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JULY 1998

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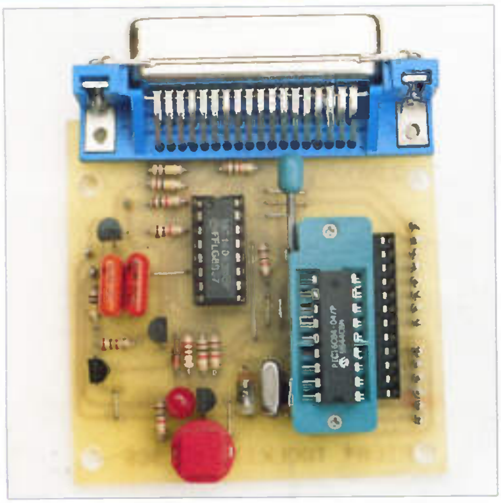

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1.14 metre dia blades, carbon matrix blades, 3 year warranty, 12vdc output, 24v version available, control electronics included, brushless neodymium cubic curve alternator, only two moving parts, maintenance free, simple roof top installation, start up speed 7mph, max output (30mph) 380w. £499 ref AIR1

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PORTABLE X RAY MACHINE PLANS Easy to construct plans on a simple and cheap way to build a home X-ray machine! Effective device, X-ray sealed assemblies. can be used for experimental purposes. Not a toy or for minors! £6/set. Ref F/XP1.

TELEKINETIC ENHANCER PLANS Mystify and amaze your friends by creating motion with no known apparent means or cause. Uses no electrical or mechanical connections, no special gimmicks yet produces positive motion and effect. Excellent for science projects, magic shows, party demonstrations or serious research & development of this strange and amazing phychic phenomenon.
£4/set Ref F/TKE1.

ELECTRONIC HYPNOSIS PLANS & DATA This data shows several ways to put subjects under your control. Included is a full volume reference text and several construction plans that when assembled can produce highly effective stimuli. This material must be used cautiously. It is for use as entertainment at parties etc only, by those experienced in its use. £15/set Ref F/EH2

GRAVITY GENERATOR PLANS This unique plan demonstrates a simple electrical phenomena that produces an anti-gravity effect. You can actually build a small mock spaceship out of simple materials and without any visible means- cause it to levitate. £10/set Ref F/GRA1.

WORLDS SMALLEST TESLA COIL/LIGHTENING DISPLAY GLOBE PLANS Produces up to 750,000 volts of discharge, experiment with extraordinary HV effects, 'Plasma in a jar', St Elmo's fire, Corona, excellent science project or conversation piece. £5/set Ref F/BTC1/LG5.

COPPER VAPOUR LASER PLANS Produces 100mw of visible green light. High coherency and spectral quality similar to Argon laser but easier and less costly to build yet far more efficient. This particular design was developed at the Atomic Energy Commision of NEGEV in Israel. £10/set Ref F/CVL1.

VOICE SCRAMBLER PLANS Minature solid state system turns speech sound into indecipherable noise that cannot be understood without a second matching unit. Use on telephone to prevent third party listening and bugging. £6/set Ref F/VS9.

PULSED TV JOKER PLANS Little hand held device utilises pulse techniques that will completely disrupt TV picture and sound! works on FM too! DISCRETION ADVISED. £8/set Ref F/TJ5.

BODYHEAT TELESCOPE PLANS Highly directional long range device uses recent technology to detect the presence of living bodies, warm and hot spots, heat leaks etc. Intended for security, law enforcement, research and development, etc. Excellent security device or very interesting science project. £8/set Ref F/BHT1.

BURNING, CUTTING CO2 LASER PLANS Projects an invisible beam of heat capable of burning and melting materials over a considerable distance. This laser is one of the most efficient, converting 10% input power into useful output. Not only is this device a workhorse in welding, cutting and heat processing materials but it is also a likely candidate as an effective directed energy beam weapon against missiles, aircraft, ground-to-ground, etc. Particle beams may very well utilize a laser of this type to blast a channel in the atmosphere for a high energy stream of neutrons or other particles. The device is easily applicable to burning and etching wood, cutting, plastics, textiles etc £12/set Ref F/LC7.

