process will be a very slow one indeed.

THE SKY THIS MONTH
Several planets are on view this month, though only Mercury and Venus are well placed. Venus continues to dominate the western sky after sunset, and its magnitude at the beginning of the month is -4.3, far brighter than any other planet and about three magnitudes brighter than Sirius, the most brilliant star in the sky.

However, Venus sets earlier and earlier as the month progresses, and the phase decreases from 25 per cent on March 1 to only 4 per cent on March 30. Inferior conjunction is reached on April 3.

This is a good time to see whether the phase of Venus can be seen with the naked eye. Very keen-sighted people can do so (though I certainly cannot!) and of course binoculars will show the phase easily.

Telescopically, this is also the right time to look for the Ashen Light, or faint luminosity of the night side of the planet. Observations of it have been made so often that it can hardly be dismissed as a contrast effect—though we can hardly agree with the last-century German astronomer Franz von Paula Grunthiisen that it is due to fires lit on the planet's surface by the local inhabitants to celebrate the election of a new Government! More probably it is due to electrical effects in the upper atmosphere of Venus.

Mars, in the evening sky, is now only of magnitude 1.3. Jupiter rises well before the Sun by mid-March, and so does Saturn, but both are low, as they are well to the south of the celestial equator. The Moon is full on March 7, and new on the 21st.

Halley's Comet, brightening steadily, is still beyond the range of any but very powerful telescopes; however, its nucleus is already showing marked signs of activity, and we may hope that the comet will be rather more of a spectacle than was originally feared. For the record: the position on March 1 is R.A. 4h 56m, dec. N.13°35'; on March 31, R.A. 4h 51m, dec. N.14°49'. This is close to the boundary between Orion and Taurus—roughly midway between Aldebaran and Betelgeux.

Orion, of course, is still the most striking constellation on view, though by the end of the month it is starting to run into the evening twilight. (Do not forget that Summer Time starts on March 31.) Capella is still very high, which means that Vega is low in the north and may not be seen at all even though it never actually sets over Britain.

The Great Bear, Ursa Major, is high in the north-east, and Leo, the Lion, has become prominent; to locate Leo it is helpful to use the Pointers in the Great Bear 'the wrong way' (that is to say, away from the Pole Star), Regulus, leader of Leo, is at the foot of a curved line of stars making up the pattern known as the Sickle.

Below Leo the sky appears rather blank; this is the region of Hydra, the Watersnake, whose only bright star, the reddish Alphard, may be found by using the Twins, Castor and Pollux, as direction indicators. Alphard is often nicknamed 'the Solitary One' because of its somewhat isolated position. It is of the second magnitude, but has been suspected of variability.
part of Mercury would be in constant sunlight and another part in constant darkness, with only a narrow 'twilight zone' in between over which the Sun would bob up and down over the horizon.

Antoniadi was wrong on both counts, though he can hardly be blamed. The Mercurian atmosphere is negligible, and the rotation period is only 58.6 days, two-thirds of the planet's 'year'—which means that each time Mercury is best placed for observation from the Earth, the same regions are turned in our direction.

MISSION ACCOMPLISHED

Virtually all our detailed knowledge of Mercury comes from a single space-probe, Mariner 10, which made three active passes of the planet: in March and September 1974 and March 1975. Since Mercury, with a diameter of 3030 miles, is not a great deal larger than the Moon, it was expected that the surface features would be basically of lunar type, and this proved to be correct. There are craters, mountains, valleys, scarps and ridges; some of the craters have central peaks, and some are the centres of systems of bright rays. In fact, the first crater to be identified as Mariner 10 drew in toward Mercury is a ray-centre; it has been named Kuiper, in honour of the late Dutch-American astronomer G. P. Kuiper, who placed such an important role in the early days of planetary probe research.

The most imposing formation is the Caloris Basin, which is a huge ringed structure. Unfortunately we have mapped only part of it. Each time Mariner 10 by-passed Mercury the same regions of the planet were in sunlight, so that a large area remains unknown, though there is no reason to believe that these regions are basically different from those which we have been able to study.

Though the crater distribution on Mercury follows the same laws as on the Moon, with smaller formations breaking into larger ones instead of vice versa, there are no smooth 'seas' comparable with the lunar Mare Imbrium or Mare Serenitatis, and there are inter-crater plains of a type not found on the Moon.

One distinct surprise was that Mercury, unlike Venus, Mars or the Moon, has a detectable magnetic field, with a strength about 1/30 of that of the Earth's field. The field is dipolar, with two equal magnetic poles of opposite polarity aligned with the rotational axis of the planet—which is almost perpendicular to the plane of the orbit.

Moreover, Mercury is about as dense as the Earth, with a specific gravity of 5.5. Probably it has a large iron-rich core, which may in fact be larger than the whole globe of the Moon.

HOSTILE WORLD

Contact with Mariner 10 was finally lost on 24 March 1975, though no doubt the probe is still in solar orbit and still makes regular close approaches to Mercury. No further missions have been announced as yet, though new launchings will probably be made in the foreseeable future.

Obviously Mercury is a very hostile world, and there is no chance of any life there; neither does it seem likely that manned landings will be practicable for a long time. However, it is always worth seeking out this curious, elusive little planet, and March this year provides an excellent opportunity.

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Until recently, printers for computers were large, noisy and expensive pieces of equipment. This picture has changed, however, with the introduction of increasingly powerful small computers in business and the home. The different needs of these new groups of computer users have brought about a re-think in printer design, resulting in desktop printers which meet the needs, and fall within the price range of today's small computer systems. This month's printer survey looks at the wide range of printers currently on the market at around £500 or less. Before we do this, however, we will take a look at some of the basic features of these printers, and suggest some points to consider when choosing a printer.

Who needs a printer

The need for a printer is not something which is immediately obvious when 'The Computer' first arrives in the home. If your computer is to be more than just a passing fancy, however, the pre-packaged games used to get things started will soon give way to an urge to 'have a go' yourself. Copying programs from magazines is usually the first step, but one which soon shows itself to have a few hidden snags. These usually take the form of the almost inevitable typing mistakes; the well-known 'finger trouble' syndrome. Tracking down these bugs can be a nightmare of "is that a '1' or is it a '7'?," particularly if you are restricted to debugging on a shimmering TV screen. However, the problem can be greatly simplified if you are able to put down a printed listing of the program side-by-side with the original.

Next, you will probably move on from published listings to writing your own programs. Here a printer will help you to develop a clear and well-structured programming style, since these are features which will stand out clearly from your listings. By the time you reach this stage, however, you are really hooked, and a terminal case of computeritis is usually diagnosed!

The discussion so far has been restricted to using the resources of the computer itself. However, computers really come into their own when we can set them to work in our everyday lives. One of the best examples in this area is probably word processing, which is arguably the greatest advance since the introduction of the typewriter. With a word processing program running on your computer, you can type letters, correct your mistakes, change your mind as often as you like, and still end up with perfectly presented letters at the end of the day; all assuming of course that you have a printer!

Whatever your reasons for wanting a printer, choosing the right one can be as important as the selection of your computer. The decision to buy a printer can easily involve spending at least as much again as the computer itself (a printer will typically cost between £180 and £450), so it is important to choose one which really is suited to your needs. Choice available is now quite considerable, and the range of facilities offered can be bewildering, so before looking at some of the printers available, we will start by looking at the basic features to be found on today's machines.

A Few Printer Basics

Inside the computer there are essentially two types of information which concern us when we talk about using a printer to produce a permanent copy; we usually think of these two types as characters and graphics. We will start by looking at characters, and will come back to graphics a little later.

Characters are the numbers, letters, and punctuation marks which make up the so-called character set of the computer. They also appear on the display screen and on the keyboard. Internally these characters are usually represented by a set of one-byte ASCII codes. When we want to print a sequence of characters, therefore, the computer simply has to send the corresponding stream of ASCII codes to the printer.

There are two ways to transfer this byte stream from the computer to the printer; serial and parallel. The serial link transfers bytes one bit at a time, and usually conforms to the RS232C standard (or an equivalent). The more popular parallel interface usually conforms to the Centronics standard, and transfers a complete byte at a time. The important thing to bear in mind here is to make sure that the printer port on the computer is compatible with that on the printer!

At the receiving end, the printer decodes each byte as it arrives, and sends the appropriate commands to the printer mechanism to cause the corresponding character to be printed. The actual form of the printed character depends on the 'font' of the printer, and is something which may or may not be variable, depending on the type and model of the printer.

Many printers have a number of built-in fonts which are selectable by the computer, whilst others have a facility to allow the operator to change fonts when required. However, and at any instant, the currently selected font determines the way in which the printer will interpret each ASCII code sent by the computer. In the main these codes correspond to the keyboard and screen symbols, but there are ranges (particularly of the lower-numbered codes) which are usually reserved for commands from the computer to the printer, e.g. new page, change font. These control codes are often referred to as escape sequences because they frequently involve a pre-defined sequence of codes, starting with an 'ESCAPE' code (decimal 27).

So far we have seen how the computer tells the printer which characters it wants printed, and how it controls various features such as the font. We will now go on to look at how the characters themselves are actually printed.

Printer Types

There are quite a number of different types of printing mechanism used today, but the major difference between them is the way in which the individual characters are formed on the paper. The most popular printers for small computers today are undoubtedly the daisywheel and dot matrix types. Printer technology is not static, however, and cheaper, quieter, and more versatile machines are constantly being announced. A particular driving force at present is the quest for low power printers suitable for portable computers. Below we look briefly at the features of today's popular types of printers which fall within our price range.

Daisywheel

The daisywheel printer works in a similar way to an electric typewriter. The font is on a plastic daisywheel with flat spokes (so called because of its similarity in appearance to the petals of a daisy), and the characters are embossed on
Model: Tanda M82A
Print format: Dot Matrix
C.P.S.: Variable
Interface: Serial/Parallel
Paper: Sprocket Feed
Notes: Viewdata graphics
Price: £299+VAT

Model: Geveke C150
Print format: Dot Matrix
C.P.S.: 20
Interface: Parallel
Paper: Friction
Notes: Optional Interface
Price: £1095+VAT
Supplier: Geveke Electronics, Unit 201, Landsbury Est., 102 Lower Guildford Rd., Knaphill, Woking, Surrey (04887 88876).

Model: DW12
Print format: Daisywheel
C.P.S.: 12
Interface: Centronics
Paper: 300mm Friction
Notes: Tractor option
Price: £275+VAT
Supplier: X-Data, 750–751 Deal Ave., The Trading Estate, Slough, Berks (0763 72331).

Model: Paper Tiger, 8010, 8020
Print format: Dot Matrix
C.P.S.: 180
Interface: RS232/Centronics
Paper: 200, 305mm Tractor
Notes: Block graphics
Price: £469, £645+VAT

Model: Tanda PPX Compact
Print format: Thermal
C.P.S.: Variable
Interface: Centronics
Paper: 110mm Thermal
Notes: Viewdata
Price: £171.35 inc. VAT

Practical Electronics - April 1985
the ends of the spokes. The wheel is rotated until the appropriate spoke is aligned with the print hammer. An electromagnetic hammer then strikes the character, which presses it against the ribbon, producing an imprint on the paper. The print head then moves across one character position, ready for the next printing operation. Daisy-wheel printers are capable of the very highest print quality, but are relatively slow and noisy in operation. Changing fonts is a simple matter of changing daisies.

**Dot Matrix**

A dot matrix printer is one which works by placing a pattern (matrix) of dots on the paper to form the characters. This is done by firing a vertical bank of fine wires (usually there are between seven and nine wires, but it can be just one) at the paper through the ribbon. The wires are fired by individual solenoids as the print-head moves across the paper. In this way each character is built up one column at a time, with the print-head moving across the paper one dot position at a time. The dot pattern for each character is usually held in ROM inside the printer; some models include more than one font, selectable by special codes from the computer. In addition, matrix printers usually allow more than one size of any particular font to be printed (again selected by the computer). This is usually done by changing the horizontal spacing and/or repeating each dot column twice, but the basic dot pattern (which defines the font) remains unchanged.

Typical matrix printers use an array of seven-by-nine dots for their standard character fonts, but larger matrix sizes are also available. In general, the larger the number of dots per line of print, the better the appearance of the characters; a typical figure is 480 dots per line. Many dot matrix printers now include a so-called near letter quality (NLQ) font. This usually makes use of columns of dots at a half-dot pitch (whereas most fonts use a whole-dot pitch), and although slower to print, the NLQ fonts do give a much smoother appearance to the printed characters.

Overall, matrix printers are typically 5 to 10 times faster than daisies, wheels, usually offer a good range of print styles, but are noisy and do not offer quite the same print quality as daisy-wheel printers. As we shall see later, many dot matrix printers also offer the possibility of graphics.

**Ink Jet**

Both daisies wheels and dot matrix printers are inherently noisy because they work by physically striking the paper through a ribbon. Ink jet printers, on the other hand, are much quieter because they have no ribbon. Instead, they fire a stream of charged ink droplets at the paper. An electrostatic arrangement then deflects the stream in much the same way as a television tube, and causes the characters to be drawn on the paper.

A recent simplification of the ink jet principle is to do away with the electrostatic deflection, and use a bank of ink nozzles instead. In much the same way as an impact dot matrix print-head, the characters are then made up from a matrix of ink dots. This approach has also been cleverly adapted to allow printing in colour; each jet produces dots of a different colour, with the characters then being built up one row at a time. The result is rather slower than with single-colour printing, and the character fonts tend to be more limited, but colour printers of this type are a very cost-effective way of producing multi-colour hard copy.

**Electro-sensitive**

The electro-sensitive system uses a special paper which is sandwich of aluminium foil, ink and paper. Printing is performed by wires which are in contact with the foils side of this sandwich. When a wire is momentarily raised to a high voltage, a small hole is melted in the foil, exposing the ink below. The result is a black dot on a silvery background. Electro-sensitive printers are not widely used due to their need for special paper, but they are quite common in lower cost, narrow-paper applications.

**Thermal Matrix**

This is another type of printer which requires special paper. It is similar to the impact dot matrix printer discussed above, but instead of striking wires through the ribbon, the printhead burns spots directly on heat-sensitive paper. Thermal printers are very quiet and relatively cheap, but the cost and need for special paper can be a distinct disadvantage.

**Thermal Transfer**

Thermal transfer printers are a relatively new development. A special heat-sensitive ribbon is used with the same sort of print-head as used in the thermal matrix printers. Plain paper is used, however, and spots of dye are transferred from the ribbon to the paper when heated. Thermal printers are quiet in operation, but the ribbons are still rather expensive, and the technology would probably benefit from a chance to mature before they become a real force to be reckoned with.

**PRINTER FEATURES EXPLAINED**

When choosing a printer there are a number of features which we must consider carefully before making a final selection. Inevitably, any choice will involve some form of trade-off between those features which are desirable, those which are essential, and cost.

**Paper Width**

The paper width quoted in the manufacturer’s specification usually relates to the maximum width that can be used in the printer. Some cheaper printers will only operate on a special size of paper (often supplied only in rolls), but most will now accept paper up to about 240 mm wide. This means that standard cut-sheet or narrow fan-fold paper can be used, depending on the type of paper feed fitted (see below), and usually allows up to 80 standard characters to be printed on a line.

**Paper Feed**

There are two main types of paper feed in common use, and most printers support one or both types. Friction-feed relies on the same principle as used in typewriters, where the paper is squeezed between two rollers, one of which is driven by a motor. This type of paper feed allows the use of either cut-sheet or roll paper.

Tractor-feed requires the use of paper which has sprocket holes down its edges; the holes are often on perforated strips which can be removed after printing. The sprockets are fed over toothed (tractor) wheels which are driven by the paper feed motor. The separation between the wheels is adjustable, so different widths of paper can be used.

Pin-feed is a variation of tractor-feed, but with either a small or no range of width adjustment. A number of printers with pin-feed also have an optional tractor-feed accessory. If you need to use narrow paper (or sets of labels), it is important to check whether the range of adjustment is adequate for your requirements.

Tractor-feed printers are suitable for many applications, but they do mean that only sprocketed paper can be used.


Print Styles

The range and ease of use of different print styles depends significantly on the type of printer. Changing styles on a daisywheel printer is a simple matter of changing the wheel, but this is not something which can usually be done in the middle of a print run. Mixing print styles with a daisywheel is therefore not usually possible, unless all of the characters are available on the same wheel.

Dot matrix printers normally have a small number of basic fonts (often only one). However, a variety of printing styles for the font(s) provided is usually possible on all but the most basic models. The change of style, in the same way as any change of font, is caused by a series of control codes sent by the computer. There is, unfortunately, little agreement between different manufacturers on the control code sequences used for this purpose.

Proportional Spacing

Proportional spacing is a facility which is available on some printers. Instead of treating each character as if it is of equal width, a proportional spacing facility takes account of the fact that, say, a 'W' is wider than an 'l'. This means that, instead of the gaps between letters being unequal, as usually produced on a computer display, there is a constant gap between adjacent letters. The result is very pleasing to the eye, and is the same as produced by conventional typesetting; the only problem is that few word processors are sophisticated enough to be able to produce both left and right margins aligned with such a print style!

Ribbons

Mundane maybe, but daisywheel and impact dot matrix printers all require ribbons in order to be able to operate. These are almost invariably now of the easily changed cartridge variety, and contain either a plastic film or an inked ribbon. The film types are common in daisywheel printers, where the highest quality print is to be expected. Inked ribbon still predominates for dot matrix printers, where they have the advantage of being re-usable (unlike the single-use films), and hence longer lasting.

GRAPHICS

As we mentioned earlier, characters are only one of the two types of potentially printable information which can be manipulated by a computer; the other is graphics. We will now look at some of the facilities which are available for producing graphical output on today's printers.