DYNAMO FLASHLIGHT Interesting concept, no batteries needed just squeeze the trigger for instant light apparently even works under water in an emergency although we haven't tried it yet! £6.99 ref SC152

ULTRASONIC BLASTER PLANS Laboratory source of sonic shock waves. Blow holes in metal, produce 'cold' steam, atomize liquides. Many cleaning uses for PC boards, jewllery, coins, small parts etc. £6/set Ref F/ULB1.

ANTI DOG FORCE FIELD PLANS Highly effective circuit produces time variable pulses of accoustical energy that dogs cannot tolerate £6/set Ref F/DOG2

LASER BOUNCE LISTENER SYSTEM PLANS Allows you to hear sounds from a premises without gaining access. £12/set Ref F/LLIST1

PHASOR BLAST WAVE PISTOL SERIES PLANS Handheld, has large transducer and battery capacity with external controls. £6/set Ref F/PSP4

INFINITY TRANSMITTER PLANS Telephone line grabber/room monitor. The ultimate in home/office security and safety! simple to use! Call your home or office phone, push a secret tone on your telephone to access either: A) On premises sound and voices or B) Existing conversation with break-in capability for emergency messages. £7 Ref F/TELEGRAB.

BUG DETECTOR PLANS Is that someone getting the goods on you? Easy to construct device locates any hidden source of radio energy! Sniffs out and finds bugs and other sources of bothersome interference. Detects low, high and UHF frequencies. £5/set Ref F/BD1.

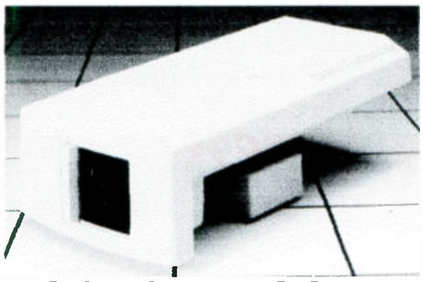
ELECTROMAGNETIC GUN PLANS Projects a metal object a considerable distance-requires adult supervision £5 ref F/EML2.

ELECTRIC MAN PLANS, SHOCK PEOPLE WITH THE TOUCH OF YOUR HAND! £5/set Ref F/EMA1.

SOLAR POWERED WIND UP RADIOS BACK IN! These FM/AM radio's have a solar panel and a hand operated charger! £17.95 ref SOLRAD

PARABOLIC DISH MICROPHONE PLANS Listen to distant sounds and voices, open windows, sound sources in 'hard to get' or hostile premises. Uses satellite technology to gather distant sounds and focus them to our ultra sensitive electronics. Plans also show an optional wireless link system. £8/set ref F/PM5

2 FOR 1 MULTIFUNCTIONAL HIGH FREQUENCY AND HIGH DC VOLTAGE, SOLID STATE TESLA COIL AND VARIABLE 100,000 VDC OUTPUT GENERATOR PLANS Operates on 9-12vdc, many possible experiments. £10 Ref F/HVM7/ TCL4.



COLOUR CCTV VIDEO CAMERAS,

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Works with most modern video's, TV's, Composite monitors, video grabber cards.

Pal, 1v P-P, composite, 75ohm, 1/3" CCD, 4mm F2.8, 500x582, 12vdc, mounting bracket, auto shutter, 100x50x180mm, 3 months warranty, 1 off price £119 ref XEF150, 10 or more £99 ea 100+ £89

CIRCUIT PACKS Packs of 35 circuit diagrams covering lasers, SW radios, geigers, bugs, char etc. Pack1, Pack2, Pack3 £4.99 each.

SMOKE ALARMS Mains powered, made by the famous Gent company, easy fit next to light fittings ,power point. £4.99 ref SMKX

CONVERT YOUR TV INTO A VGA MONITOR FOR £25! Converts a colour TV into a basic VGA screen. Complete with built in psu, lead and s/ware.. Ideal for laptops or a cheap upgrade. Supplied in kit form for home assembly. **SALE PRICE £25** REF SA34

***15 WATT FM TRANSMITTER** Already assembled but some RF knowledge will be useful for setting up. Preamp req'd, 4 stage 80-108mhz, 12-18vdc, can use ground plane, yagi or dipole £69 ref 1021

***4 WATT FM TRANSMITTER KIT** Small but powerful FM transmitter kit. 3 RF stages, mic & audio preamp included £24 ref 1028

YUASHA SEALED LEAD ACID BATTERIES 12v 15AH at £18 ref LOT8 and below spec 6v 10AH at £5 a pair

ELECTRIC CAR WINDOW DE-ICERS Complete with cable, plug etc **SALE PRICE JUST £4.99** REF SA28

AUTO SUNCHARGER 155x300mm solar panel with diode and 3 metre lead fitted with a cigar plug. 12v 2watt **£12.99** REF AUG10P3.

SOLAR POWER LAB SPECIAL You get 2 6"x6" 6v 130mA cells, 4 LED's, wire, buzzer, switch + 1 relay or motor. **£7.99** REF SA27

SOLAR NICAD CHARGERS 4 x AA size £9.99 ref 6P476, 2 x C size £9.99 ref 6P477

GIANT HOT AIR BALLOON KIT Build a 4.5m circumfrence, fully functioning balloon, can be launched with home made burner etc. Reusable (until you loose it!) £12.50 ref HA1

AIR RIFLES .22 As used by the Chinese army for training puposes, so there is a lot about! £39.95 Ref EF78. 500 pellets £4.50 ref EF80.

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INFRA RED FILM 6" square piece of flexible infra red film that will only allow IR light through. Perfect for converting ordinary torches, lights, headlights etc to infra red output only using standard light bulbs. Easily cut to shape. 6" square £15 ref IRF2

HYDROGEN FUEL CELL PLANS Loads of information on hydrogen storage and production. Practical plans to build a Hydrogen fuel cell (good workshop facilities required) £8 set ref FCP1

STIRLING ENGINE PLANS Interesting information pack covering all aspects of Stirling engines, pictures of home made engines made from an aerosol can running on a candle! £12 ref STIR2

12V OPERATED SMOKE BOMBS Type 3 is a 12v trigger and 3 smoke cannisters, each cannister will fill a room in a very short space of time! £14.99 ref SB3. Type 2 is 20 smaller cannisters (suitable for simulated equipment fires etc) and 1 trigger module for £29 ref SB2 Type 1 is a 12v trigger and 20 large cannisters £49 ref SB1

HI POWER ZENON VARIABLE STROBES Useful 12v PCB fitted with hi power strobe tube and control electronics and speed control potentiometer. Perfect for interesting projects etc 70x55mm 12vdc operation. £6 ea ref FLS1, pack of 10 £49 ref FLS2

RUSSIAN BORDER GUARD BINOCULARS £1799 Probably the best binoculars in the world! ring for colour brochure

NEW LASER POINTERS 4.5mw, 75 metre range, hand held unit runs on two AA batteries (supplied) 670nm £29 ref DEC49

HOW TO PRODUCE 35 BOTTLES OF WHISKY FROM A SACK OF POTATOES Comprehensive 270 page book covers all aspects of spirit production from everyday materials. Includes construction details of simple stills etc. £12 ref MS3

NEW HIGH POWER MINI BUG With a range of up to 800 metres and a 3 days use from a PP3 this is our top selling bug! less than 1" square and a 10m voice pickup range. £28 Ref LOT102

BUILD YOU OWN WINDFARM FROM SCRAP New publication gives step by step guide to building wind generators and propellors. Armed with this publication and a good local scrap yard could make you self sufficient in electricity! £12 ref LOT81

NEW LOW COST VEHICLE TRACKING TRANSMITTER KIT £29 range 1.5-5 miles, 5,000 hours on AA batteries, transmits info on car direction, left and right turns, start and stop information. Works with any good FM radio. **£29 ref LOT101a**

CCTV CAMERA MODULES 46X70X29mm, 30 grams, 12v 100mA. auto electronic shutter, 3.6mm F2 lens, CCIR, 512x492 pixels, video output is 1v p-p (75 ohm). Works directly into a scart or video input on a tv or video. IR sensitive. £79.95 ref EF137.

IR LAMP KIT Suitable for the above camera, enables the camera to be used in total darkness! £6 ref EF138

UK SCANNING DIRECTORY As supplied to Police, MOD, M15 and GCHQ! coverers everything from secret government frequencies, eye in the sky, prisons, military aviation etc £18.50 ref SCANB

INFRA RED POWERBEAM Handheld battery powered lamp, 4 inch reflector, gives out powerful pure infrared light! perfect for CCTV use, nightsights etc. £29 ref PB1.