There are basically two types of graphics printing available, and these tend to complement the low-resolution and high-resolution graphics modes on computers. The first, known as a block graphics facility, is usually controlled by ASCII codes in the range decimal 128 to 192. The block graphics facility defines a set of shapes, based on a matrix of two blocks wide and three blocks high, which fill the space defined for a character. Each block within the matrix is either completely filled or empty. By printing a series of such graphics symbols, it is possible to build up a pictorial output, although it can require a significant amount of programming.

Block graphics is often available on daisywheel printers (although it may require a special wheel), and is offered on a number of other printers. Where a higher resolution facility is available, however, the block graphics facility is frequently omitted and the ASCII codes re-allocated for another purpose, e.g. the italic character set. Such printers also often allow the user to programme his own character set (although it must be said that working out the necessary sequence of control codes for the first time can lead to an acute case of mental indigestion!), and if need be, a block graphics facility can then always be added by the user.

The second type of graphics involves the ability to be able to control the positioning of individual dots from the print-head. With such a capability, the programmer is able to produce any dot pattern he desires. With this type of graphics facility, the number of dots per line and the degree of control are critical to the performance. To achieve true screen images of high resolution displays will typically require a minimum of 640 dots per line; more if the ability to produce shaded dumps of multi-colour displays is required. For a true high resolution graphics dump, therefore, a minimum of 640 dots, and desirably 960 dots per line are necessary.

A BUYER'S CHECKLIST

Now that we have looked at the basic features of today's printers, we will conclude this section of our printer guide by suggesting a buyer's checklist. The first step, however, before trying to decide on a printer, is to decide exactly what it is that you want to be able to do with it. Only then are you in a position to start the selection process in earnest. By answering the questions below, you should be able to narrow down your field of choice. Many printers will probably give you more facilities than the minimum that you require, but at least you will have narrowed the field, and cost will then probably also have an effect on your final choice.

Print quality—letter quality, NLQ, or is standard dot matrix quite adequate?

Paper width—wide, standard, or is a non-standard width acceptable?

Paper handling—friction (essential for cut sheet), pin-feed, tractor-feed, or a combination?

Paper—standard or special? If you want to use multi-copy stationery, then either a daisywheel or an impact dot matrix printer is essential.

Graphics—none, block or dot-addressable (matrix only)?

Print styles—more than one font (e.g. italics), number of styles for each font, facility to have user-defined characters, proportional spacing, sub-/super-scripts, underlining?

Interface—serial or parallel?

Speed—the figures quoted in Characters Per Second are always only a guide, but they are useful for comparisons; first ask how important is speed?

Size—will it fit on the bench?

Options/Extras—what is available?

Other—always check that what you expect is provided, e.g. true descenders (tails on g, p, etc.), and bi-directional logic-seeking printing are now usual but are not yet universal features.

EXTRAS

When you have made your choice and set out to buy a printer, it is worth thinking of a few extras which you might add to your shopping list to make life with a printer a little easier, sooner or later.

Interface cable—this is absolutely essential, but not likely to be cheap at around £15.

Paper—easy to forget!

Dust cover—keep the dust out of the moving parts and avoid problems.

Spare ribbons—keep spares; the shop is always shut when you need one.

Stand—allows paper to be kept under the printer, saving precious space.

Software—word processors and screen dumps are easy to use, but difficult to write.

Practical Electronics April 1985
Model: X-Data Microline 82A, 83A
Print format: Dot Matrix
C.P.S.: 120
Interface: Centronics/RS232
Paper: 201mm, 308mm
Friction
Notes: Optional interfaces
Price: £299+VAT, £489+VAT
Supplier: X-Data, 750–751 Deal Ave., The Trading Estate, Slough, Berks (0753 72331).

Model: Geveke L32
Print format: Dot Matrix
C.P.S.: 150
Interface: Centronics compatible
Paper: 381mm
Friction/Tractor
Notes: Adjustable tractor
Price: Not known
Supplier: Geveke Electronics, Unit 201, Landsbury Est., 102 Lower Guildford Rd., Knaphill, Woking, Surrey (0486 78876).

Model: Silver Reed EXP400
Print format: Daisywheel
C.P.S.: 10
Interface: Centronics compatible
Paper: 300mm
Friction
Notes: Tractor option
Price: £275+VAT

Model: Aculab 1200DL
Print format: Daisywheel
C.P.S.: 25
Interface: Centronics/RS232
Paper: 103mm
Friction
Notes: Letter-guide option
Price: £425+VAT
Supplier: Aculab, Unit A, Station Approach, Leighton Buzzard, Beds (0525 371 393).

Model: Riteman Plus
Print format: Dot Matrix
C.P.S.: 120
Interface: Centronics
Paper: 300mm
Friction
Notes: Tractor option
Price: £249+VAT
Supplier: Micro Peripherals, 69 The Street, Basing, Basingstoke, Hants (0256 473232).

Model: Datafax SCP 800
Print format: Colour Pen
C.P.S.: 6–12
Interface: Centronics
Paper: 220mm Pin feed
Notes: 4-colour plotter
Price: £199+VAT
Supplier: Datafax House, Bounty Rd., Basingstoke (0256 64187).
Model: Epson P-40 Print format: Thermal C.P.S.: 45
Interface: Serial/Parallel Paper: 250mm Thermal/Friction
Notes: Bit-image Graphics Price: £95+VAT Supplier: Epson (UK) Ltd., Dorland House, 388 High Rd., Wembley, Middlesex (01-902 8892)


Model: X-Data Microline 92 Print format: Dot Matrix C.P.S.: 180 Interface: Centronics Paper: 240mm Tractor/Friction Notes: Various interfaces and feeds Price: £429+VAT Supplier: X-Data, 750-751 Deal Ave., The Trading Estate, Slough, Berks (0753 72331)

Price:
Epson: £95
Electronic Compact R0: £399
Commodore DPS 1101: £399
Smith-Corona D100: £249
X-Data Microline 92: £429

Supplier:
Epson (UK) Ltd.: Dorland House, 388 High Rd., Wembley, Middlesex (01-902 8892)
Intelligent Interfaces: 436 Wood St., Stratford-upon-Avon, Warwickshire (0789 296879)
Commodore: 1 Hunters Rd., Weldon, Corby, Northampton (0536 205252)
Smith-Corona: Unit 23, Northfield Inc Est., Beresford Ave., Wembley, Middlesex (01-900 1222)
X-Data: 750-751 Deal Ave., The Trading Estate, Slough, Berks (0753 72331)
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<thead>
<tr>
<th>Model</th>
<th>Print format</th>
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<th>Interface</th>
<th>Paper</th>
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<td>Middlesex (01-902 8892).</td>
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<td>Centronics</td>
<td>381mm Tractor</td>
<td>Adjustable tractor</td>
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<td></td>
<td>Notes: Adjustible</td>
<td>Price: £438+VAT</td>
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<td></td>
<td>tractor</td>
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**Model:** PhiPrint  
**Print format:** Thermal Dot  
**C.P.S.:** 20  
**Interface:** Centronics  
**Paper:** 112mm Thermal  
**Notes:** Bit-image graphics  
**Price:** Not known  
**Supplier:** Phi Mag Systems Ltd., Trigoniggle Ind. Est., Falmouth, Cornwall (0326 76060).

**Model:** Smith-Corona L1000  
**Print format:** Daisywheel  
**C.P.S.:** 12  
**Interface:** Centronics/Serial  
**Paper:** 330mm Friction  
**Notes:** Tractor option  
**Price:** £260+VAT  
**Supplier:** Smith-Corona, Unit 23, Northfield Ind. Est., Wembley, Middlesex (01-900 1222).

**Model:** X-Data Microline 84  
**Print format:** Dot Matrix  
**C.P.S.:** 200  
**Interface:** Centronics  
**Paper:** 308mm Friction  
**Notes:** Serial interface option  
**Price:** £489+VAT  
**Supplier:** X-Data, 750–751 Deal Ave., The Trading Estate, Slough, Berks (0753 72331).

**Model:** X-Data DW16  
**Print format:** Daisywheel  
**C.P.S.:** 16  
**Interface:** Parallel/Serial  
**Paper:** 300mm Friction  
**Tractor option:**  
**Notes:**  
**Price:** £329+VAT  
**Supplier:** X-Data, 750–751 Deal Ave., The Trading Estate, Slough, Berks (0753 72331).

**Model:** Taxan KP 910PC  
**Print format:** Dot Matrix  
**C.P.S.:** 140  
**Interface:** Centronics  
**Paper:** 390mm Friction/Tractor  
**Notes:** Various types  
**Price:** £499+VAT  
**Supplier:** Data Efficiency, Finway Rd., Hemel Hempstead, Herts (0442 60155).
INSIDE THE BBC MICRO

What goes on inside the BBC Micro is often a complete mystery to many owners. Indeed, the fear of an invalidated warranty often prevents even the lid being taken off for inspection. On the other hand an engineer has been described as someone whose first action with a new ‘toy’ is to dismantle it. Most owners fall somewhere between these two extremes, although your scribe tends towards the latter extreme. If you venture inside the case, however, the view is of a keyboard, power supply, and a large double-sided printed circuit board, and you may be left little the wiser. The problem here is the traditional one of not being able to discern the wood for the trees. The components may be familiar, if only by repute, but what do they all do?

In simple equipment, the usual approach is to try to work out the design by seeing what everything is connected to, but this seems rather inappropriate in this case. Anyone trying this with anything as complex as a micro is assured of hours of entertainment, but may be left little the wiser if the exercise is undertaken without at least a few hints and pointers.

Fig. 1 shows the overall block schematic for the BBC Micro. We shall be referring back to parts of this complete picture many times in the future when we look at the various interface ports, but for the moment the drawing is presented in its entirety to serve as a reference. Rather than attempt to describe the system configuration in one configuration, we will confine ourselves to looking at any new area as we meet it, month by month. For readers who wish to look further into the design of the micro, there are now many good books available, and we shall be including brief reviews of a selection of useful books in future columns. For the moment our concern is with the user port, so let us look a little closer at what lies behind the port.

THE USER PORT

The hardware in the BBC Micro is memory mapped, which means that the registers in the hardware devices (i.e. in the interface hardware inside the computer) appear as addresses in the main memory. It also means that the registers may be set-up/read-back using ordinary CPU write/execute instructions.

There are in fact 3 pages of addresses which have been reserved for memory mapped hardware operations; a page is 256 bytes of memory, starting at an address which is a multiple of 256. The addresses from &FE00 to &FEFF (page &F) are reserved specially for the system hardware. This page of memory has been given the name ‘SHEILA’, while two other pages (&FC = ‘FRED’ and &FD = ‘JIM’) have been reserved for use with the 1MHz bus. Be assured that these names are not misprints! The 256 addresses within Sheila are allocated as shown in Table 1.

<table>
<thead>
<tr>
<th>Address (Hex)</th>
<th>Description</th>
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<tbody>
<tr>
<td>&amp;FE00-07</td>
<td>Video controller</td>
</tr>
<tr>
<td>&amp;FE08-0F</td>
<td>Serial controller</td>
</tr>
<tr>
<td>&amp;FE10-1F</td>
<td>Serial ULA</td>
</tr>
<tr>
<td>&amp;FE20-2F</td>
<td>Video ULA</td>
</tr>
<tr>
<td>&amp;FE30-3F</td>
<td>Paged ROM selector</td>
</tr>
<tr>
<td>&amp;FE40-4F</td>
<td>System VIA</td>
</tr>
<tr>
<td>&amp;FE60-6F</td>
<td>User VIA</td>
</tr>
<tr>
<td>&amp;FE80-8F</td>
<td>Floppy disc controller</td>
</tr>
<tr>
<td>&amp;FEA0-8F</td>
<td>ECONET controller</td>
</tr>
<tr>
<td>&amp;FEC0-DF</td>
<td>A-to-D converter</td>
</tr>
<tr>
<td>&amp;FEED-FF</td>
<td>Tube interface</td>
</tr>
</tbody>
</table>

Table 1. Sheila addresses

Looking at Fig. 1 and Table 1, we see that the user port is connected to the user VIA (Versatile Interface Adaptor), which is allocated addresses &FE60–&FE7F. This VIA has two sections (A and B) which are used for the printer and user ports, respectively. As shown last month, all of the port B lines (i.e. PB0–PB7 and CB1/2) appear on the user port connector (on even-numbered pins 6–20 and 2/4, respectively). The circuit behind the connector (see p. 503 of the User Guide) shows that there are direct connections from the VIA pins to the user port’s connector.

The 6522 is a 40-pin package which contains the micro, there are now many good books available, and we shall be including brief reviews of a selection of useful books in future columns. For the moment our concern is with an extremely complex device, but its basic features are really quite easy to use for most applications. Let us have a look therefore at some of the VIA’s basic features to see how they can be used.

The 8 lines in the B port can be individually programmed as inputs or outputs using the Data Direction Register (DDRB). When the VIA’s register (as when the BREAK key is pressed, for example) all of the lines are programmed as inputs. Table 2 shows that DDRB is VIA register 2, which appears as address &FE63 (i.e. &FE60 + register number). Setting a bit to a 0 in DDRB configures the corresponding I/O line as an input, while a 1 makes it an output. Thus, for example, writing &F0 to DDRB will set PB7–4 as outputs and PB3–0 as inputs. Each time a new byte is written to DDRB, it overwrites the previous settings.

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<th>Register Number</th>
<th>Designation</th>
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<td>0</td>
<td>ORB/IRB</td>
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<tr>
<td>&amp;FE61</td>
<td>1</td>
<td>ORA/IRA</td>
</tr>
<tr>
<td>&amp;FE62</td>
<td>2</td>
<td>DDRB</td>
</tr>
<tr>
<td>&amp;FE63</td>
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<td>DDRA</td>
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<td>&amp;FE65</td>
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<td>TIC-H</td>
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<td>7</td>
<td>TIL-H</td>
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<td>T2C-L</td>
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<td>&amp;FE69</td>
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<td>&amp;FE6A</td>
<td>10</td>
<td>SR</td>
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<tr>
<td>&amp;FE6B</td>
<td>11</td>
<td>ACR</td>
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<tr>
<td>&amp;FE6C</td>
<td>12</td>
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<tr>
<td>&amp;FE6D</td>
<td>13</td>
<td>IFR</td>
</tr>
<tr>
<td>&amp;FE7E</td>
<td>14</td>
<td>IER</td>
</tr>
<tr>
<td>&amp;FE7F</td>
<td>15</td>
<td>ORA/IRA</td>
</tr>
</tbody>
</table>

Table 2. User VIA Registers

The data lines which have been configured as outputs may be set high or low by writing 1 or 0, respectively, to the output/input register ORB/IRB at address &FE60. Writing a value to a line configured as an input will have no effect. Sensing the state of a line configured as an input is accomplished by reading from &FE60. So much for how to control the PB0–PB7 data lines, but how can we use them as outputs to drive real loads?

8-LINE DRIVER

The I/O lines on the B port are capable of sourcing up to 1mA at 1.5 volts in output mode, while in the low state they can sink up to one standard TTL load of 1–6mA at 0.4 volts. This is not enough to drive the majority of ‘real-life’ loads, but it does allow the
PB0-PB7 to drive Darlington transistor circuits directly. A Darlington driver then allows loads requiring much heavier currents to be switched on and off, and provides a useful safety barrier between the loads and the VIA.

Fig. 2 shows a high current Darlington output driver arrangement. An octal driver of this type is shown in Fig. 3 connected to eight I.E.D.s, which are acting as loads and indicate the state of the output lines. The driver i.c. comes in an 18-pin package, and is type UL-N2803A, available from 'RS Components' as part number 303-422. In this arrangement a logic 1 at the input of a driver will illuminate the corresponding diode. Each of the eight drivers is an open collector stage which has a maximum operating voltage of 50V, and will sink up to 500mA. The stages all incorporate diodes to protect them when switching inductive loads, and more than one stage may be paralleled to increase the output sink current.

In a practical application, the I.E.D.s can be replaced by relay coils, lamps, or another type of load. The I.E.D.s are shown connected between the driver output and the +5V supply, but any other supply (up to the maximum) can be used, as shown in Fig. 2.

The prototype 8-line driver unit was built on a small piece of veroboard. A piece of 20-way ribbon cable with a 20-way IDC socket at the computer end (RS 469-881, 467-289, or equivalent) was used for the connection between the computer and the unit. Pin 1 at the computer's connector is indicated by a small triangular symbol on the case. At the board end in the prototype a second IDC socket/plug pair was used, but the wires may just as easily be soldered directly to the vero tracks. The exact constructional details are not critical, and will depend very much on the load arrangement you wish to drive.

The adjacent listing is a simple test program which sets up the user port, and then causes the eight I.E.D.s to count continuously in binary from 0 to 255. Exit from the program by pressing ESCAPE. As we shall see next,

```
10 REM User Port Test
20 REM ***************
30 REM
40 REM Produces a
50 REM binary count
60 REM on PB0->PB7.
70 REM
80 REM Initialise to
90 REM all O/Ps and
100 REM reset time.
110 REM
120 REM P produces a
130 REM I.nitise to
140 REM Count=TIME DIV 100
150 REM P produces a
160 REM Count=TIME DIV 100
170 REM UNTIL FALSE
180 REM
```

Listing for Test Program

Fig. 1. System block diagram
month, this type of direct programming of the hardware is not the only way to control the system's hardware (and is certainly not the recommended method for compatibility with 2nd processors, etc.), but it is a simple and effective demonstration (after all this is not a software column!). A reminder in passing is that, at start-up, PBO-7 are configured as inputs, and the driver behaves as if these are outputs set to logic 1, so beware that the loads will all be on! The driver described next month will overcome this problem.

FINALLY

It is now over to you to develop some practical applications for this unit. Your scribe's test project involved some flashing lights for the festive season, but the range of applications for this simple interface is enormous.

NEXT MONTH

We have looked at how to connect the computer to the outside world. Next month we look at a more sophisticated interface, and then move on to connecting inputs to the micro.