SUPER WIDEBAND RADAR DETECTOR Detects both radar and laser , X K and KA bands, speed cameras, and all known speed detection systems. 360 degree coverage, front &earwaveguides, 1.1"x2.7"x4.6" fits on sun visor or dash £149 ref

CHIEFTAN TANK DOUBLE LASERS 9 WATT+3 WATT+LASER OPTICS

Could be adapted for laser listener, long range communications etc. Double beam units designed to fit in the gun barrel of a tank, each unit has two semi conductor lasers and motor drive units for alignement. 7 mile range, no circuit diagrams due to MOD, new price £50,000? us? £199. Each unit has two gallium Arsenide injection lasers, 1 x 9 watt, 1 x 3 watt, 900nm wavelength, 28vdc, 600hz pulse frequency. The units also contain an electronic receiver to detect reflected signals from targets. £199 for one. Ref LOT4

NEW LOW PRICED COMPUTER/WORKSHOP/HI-FI RCB UNITS Complete protection from faulty equipment for everybody! Inline unit fits in standard IEC lead (extends it by 750mm), fitted in less than 10 seconds, reset/test button, 10A rating £6.99 each ref LOT5. Or a pack of 10 at £49.90 ref LOT6. If you want a box of 100 you can have one for £250!

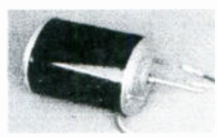
DIGITAL PROPORTIONAL B GRADE RADIO CONTROLLED CARS From World famous manufacturer these are returns so they will need attention (usually physical damage) cheap way of buying TX and RX plus servos etc for new projects etc £20 each sold as seen ref LOT2DP.

MAGNETIC CREDIT CARD READERS AND ENCODING MANUAL £9.95 Cased with flyleads, designed to read standard credit cards! complete with control elctronics PCB and manual covering everything you could want to know about whats hidden in that magnetic strip on your card! just £9.95 ref BAR31

WANT TO MAKE SOME MONEY? STUCK FOR AN IDEA? We have collated 140 business manuals that give you information on setting up different businesses, you peruse these at your leisure using the text editor on your PC. Also included is the certificate enabling you to reproduce (and sell) the manuals as much as you like! £14 ref EP74

HIGH POWER DC MOTORS, PERMANENT MAGNET

12 - 24v operation, probably about 1/4 horse power, body measures 100m x 75mm with a 60mm x 5mm output shaft with a machined flat on it. Fixing is simple using the two threaded bolts protruding from the front



£22ea REF mot4

ISSN 0262 3617
PROJECTS . . . THEORY . . . NEWS . . .
COMMENT . . . POPULAR FEATURES . . .

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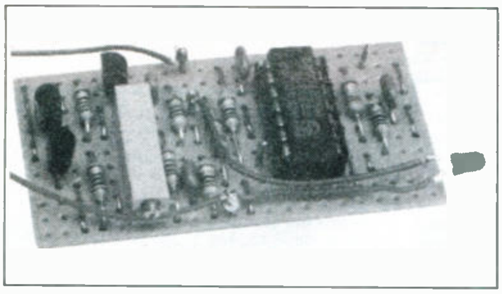

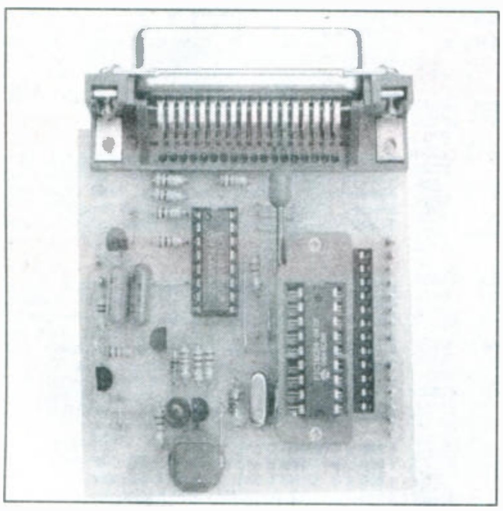

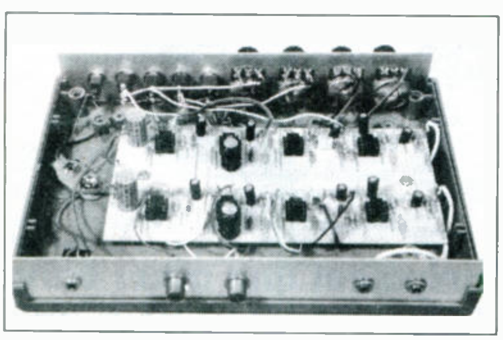

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Our August '98 issue will be published on Friday, 3 July 1998. See page 475 for details.