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MAY 1985 ISSUE ON SALE THURSDAY, APRIL 4
BLACK WATCH ON WHEELS?

What surprises me about the Sinclair car, or more accurately pedal-powered side-car with battery on board, is how no-one seems to have done the obvious and simple sums. It brings to mind one of Sir Clive Sinclair’s past disasters, the ‘Black Watch’. People who bought construction kits found the component parts too large to fit into the housing.

No launch in history can ever have been so widely leaked as the Sinclair vehicle. But even after the launch, at which a very nervous Sir Clive corrected the press, people were still tempted to say that the drive motor is a modified Hoover washing machine motor. It is not. It is a 12 V d.c. brush motor made by Polymotor, an Italian subsidiary of Philips. This motor uses ceramic permanent magnets, a 2-pole commutator and a pair of brushes.

To comply with the Government 1983 regulations for electrically or assisted cycles, which allow untaxed, uninsured, untrained, unbelted, unhelmested, 14 years olds or disqualified drivers to drive and park with impunity, the onboard motor must have a maximum power consumption of 250 watts.

The Polymotor drive has a maximum free running speed of 4100 rpm; the 250W rating is for continuous running at 3300rpm. This is geared down to two stages (epicyclic and belt) by a ratio of 13:1. Obviously this is necessary to increase torque.

The front brake is a bicycle calliper and the rear brake is a drum. There is no attempt at recharging the battery with regenerative braking. So all inertial energy is lost as heat when the brakes are applied.

For no-load 250W running, the motor is drawing just over 20 amps from a 12 volt battery. When the motor starts to work, for instance over grassy ground or up a slight incline, the current drain increases to 80 or 90 amps.

When the motor is labouring, it gets slower and slower with increasing torque until there is maximum torque at stall speed. At this point 140 amps are running through the windings.

Obviously this would very soon burn out the motor and drain the battery, probably buckling the plates. So the Sinclair vehicle has a series which integrates current and time whenever the battery is connected.

At stand still with 140A drain, this circuit trips a relay after around 4 seconds. At 80 or 90A consumption it trips in two or three minutes. At high running, with minimal load, there is no need for tripping. Warning lights tell the driver to “get pedalling” as an early warning before switching the relay.

Because the vehicle body and component parts are moulded from plastics, which will melt and might even burn if there is serious overheating, there are two back up systems for the control chip. The first back up is a temperature sensitive thermistor mounted in a probe inside the motor housing. The second back-up is a primitive bimetallic strip on the housing.

PEDAL POWER

The battery is a 35 amphere hour lead acid unit. This is around the size of a car battery. The press and media have talked about 20 or 24 miles per charge. Sinclair’s own publicity material puts the range for a single battery charge at “up to 20 miles” and promises “one thousand miles running for the average price of a gallon of petrol”.

Although strictly true these claims are very misleading and are bound to be mis-reported by the popular media. There is no way in the world that a 35 amphere battery can run the vehicle over average terrain for 20 miles on a single charge, unless the driver is doing most of the work with ‘pedals’. Without pedalling, and with starts, stops and stops without regenerative braking, the vehicle will be lucky to get more than a few miles.

Sinclair might just as well have claimed 200 or 2000 miles per charge, for all the sense the 20 mile claim makes. With almost 100 per cent pedalling, the battery could stay charged for hundreds of miles.

Is this a joke? Some of ours someone told me at the press conference. Someone else had a wonderful idea. Summer holiday camps should buy a fleet of these vehicles, keep them permanently on charge and let campers drive them round the safe private roads and pathways, like dodgem funfair cars.

A nice idea, but by no means what Sir Clive Sinclair has in mind. He says he stands to lose around £7 or £8 million of his own money. Personally I should think that loss is a guaranteed certainty.

VIDEO CHANGE

Watch out for a major change in policy from Philips over LaserVision. The company is now going to stop trying to flog a dead horse and sell its videodisc system as a dumb carrier for feature films.

If videodisc had come on the market before video tape, everyone would have raved about the clear pictures, clean sound and convenience of use. They would have bought a videodisc player first and then bought a video tape recorder when they later became available.

But because videodisc came late on the market there was already a large park of video recorders in people’s homes. Libraries by then were renting feature films on pre-recorded video tape. Not surprisingly only a very few people were prepared to buy videodisc instead of, or as well as, video tape.

Foolishly RCA and Hitachi tried launching their technically primitive, grooved capacitance disc system, CED. Predictably it failed commercially.

Widely Thorn EMi decided to launch JVC’s VHD groovless capacitance disc system on the domestic market. Instead Thorn invested money in producing interactive programmes, so that industry and education could use VHD players under computer control with interactive programmes. But still Philips spent a fortune trying to persuade the public to watch films on optical videodisc.

In 1984 Philips cut player prices to less than half the original 1982 launch price of £500. Because film companies didn’t think it was worth issuing and distributing programmes on videodisc for the few people buying players, Philips cooked up a convoluted subsidy system.

The film company pays Philips’ disc pressing plant in Blackburn to press discs. Philips then buys the discs from the film company and tries to sell them to the public through trade dealers. In return for making programmes available, the film companies get guaranteed payment, and Philips shoulders the burden of selling the unsaleable mountains of discs.

In July 1984 Philips claimed that LaserVision sales were “double those for the corresponding period for 1983 and that disc purchases had “greatly increased”. But the company would not say double what or quantify the great increase.

Now the Philips headquarters in Eindhoven has taken a hand. It has sold a large quantity of players to China, which uses the same PAL TV system as Britain, and has cancelled a domestic launch in France.

Philips subsidiaries in Britain, Germany, Holland, Austria and Switzerland, where LaserVision is already on sale, have been told that they must adopt a completely new strategy. Instead of pushing the system for feature films, they must spend money on developing its potential for interactive video, and at the same time try to sell to specialist markets. This is exactly what Thorn EMi has been doing all along.

Philips in Britain has struck a deal with the BBC, whereby Philips puts up £0-5 million to help the BBC produce a modern version of the Doomsday Book on videodisc. Philips has also mailed out 90,000 direct advertisements to opera and ballet lovers, using the subscription lists from Covent Garden, Glyndebourne and the National Opera, offering them performances on disc at around £20 a time.

Now Philips is looking at other specialist groups, like fishermens, naturalists, sports enthusiasts and car buffs. Although Philips says bravely that some feature films will still be issued, it’s clear that this market is being phased out.

The specialist play could well work. The only puzzle is why Philips spent so long and so much money flogging what was so obviously the dead horse of feature film release.

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Practical Electronics April 1985
"Rugby" Controlled Clock

THE National Physical Laboratory at Teddington in Middlesex contains one of the master time standards that exist around the world, others being in Germany, Canada, U.S.A., etc. These are maintained and referenced to each other so that all precision timings can be related to a known constant. The actual definition of the SI unit of time, the second, was decided in 1967 at the 13th General Conference of Weights and Measures as: "the duration of 9,192,631,770 periods of the radiation corresponding to the transition between the two hyperfine levels of the ground state of the Caesium 133 atom"... out goes Big Ben!!

The 1Hz signal derived from the standard is transmitted as a radio signal from Rugby, and is coded by interrupting the carrier wave with 100 or 200ms breaks to indicate a binary 0 or 1, the binary code containing information about the time, date, year, etc. The code is transmitted during each cycle of 1 minute, and becomes correct at the following 60th or 0 second, when the same information is sent again as a fast code on second 0. Originally, only the fast code was sent, with carrier interruptions only marking the start of each second, but the introduction of the slow code has enabled decoders to be designed with relative ease.

The time transmitted is UK CIVIL TIME, i.e. changing automatically for GMT and BST, and each minute contains the following information: minute, hour, day, date, month, year. In addition, data about GMT/BST indication, parity checks, etc., are sent by continuing some carrier breaks for an extra 100ms and seconds 1-16 transmit data about Universal time as obtained from the Caesium standard, and the time obtained from the earth's rotation.

Because the earth's rotation is not exactly uniform, the time obtained by these two forms of measurement varies, and the difference is transmitted as double carrier breaks, the number of seconds affected being multiples of 0-1 secs. In difference. Double breaks of seconds 1 and following show a positive difference... i.e., earth's rotational time is ahead of Universal time, and double breaks from seconds 9 and following show a negative difference. When either exceeds 0-8 secs, a 'leap' second is inserted or deleted at the 16th second during June or December. This happens every few years and readers may remember such an occurrence a short time ago. At the time of writing, the earth's rotational count is 0-1 sec. ahead of Universal time, indicated by one double break at the 1st sec. If the Rugby transmitter requires maintenance, this is scheduled for a few hours on the first Tuesday of the month.

This project will show how you can decode the time pips to produce a digital display of the date, hours, minutes and seconds. Further options will show how you can obtain the day information as well. It has been deliberately kept quite simple; consequently it will not be able to tell valid from invalid data, e.g., caused by radio interference, and it will obviously not display the correct time when 'Rugby' is off the air for maintenance. However, it will always reset itself as soon as it has received correct data. Green and yellow 7-segment displays have been used, and with a 'G' range Vero case, the result is a very smart and accurate clock that will baffle people because it has no setting buttons!