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Order as HIGRADE 286 ***ONLY £99.00*** (E)

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1.4Mb 3½" floppy disk drive (instead of 1.2 Mb)	£19.95
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2½" TOSHIBA (19 mm H) MK2101MAN 2.16 Gb. *New*	£199.00
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3½" CONNER CP3024 20 mb IDE I/F (or equiv.) RFE	£59.95
3½" CONNER CP3044 40mb IDE I/F (or equiv.) RFE	£69.00
3½" RODIME RO3057S 45mb SCSI I/F (Mac & Acorn)	£69.00
3½" QUANTUM 40S Prodrive 42mb SCSI I/F, New RFE	£49.00
3½" WESTERN DIGITAL 850mb IDE I/F *New*	£185.00
5¼" MINISCRIBE 3425 20mb MFM I/F (or equiv.) RFE	£49.95
5¼" SEAGATE ST-238R 30 mb RLL I/F Refurb	£69.95
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Many other drives in stock - Shipping on all drives is code (D)

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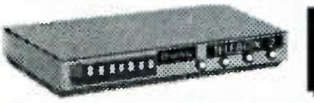
Converts your colour monitor into a QUALITY COLOUR TV!!



TV SOUND & VIDEO TUNER
CABLE COMPATIBLE

The TELEBOX is an attractive fully cased mains powered unit, containing all electronics ready to plug into a host of video monitors made by makers such as **MICROVITEC, ATARI, SANYO, SONY, COMMODORE, PHILIPS, TATUNG, AMSTRAD** etc. The composite video output will also plug directly into most video recorders, allowing reception of **TV channels not normally receivable on most television receivers*** (TELEBOX MB). Push button controls on the front panel allow reception of 8 fully tuneable 'off air' UHF colour television channels. **TELEBOX MB** covers virtually all television frequencies VHF and UHF **including the HYPERBAND as used by most cable TV operators.** A composite video output is located on the rear panel for direct connection to most makes of monitor or **desktop computer video systems.** For complete compatibility - even for monitors without sound - an integral 4 watt audio amplifier and low level Hi Fi audio output are provided as standard.

TELEBOX ST for composite video input type monitors	£36.95
TELEBOX STL as ST but fitted with integral speaker	£39.50
TELEBOX MB Multiband VHF/UHF/Cable/Hyperband tuner	£69.95

For overseas PAL versions state 5.5 or 6 mHz sound specification. *For cable / hyperband signal reception Telebox MB should be connected to a cable type service. Shipping on all Telebox's, code (B)

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One of the highest specification monitors you will *ever* see - At this price - Don't miss it!!

Mitsubishi FA3415ETKL 14" SVGA **Multisync** colour monitor with fine 0.28 dot pitch tube and resolution of 1024 x 768. A variety of inputs allows connection to a host of computers **including IBM PC's** in CGA, EGA, VGA & SVGA modes, **BBC, COMMODORE** (including Amiga 1200), **ARCHIMEDES** and **APPLE**. Many features: Etched faceplate, text switching and **LOW RADIATION MPR** specification. Fully guaranteed, supplied in EXCELLENT little used condition.
Tilt & Swivel Base £4.75 **Only £119** (E) **Order as MITS-SVGA**
VGA cable for IBM PC included.
External cables for other types of computers CALL

As New - Ex Demo
17" 0.28 SVGA Mitsubishi Diamond Pro monitors
Full multisync etc. Full 90 day guarantee. £325.00 (E)

Just In - Microvitec 20" VGA (800 x 600 res.) colour monitors. Good SH condition - from £299 - CALL for info