CIRCUIT DESCRIPTION

The circuit (Fig. 1) for this receiver was designed by John Robinson, to whom many thanks are extended for permission to publish it here. It should be stated at the outset that if readers have not had any experience of building an RF project, they might find some of the construction details a little awkward. For this reason the decoder has been designed to accept a receiver kit that can be purchased from 'Cirikit' and built without special test equipment.

This design is not difficult to build and align if an oscilloscope is available. L1, C1 and C3 form a resonant circuit, tuned by C3 to 60kHz, the frequency of the Rugby transmission. Pin 11 and 10 of IC1a are joined together and, being an inverter gate, the only stable state it can maintain is exactly ½ supply voltage. Thus it acts as a very stiff bias source for pin 9 of IC1d, L1 providing the d.c. path. This causes IC1d to perform within its linear region, acting as an
Fig. 1. Circuit diagram of the Receiver

Fig. 2. Circuit diagram of the Decoder
amplifier for the received signal. The signal is further amplified by two transistors contained within the 3046 before being fed to the emitters of the long-tailed pair of transistors, one of which has L2 as its collector load, tuned to 60 kHz by a ferrite core.

The signal then goes to IC1c, again biased into its linear region by IC1b, where it is amplified before being fed into the emitter-follower TR1, acting as a buffer. Feedback is provided by R3, D1 and C6 for stability, and the signal goes into TR2. VR1 acts as a gain control, and D2 cuts off the negative peaks. The Rugby pulses consist of breaks in the otherwise very pure carrier wave, and so during these breaks

**COMPONENTS ...**

**DECODER BOARD**

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<th>Resistors</th>
<th>Capacitors</th>
<th>Semiconductors</th>
<th>Miscellaneous</th>
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<tbody>
<tr>
<td>R1 560k</td>
<td>C1, C2 1μ tan (2 off)</td>
<td>IC1 4001</td>
<td>AEG/Telefunken yellow displays D353 (4 off)</td>
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<td>R2 220k</td>
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<td>IC2 4093</td>
<td>AEG/Telefunken green displays D352 (4 off)</td>
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<td>R3–R59 150 (57 off) or 8 off d.i.l. resistor packs (RS 140–322)</td>
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<td>Vero case G-range 3G</td>
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<td>IC14, IC15 4026 (2 off)</td>
<td>3.5mm stereo jack plug and socket</td>
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<td>20mm fuseholder and fuse (250mA)</td>
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<td><strong>POWER SUPPLY</strong></td>
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<td>C3 5–60p trimmer</td>
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**RECEIVER**

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<td>IC1 4015</td>
<td>P.c.b.</td>
</tr>
<tr>
<td>R3 1k</td>
<td>C10, C11, C12</td>
<td>IC2, IC3, IC4, IC5 4015 (4 off)</td>
<td><strong>YEAR AND MONTH OPTION</strong></td>
</tr>
<tr>
<td>R4 39k</td>
<td>C14, C15 100n min, ceramic (9 off)</td>
<td><strong>Constructors's Note</strong></td>
<td></td>
</tr>
<tr>
<td>R7 27k</td>
<td>C3 5–60p trimmer</td>
<td>The Rugby receiver and Toko coil is available from Cirkit, Park Lane, Broxbourne, Herts. Receiver stock no. 40-06002.</td>
<td></td>
</tr>
<tr>
<td>R8 330k</td>
<td>C4 100p ceramic</td>
<td>The displays are available from AEG/Telefunken, 217 Bath Road, Slough, Berkshire.</td>
<td></td>
</tr>
<tr>
<td>VR1 100k min. 3mm preset (Cirkit)</td>
<td>C5 3n ceramic</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>C6 47μ tan</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>C13 10μ tan</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Fig. 3. The ‘Rugby’ pulse waveforms**

---

*Practical Electronics April 1985*
TR2 will have nothing to amplify; consequently its collector will be pulled high by R6, taking with it pin 1 of IC1a. This gate, along with IC1f, is arranged as a Schmitt trigger to ensure a clean, fast rise and fall time to the final pulse train which then goes to the decoder board. When the carrier resumes, after either 100ms or 200ms, TR2 conducts, pulling pins 1 and 12 of IC1 down to 0V (Fig. 3).

**DECODER**

The circuit diagram of the Decoder is shown in Fig. 2. The reason for so many i.c.s is to avoid multiplexing the data into the display drivers. This can produce so much noise with the digits constantly switching, causing sudden current-dumping, that the 'Rugby' signal would be swamped by the noise.

The pulses coming from the receiver enter pin 13 of the first monostable formed by IC1c and d. This acts as a latch to prevent the circuit being triggered twice (by the double pulses), by lasting for approx. 600–700ms. Its output changes state at the same time as the trigger pulse, and fires another monostable, IC1a and b, which, after approx. 150ms, via IC2d, clocks the shift register formed by IC4 to 7. Note that a Schmitt trigger is specified for IC2d to ensure that the rise time is fast enough.

![Internal view of the Decoder](Image)

Fig. 4. Data level at pin 13 IC1

It will be seen from Fig. 4 that the data level sampled at pin 13 of IC1 (pin 15, IC4), 150ms after triggering will be the required '0' or '1'. On each subsequent clock-pulse, this serial data stream shifts through the eight outputs of each of the four registers cascaded together. Thus IC4 to 7 act almost as a serial to parallel converter because, on the 59th sec., the 32 output pins will be displaying the state dictated by the last 32 secs. of 'Rugby' pulses.

The six '1's from the framing pattern will form six of the outputs of IC4, and these are connected to seven of the inputs of a 4068 NAND gate. The 8th and final NAND input comes from the rising edge of the 60th sec. data pulse (taken from the 150ms monostable to avoid double-loading of data caused by the double pulses), at which point the output of the 4068 goes low, latching the data from the register outputs into the display drivers, providing the date, hours and minutes display.

**SECONDS DISPLAY**

The seconds display is produced by using the data pulses from the 150ms monostable to clock two cascaded BCD counters with built-in 7-segment decoders and display drivers. The '60th sec.' pulse from the 4068 is inverted and used to reset the counters so that they constantly re-cycle through 0–59. All the display drivers require current-limiting resistors and readers can either use separate resistors (150 ohms), which is the cheaper alternative, or, as in the prototype, d.i.l. resistor packs which are more expensive but much quicker to install, and give a neater finish. The decimal point of one of the displays is activated to mark the separation of the hours from the minutes.

**POWER SUPPLY**

The power supply (Fig. 5), being a standard transformer, bridge rectifier and regulator circuit needs little comment, but it is mounted on its own p.c.b. for safety reasons.

![Circuit diagram of the p.s.u.](Image)

Fig. 5. Circuit diagram of the p.s.u.
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Thor EM1’s share being worth some £1.5 million.

It is the first major co-development programme under a Memorandum of Understanding between the four nations. The two-way street across the Atlantic which has been virtually one-way for many years could now start to have real substance.

Social Responsibility

Ferranti is actively recruiting engineers for the sonar contract and, in fact, most defence equipment contractors are constantly searching for new talent. But in the background is a debate that has been running for a number of years. Should an engineer use his talent for potentially destructive activities or, on principle, undertake only constructive or humanitarian work?

A number of the early atomic scientists, shocked at the monster bomb they created, pulled out. An extreme case, perhaps, but illustrating the point. It is estimated that 40 per cent of the world’s scientists and engineers are engaged in one form or another on designing and building military equipment. So clearly very large numbers are prepared tolerate if not actually relish such employment.

Social responsibility is very much a matter of personal conscience. The IEE lays down rules of conduct for professional engineers. A member’s work should constitute as unavoidable danger of death or injury or illness, to himself or to anyone.

A member must also take all reasonable steps not to waste natural resources, and not to damage the environment. But lawful work in connection with equipment intended for the defence of a nation is not considered an infringement of the guidelines although it obviously, if the equipment is used in anger, kills people, wastes natural resources and damages the environment.

If one works in a munitions factory the choice is clear-cut. One helps make shells, bullets and bombs or, if a pacifist in the true sense, one finds more congenial employment elsewhere.

For the scientist and engineer the position is ambiguous. The laser scientist is interested in lasers. They have many beneficial applications in fields as diverse as surveying and eye surgery. But also as military target markers and rangefinders, not to mention potential use in the US Strategic Defence Initiative, popularly described as ‘Star Wars’, although in this case they would be purely protective against incoming missiles and thus arguably humanitarian.

The communications engineer is in equal difficulty. His military radios may be ordered to order a salvo to be fired, aiding destruction. Or to call up an ambulance to save a life. Even civil broadcasting is used by many countries to poison the mind (evil) as well as to educate and entertain (good).

Sonar and radar have both peaceful and aggressive applications and the same may be said of any engineering discipline or any type of product. Even the humble toilet roll gives aid and comfort to those engaged in military operations just as much as to those in the home.

It is worth remembering that the armed services have beneficial use in other than military operations. Hundreds of lives are saved annually by air-sea and mountain rescue military helicopters. Armies throughout the world are employed in natural disasters, building temporary bridges, providing transport and other relief facilities. Naval craft are often first on the scene of a shipwreck.

It is right that social responsibility should be a subject of discussion among engineers, always bearing in mind that even good intentions can have evil consequences. It could be argued from a moral stand-point that the whole of Britain’s defence industry should be closed down and the armed forces disbanded. But the resultant unemployment and economic disturbance would be disastrous for thousands of families immediately and for the whole nation in the event of attempted subjugation by a foreign power.

Cellular War

No moral dilemma was involved in RAC’s decision to sponsor Grand Prix yachting as part of the publicity campaign for Vodafone. The £45ft craft with its 12-man crew is to compete under the name of Vodafone Venture ‘85 and is expected to provide a strong challenge in the classic Admirals Cup as well as other races during the working-up period.

RAC won the race to get Vodafone cellular radio into service a few days before rival Cellnet. No doubt Cellnet will be responding with some publicity ideas of like nature.

With so many new names around it is good to see that cellular radio has brought back a real old timer, Marconiphone. This brand name was popular in the 1930s on domestic radio receivers made in the Hayes factory of EMI alongside the HMV models. Both had the same chassis internally, the difference being in cabinet styling when a radio was a piece of furniture as well as a source of entertainment.

Marconi, the original owners I suspect, must have reacquired the brand name because it now appears as Marconiphone cellular products in a range of telephones for the cellular market.

How commentators successful the new service will be is anyone’s guess at the moment. The other much-heralded innovation, the cabling of Britain, is proceeding more slowly than anticipated with no overnight fortunes being made. Cellular radio has the advantage of being directed, initially at least, to the professional person where the cost benefit equation is fairly easy to work out. Also to the well-heeled such as fellow competitors to Vodafone Venture ‘85. I recall yacht-racing once described as equivalent to standing fully clothed under a cold shower tearing up £5 notes. Cellular radio costs peanuts in comparison.
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MY WELL-THUMB ED copy of Collins English Dictionary which, I may have mentioned before, doubles as a doortop, defines the word 'materialism' as 'interest in and desire for money and possessions rather than spiritual or ethical values'.

This is why I hesitated at first to label an old friend of mine, Dr. Max Smollett, a materialist. Nevertheless, that's what he is alright. But in quite another and much more complimentary sense of the moniker.

Dr. Smollett heads a tight-knit 45-strong team of which 25–30 are qualified scientists and engineers, which forms the Central Materials Laboratory of the Philips organisation in the UK. In these modest numbers the Laboratory serves in many vital ways the 20-odd establishments that make up the manufacturing side of the group.

But let Max take up the story which puts into perspective the key role that materials research has played and is still playing in the forward march of electronic technology.

"We're organised into a number of groups," he said. "One of the most important in this safety-conscious age deals with hazardous materials and environmental hygiene. Here we're intimately concerned with the proper protection of the company's employees.

"Our hazardous materials adviser assists local plant managements on all aspects of the measurement and control of potentially dangerous situations arising from the use of various chemical products. He also works closely with the company's medical advisers and sites are visited regularly to inspect and advise on current procedures. Backing this activity we have an environmental hygiene co-ordinator whose field covers the legal situation, modification of production processes to reduce the quantity of materials discharged, the design of effluent disposal and treatment processes, air filtration, the storage of hazardous materials on site, water treatment, soil pollution and so on.

"Our development group works on what I'd call non-standard projects".

"The analysis and measurement of various materials used in the manufacture of Philips products is another of our responsibilities. We also undertake short-run pilot production of components and devices on an experimental basis. Particularly we concentrate on metals, chemicals, PCBs and ceramic boards."

"Our development group works on what I'd call non-standard projects. In other words, those which do not fall easily into any other category. This group's job is to exploit new technologies in order to provide devices either for selling in the market place or for use in our plants. And all along the line we are adding to our knowledge and experience of new materials as they come into use.

"A wide range of services is provided by the metallurgical section. They include the manufacture of trial quantities of experimental alloys, the production of microsections for examination and interpretation, microhardness testing and the metallurgical suitability of components and materials and quality checks in terms of mechanical properties and dimensions.

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PRACTICAL ELECTRONICS

April 1985

55
LAST month we looked at an i.c. which could monitor four voltage levels simultaneously in a very sophisticated way. This month we stay on the theme of voltage monitoring and look at a couple of fairly simple yet extremely useful programmable voltage detectors made by Intersil.

The ICL8211 and ICL8212 (the 'CPA' suffix simply refers to their temperature range and package type) are very low power bipolar i.c.s intended for precise voltage detection or generation. Each device contains an accurate voltage reference, a comparator, and a pair of output buffers/drivers. Fig. 1 shows the pinout for both i.c.s, and Fig. 2 their specifications.

BASIC OPERATION

The internal voltage reference for both i.c.s is nominally 5.5V. The voltage which is fed to the threshold input (pin 3) by the external circuitry is compared with this internal reference voltage. In the case of the 8211, when the threshold input voltage drops below the reference, the output turns on. The 8212 operates in the inverse mode; when the threshold input voltage rises above the reference, its output turns on.

The output for both i.c.s is an open collector npn transistor, with its emitter connected to 0 volt. Hence, when the output turns on, current will be sunk from the load into pin 4. The output of the 8211 is current limited to typically 7mA, which makes it suitable both for general use and for directly driving an indicator i.e. without the need for a series resistor. The output of the 8212 has no current limit, so care must be taken to avoid exceeding the 30mA maximum current shown in the specification. (An upper limit of 25mA is recommended in practice.) In both cases the load should be connected between a positive supply rail (not necessarily the i.c.'s own supply: the load supply should not exceed ±30 volts, however) and pin 4.

TYPICAL USE OF THE I.C.s

Fig. 3 shows a typical application of the 8211. (Assume that R3 is omitted for the moment.) A potential divider, R1 and R2, across the supply rails feeds a voltage to the threshold input of the i.c. If this voltage drops below 1.15V the output of the i.c. turns on, sinking typically 7mA from the 'low voltage' warning i.e. into pin 4. The values of R1 and R2 are chosen to scale the voltage at pin 3 such that the i.c. output turns on at the required supply voltage. The i.c. itself can work over a range of 2.2 to 30V, allowing considerable flexibility in the range of voltages which can be monitored. The values of R1 and R2 are determined by:

\[
\text{Supply voltage to cause i.c. to 'trip' } = \frac{1.15(R1 + R2)}{R1}
\]

The current which is allowed to flow down the resistor chain could be as high as 50µA. On the other hand, an obvious application of the i.c. is in monitoring battery voltage, where high current consumption is undesirable. Both i.c.s are optimised for low quiescent current consumption in their 'output turned off' state (22µA for the 8211 and 20µA for the 8212) to minimise their effect on battery life. Hence, a very low resistor chain current is to be aimed for when designing within battery powered systems. The practical minimum is 6µA, since currents below this become comparable with the input current at pin 3 of the i.c., and inaccuracies can result. In conjunction with the equation shown above for the 'trip' voltage, we can therefore add the current determining equation:

\[
\text{Resistor chain current } = \text{supply voltage} (\text{i.e. } 0.000006\text{A up to } 0.000050\text{A})
\]

HYSTERESIS

Both i.c.s have a low current switched output, the 'hysteresis' output, connected to pin 2. This is an open collector npn transistor with its emitter connected to the positive supply rail, and is switched on (causing pin 2 to be pulled up to near the positive supply) for input voltages to pin 3 in excess of the nominal 1.15V. It can be used with simple feedback arrangements (for example, R3 in Fig. 3) to provide some positive feedback, or hysteresis, around the i.c. The hysteresis ensures that once the i.c. output has turned on, the input voltage has to change by a considerable amount before the i.c. will turn off again. This is very useful in stopping oscillation or 'hunting' around the threshold point. In the case of the 8212 without hysteresis, for example, the i.c. turns on as soon as the threshold input exceeds 1.15V. This causes the output to be turned on, sinking current from the load, which as a result might cause the supply voltage to drop slightly, turning off the i.c. again ... etc, etc! Hysteresis establishes a 'dead band', helping to prevent or reduce this oscillatory effect.

There are several ways of introducing hysteresis into the system, the two most common ones being shown in Fig. 4. The circuit of Fig. 4a requires that all of the current flowing in the resistor network should be able to be sourced by the hysteresis output, which is capable of supplying 15µA according to the specifications. For the circuit of Fig. 4b, the current to be sourced by the hysteresis output will be defined by the values of the two trip voltages. For low values of hysteresis, circuit (b) is to be preferred. The equations shown define the low and high trip voltages; the low trip voltage is the voltage at which the i.c. output changes state when the supply voltage is decreasing, and the high trip voltage is the voltage at which the output changes when the supply is increasing. If used for other purposes in the circuitry (other that simply switching the threshold resistor network as shown in Fig. 4), it is recommended that the hysteresis output current should be limited to 10µA.