PHILIPS HCS35 (same style as CM8833) attractively styled 14" colour monitor with **both RGB and standard composite 15.625 Khz video inputs via SCART socket** and separate phono jacks. **Integral audio power amp and speaker for all audio visual uses.** Will connect direct to **Amiga and Atari** BBC computers. **Ideal for all video monitoring / security applications with direct connection to most colour cameras.** High quality with many features such as front concealed flap controls, VCR correction button etc. Good used condition - fully tested - guaranteed
Dimensions: W14" x H12¾" x 15½" D. **Only £99** (E)

PHILIPS HCS31 Ultra compact 9" colour video monitor with **standard composite 15.625 Khz video input via SCART socket.** Ideal for all monitoring / security applications. High quality, ex-equipment fully tested & guaranteed (possible minor screen burns). In attractive square black plastic case measuring W10" x H10" x 13½" D. 240 V AC mains powered. **Only £79.00** (D)

KME 10" 15M10009 high definition colour monitors with 0.28" dot pitch. Superb clarity and modern styling. Operates from any 15.625 khz sync RGB video source, with RGB analog and composite sync such as Atari, Commodore Amiga, Acorn Archimedes & BBC. Measures only 13½" x 12" x 11". Good used condition. **Only £125** (E)

20" 22" and 26" AV SPECIALS

Superbly made UK manufacture. PIL all solid state colour monitors, complete with composite video & *optional* sound input. Attractive teak style case. Perfect for Schools, Shops, Disco, Clubs, etc. In EXCELLENT little used condition with full 90 day guarantee.

20"....£135 22"....£155 26"....£185 (F)

SPECIAL INTEREST ITEMS

MITS. FA3445ETKL 14" Industrial spec SVGA monitors	£245
1kW to 400 kW - 400 Hz 3 phase power sources - ex stock	£POA
IBM 8230 Type 1, Token ring base unit driver	£760
Wayne Kerr RA200 Audio frequency response analyser	£2500
IBM 53F5501 Token Ring ICS 20 port lobe modules	£750
IBM MAU Token ring distribution panel 8228-23-5050N	£95
AIM 501 Low distortion Oscillator 9Hz to 330Khz, IEEE	£550
Trend DSA 274 Data Analyser with G703(2M) 64 i/o	£POA
Marconi 6310 Programmable 2 to 22 GHz sweep generator	£6500
HP1650B Logic Analyser	£3750
HP3781A Pattern generator & HP3782A Error Detector	£POA
HP6621A Dual Programmable GPIB PSU 0-7 V 160 watts	£1800
HP6264 Rack mount variable 0-20V @ 20A metered PSU	£675
HP54121A DC to 22 GHz four channel test set	£POA
HP7580A A1 8 pen HPGL high speed drum plotter	£1850
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Philips PW1730/10 XRAY generator with accessories	£POA
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Fiskers 45KVA 3 ph On Line UPS - New batteries	£9500
ICI R5030UV34 Cleanline ultrasonic cleaning system	£POA
Mann Tally MT645 High speed line printer	£2200
Intel SBC 486/133SE Multibus 486 system. 8Mb Ram	£945
Intel SBC 486/125C08 Enhanced Multibus (MSA) NEW	£1450
Zeta 3220-05 A0 4 pen HPGL *fast* drum plotters	£1150
Nikon HFX-11 (Ephiphot) exposure control unit	£1450
Motorola VME Bus Boards & Components List. SAE / CALL	£POA
Trio 0-18 vdc linear, metered 30 amp bench PSU. New	£550
Fujitsu M3041R 600 LPM band printer	£1950
Fujitsu M3041D 600 LPM printer with network interface	£1250
Perkin Elmer 2998 Infrared spectrophotometer	£500
Perkin Elmer 597 Infrared spectrophotometer	£3500
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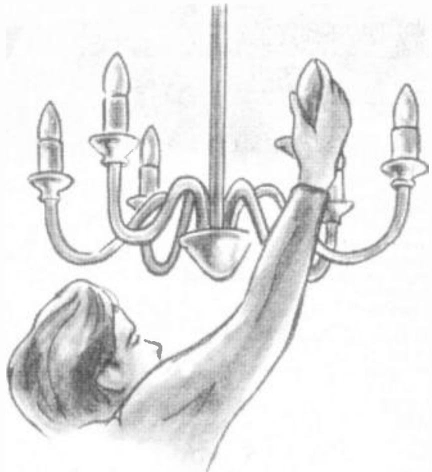

PC TRANSISTOR TESTER

Put your PC to practical work. This PC Transistor Tester *connects to the parallel printer port of a PC, and provides a digital readout of d.c. current gain via the monitor. This full constructional project is an "improved" version of a circuit first featured in the September 1996 issue of* EPE *(*Interface*, pp. 690 and 691).*

It is also the first of several PC test gear projects having their origins in past articles in the Interface *series. This* PC Transistor Tester*, in common with the other designs, is very simple and quite inexpensive to build, but offers a high level of performance.*

There is a big advantage in basing test gear projects on a PC in that it provides a sophisticated digital readout at virtually no cost, provided you already have access to a PC. Where necessary, the PC and the software can effectively provide much of the control logic for the program.

Both NPN *and* PNP *transistors can be checked using this system.*

FLOAT CHARGER

Don't get caught flat in an emergency. Keep your sealed lead/acid batteries in tip-top condition with this low-cost charger.

In recent years, small sealed lead/acid batteries have become widely available, and are becoming recognised as a useful alternative to nickel-cadmium cells for many applications.

They are available in a wide range of capacities and usually have a nominal voltage of either 6V (3 cells) or 12V (6 cells). They can provide very high output currents and do not exhibit the "memory" effect of NiCads, making them ideal for situations where they are to be continuously topped up by a "float" charger, ready to supply emergency power when required.

This unit provides a precisely regulated voltage, together with a current limit to prevent excessive charging currents and therefore prolong the life of the battery.

LAMPSAVER

Lightbulbs tend to blow when they are switched on, this is because when the filament is cold its resistance is low and it can be instantly placed across the peak mains voltage of 325 volts. A 100W bulb, which would normally draw around 430mA, could therefore pass up to 5A instantaneously. If you arrange to always connect the bulb to the mains when the mains alternating voltage is at zero volts – which it is 100 times a second – you can prolong the life of the bulb.

This simple, inexpensive circuit does just that using an opto-isolator i.c. to provide zero voltage switching. Users will not be aware of the operation of the circuit until they relise that the time between bulb changes has increased.

EVERYDAY PRACTICAL ELECTRONICS

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EXPENSIVE?

It is interesting to note how various readers view the hobby of electronics; we sometimes get response from readers regarding the cost of the hobby being rather high, what with the price of test gear and tools, plus components and hardware by mail order for projects, etc. However, if we see any response from industry, perhaps on the price of the magazine, books or manuals, it is usually commenting on the excellent value for money we can offer.

It all comes down to how you view electronics – as a constructional hobby or for training and education. Do you simply want to be able to construct the equivalent of a commercial product at a significant saving? – often no longer possible with the manufacturers' buying power and mass production savings; or do you look upon it as a true hobby which gives the pleasure of doing, learning and developing your skills? There is, of course, the added fillip with some projects of being able to build something which you cannot buy, or of being able to tailor a design to meet your own individual requirements.

I.C. INSIDE

Sometimes we are asked to explain what goes on inside i.c.s and perhaps to give an internal circuit. Basically that is not possible; when you think that the latest Pentium chip contains over seven million (yes million) active devices and that even a very basic op.amp or timer i.c. probably has hundreds of active components inside it, it would take nearly the whole magazine to give a reasonable explanation of the circuit, including a circuit diagram. Such knowledge is really unnecessary; provided you understand what the chip does and what the figures on the data sheet mean, then you can use it simply as an active component. Few equipment design engineers will have any knowledge of the "component level" internal circuitry of the i.c.s they use.

Our *Teach-In '98* series lets you into the secrets of operation of digital i.c.s and how to design circuits which use them. With the whole world becoming more digital every month, it is useful knowledge.

ON-LINE

Observant readers will notice another name on our list of *EPE* workers (right). Alan Winstanley has been producing our Web Pages from the start of our electronic presence. Alan works for us on a freelance basis, but our Web site and ftp site are such an important part of the operation, and Alan has total control over them, that we felt it was high time we recognised his contribution in that area. Regular readers will also be aware of his not insignificant editorial contributions; he is a valuable member of our team and the one who keeps *EPE* in front of an ever-growing high tech. Web audience.