USING THE I.C.s

Although any voltage between -5V and the positive supply rail may be applied to the threshold input (pin 3), it is advisable to limit it to below +6V, since above that voltage the input current increases dramatically. Prolonged operation above this voltage can cause a decrease in performance of the i.c. When resistive dividers are used to feed the threshold input, the monitored voltage can be higher than the i.c.'s own supply voltage, as long as the voltage at pin 3 (and pin 2 if appropriate) is kept below the i.c. positive supply, and preferably below +6V as explained above.

If the output is to be used to feed into logic circuitry, a pull-up resistor must be provided...
### Applications

There are many applications of the ICL8211CPA and ICL8212CPA which are

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Notes</th>
<th>ICL8211CPA</th>
<th>ICL8212CPA</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Supply Voltage</strong></td>
<td>0 to +70°C (Spec’s are measured at +5V unless otherwise stated)</td>
<td>Minimum 2.2 Typically 30</td>
<td>Minimum 2.2 Typically 30</td>
</tr>
<tr>
<td><strong>Quiescent current</strong></td>
<td>Voltage at Pin 3 (V+) = 1.3V</td>
<td>Maximum 10 22 40</td>
<td>Maximum 50 110 250</td>
</tr>
<tr>
<td><strong>Temperature range</strong></td>
<td>Voltage at pin 3 (V-) = -0.9V</td>
<td>Maximum 50 140 250</td>
<td>Maximum 10 20 40</td>
</tr>
<tr>
<td></td>
<td>Spec’s are measured at +25°C unless otherwise stated</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Output current, max</strong></td>
<td>Sunk into pin 4 (or out of any pin), absolute maximum</td>
<td>Maximum 4 7 12</td>
<td>Maximum 15 30</td>
</tr>
<tr>
<td><strong>Output voltage</strong></td>
<td>At pin 4</td>
<td>Maximum -0.5 +30</td>
<td>Maximum -0.5 +30</td>
</tr>
<tr>
<td></td>
<td>For supply voltages of 2.2 to 25V</td>
<td>Maximum 5 (+ve) supply</td>
<td>Maximum (+ve) supply</td>
</tr>
<tr>
<td></td>
<td>For supply voltages of 25 to 30V</td>
<td>(-30) (+ve) supply</td>
<td>(+ve) supply</td>
</tr>
<tr>
<td><strong>Hysteresis voltage</strong></td>
<td>i.e. voltage at pin 2</td>
<td>Maximum (+ve) supply (+0.5)</td>
<td>Maximum (+ve) supply (+0.5)</td>
</tr>
<tr>
<td></td>
<td>Variation in threshold voltage for +10% supply change</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Output saturation voltage</strong></td>
<td>Voltage at pin 3 = 1.15V</td>
<td>Maximum 100 250</td>
<td>Maximum 100 250</td>
</tr>
<tr>
<td></td>
<td>Voltage at pin 3 = 1.00V</td>
<td>Maximum 5</td>
<td>Maximum 5</td>
</tr>
<tr>
<td><strong>Maximum Hysteresis current</strong></td>
<td>i.e. Available from pin 2 (voltage at pin 3 = 1.3V)</td>
<td>Maximum 15 21</td>
<td>Maximum 15 21</td>
</tr>
<tr>
<td><strong>Hysteresis saturation voltage</strong></td>
<td>7µA flowing from pin 2 (voltage at pin 3 = 1.3V)</td>
<td>+ve supply supply (+ve) supply</td>
<td>+ve supply supply (+ve) supply</td>
</tr>
<tr>
<td><strong>Hysteresis leakage current</strong></td>
<td>+ve supply = +10V, pin 2 = 0V, pin 3 = 1.0V</td>
<td>-0.2 -0.1</td>
<td>-0.2 -0.1</td>
</tr>
<tr>
<td><strong>Output saturation voltage</strong></td>
<td>Pin 4, output current = 4mA</td>
<td>Maximum 0.17 0.4</td>
<td>Maximum 0.17 0.4</td>
</tr>
<tr>
<td><strong>Output leakage current</strong></td>
<td>+ve supply = +5V</td>
<td>Maximum 1.0</td>
<td>Maximum 1.0</td>
</tr>
<tr>
<td><strong>Power dissipation</strong></td>
<td>Up to 50°C</td>
<td>Maximum 300</td>
<td>Maximum 300</td>
</tr>
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**Fig. 2—Specifications**

**Fig. 3. Low voltage supply indicator**

between pin 4 and the logic positive supply rail. For TTL use 1k, for LSTTL use 4k7, or in the case of CMOS logic use any suitable value, typically between 10k and 1M. The 8211 is guaranteed to be able to drive 2 conventional TTL or 8 LSTTL inputs, and the 8212 to drive 4 conventional or 16 LSTTL inputs.

**Applications**

There are many applications of the ICL8211CPA and ICL8212CPA which are

- Voltage monitoring
- Supply monitoring
- Transducer level detection
- Etc.

Such is the versatility of those i.c.s, however, that more diverse uses for them are possible. Fig. 5, for example, shows a simple voltage regulator using an external npn power transistor as the series pass element. The output voltage is defined by:

\[
V_{out} = 1.15 \frac{R_1 + R_2}{R_1}
\]

The two capacitors are necessary to ensure

**Fig. 4. Two alternative methods of adding hysteresis**

in the area of voltage monitoring, supply monitoring, transducer level detection, etc.
stability, since the 8212 has no internal frequency compensation. This regulator can be used with lower input voltages than most commercially available regulators, and uses less power than almost any commercially available device. It is ideal, therefore, for use as a supply regulator in battery powered systems.

Fig. 6 shows the 8212 being used as a 'programmable Zener diode'. R2 is the resistor which would normally be provided between the positive supply rail and the Zener's cathode. VR1 and R1 set the 'Zener' output voltage, and C1 stabilises the circuit, again due to the lack of internal compensation in the i.c. The value of the Zener voltage is given by:

\[ V_{Zener} = 1.15 (R_1 + \text{the set value of VR1}) / R_1 \]

Typical 'Zener' equivalent impedances over the current range 300µA to 25mA will vary from 4 to 7 ohms.

Finally, the i.c.s can be used as a constant current source or sink, as shown in Fig. 7. The 8211 will provide approximately 130µA, and the 8212 approximately 250µA of current. Hysteresis is provided for IC2, as shown in Fig. 4a. The high trip voltage (i.e. the voltage at which the i.c. turns off when the power supply voltage is increasing) is chosen to be higher than the voltage at which IC1 trips. The low trip voltage is chosen to be the voltage at which the power supply is considered to be excessively low. By this means the 'watchdog' circuit is non-volatile—once it has been turned on it cannot reset itself, even if the power supply has gone down to 0V and back up again, since the voltage applied to the IC2 resistor chain would have to exceed the voltage necessary to turn IC1 on if IC2 were to be turned off, and this in turn would force IC2 to turn hard on again! A momentary reset switch is provided to set up the system when power is first applied. It must be pressed to reset the system after every occasion on which the circuit is tripped.

THE ALARM

IC3 with its associated components forms an audible alarm to warn that the circuit has been tripped. IC3a and IC3b act as a slow running oscillator with a wide mark/space ratio, which in turn gates on and off the audio oscillator formed by IC3c and IC3d. The audio oscillator directly drives a small piezo sounder X1. The slow running oscillator is arranged to turn on the audio oscillator for only a fraction of a second, once every few seconds, providing a slow regular 'blip' sound. R8 determines the 'off' time, and R9 the 'on' time; varying either of these will vary the respective durations of the silence and the audible tone. This has been arranged to minimise power consumption, since the triggering of the alarm indicates that the power supply might be failing—a situation which might be made even worse by a dramatic increase in power consumption of the circuit.

D1 and D2 allow for a standby battery to be provided for the audible alarm, to allow it to function even with the main power supply turned off. The alarm battery should preferably have a voltage just below that of the main power supply, so that it will only be used if the main supply drops significantly in
Applications

This circuit is ideal for long term monitoring of a supply which must be continuously present. For example, this could be a battery backup supply for an otherwise volatile memory system or a comprehensive timing circuit. Any failure of the supply, either high or low, will cause a logic 0 to appear at the logic output and the alarm to sound, even if the supply is quickly reinstated, until the reset button is pressed.

Resistors R1, R2, R3, R4, R5 and the alarm battery, are all shown for a 5 volt supply rail, but they can all be scaled for other voltages using the principles described earlier. With such high values used for the resistors, the trip voltages can be a little in error from those predicted by the equations, so some experimentation may be necessary. Variations in the 1-15V internal reference should be borne in mind, also; these are shown in the specifications, Fig. 2. The logic output should feed into CMOS logic, or into suitable buffering prior to TTL circuitry, since the input of TTL or LSTTL, if connected directly to the logic output, could feed a logic 1 into IC3 pin 1 in the absence of a power supply to IC1 and IC2, preventing correct alarm operation. This circuit is ideal for use in battery systems, largely due to its low current consumption (well under 100 µA) in the ‘normal’ state.
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