Mike Kenward

READERS' ENQUIRIES

We are unable to offer any advice on the use, purchase, repair or modification of commercial equipment or the incorporation or modification of designs published in the magazine. We regret that we cannot provide data or answer queries on articles or projects that are more than five years old. Letters requiring a personal reply *must* be accompanied by a **stamped self-addressed envelope or a self-addressed envelope and international reply coupons. Due to the cost we cannot reply to overseas queries by Fax.**

All reasonable precautions are taken to ensure that the advice and data given to readers is reliable. We cannot, however, guarantee it and we cannot accept legal responsibility for it.

COMPONENT SUPPLIES

We do not supply electronic components or kits for building the projects featured, these can be supplied by advertisers (see *Shoptalk*).

We advise readers to check that all parts are still available before commencing any project in a back-dated issue.

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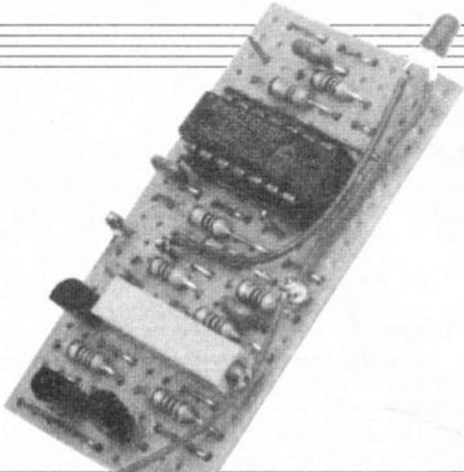
Constructional Project

LOW BATTERY INDICATOR



ANDY FLIND

A micropower in-circuit, l.e.d. battery condition indicator for your projects.

THIS project began life as a battery condition monitor for the *EPE Mood-Changer* design described in last month's issue. As it is not immediately apparent to the user whether the *EPE Mood-Changer* is operating or not a low-battery warning of some kind is essential. However the usual method, using an l.e.d. that remains lit above a pre-set supply voltage, appeared unsatisfactory as it would inevitably draw more current than the main circuit!

MICROPOWER

Thoughts on the problem eventually led to the design of this circuit and it was then realised that, with micropower operation and a wide supply voltage range, it could be used in many other designs. Because of this it is presented here as a completely separate project. The use of a compact stripboard layout allows it to be constructed cheaply and fitted into an odd corner of space that will exist in almost any project, and it can be adjusted to work with most common battery voltages.

In use the circuit gives one long flash of the l.e.d. (light emitting diode) when first switched on to confirm that the battery is actually present and not completely "dead". If the supply voltage subsequently falls below a pre-set voltage, generally about two thirds of the original value given by a fresh battery, it will flash briefly at intervals of about five seconds.

This minimal use of the l.e.d. coupled with a CMOS control circuit keeps the average current consumption below 50µA for most supply voltages, which is considerably less than that of most battery indicators.

CIRCUIT DESCRIPTION

The full circuit diagram for the Low Battery Indicator appears in Fig.1. The first part, constructed around two CMOS NAND gates IC1a and IC1b, is an oscillator with a period of about five seconds.

The output of this oscillator drives input pin 13 of IC1d through a differentiating circuit consisting of capacitor C2 and resistor R6, pulsing it high for about 100ms each cycle. At the same time the output from the oscillator passes through a potential divider consisting of pre-set VR1 with resistors R3 and R4 to the base of transistor TR1.

So long as the battery supply voltage is sufficient for the voltage to TR1 base (b) to exceed about half a volt TR1 will be turned on and its collector (c) voltage will go low. This low voltage goes to the other input, pin 12, of IC1d, ensuring that the output of IC1d remains high whilst the battery voltage is above the pre-set "failure" level.

When it falls below this level however, transistor TR1 will not conduct, so the voltage at pin 12 will remain high. When this happens the output of IC1d will pulse low each time pin 13 is pulsed high.

The output from IC1d pin 11 goes to pin 9, an input to IC1c. The other input to this gate, pin 8, is normally high as capacitor C3 is kept charged by resistor R7, so the output at IC1c pin 10 is normally low, but begins pulsing high when the negative-going pulses start appearing from IC1d. These positive-going output pulses drive the output stage for the l.e.d. D1.

On power-up, charging of capacitor C3, with current from R7, takes a couple of seconds. During this period, input pin 8 of IC1c is effectively pulled low so the output from pin 10 goes high to provide a

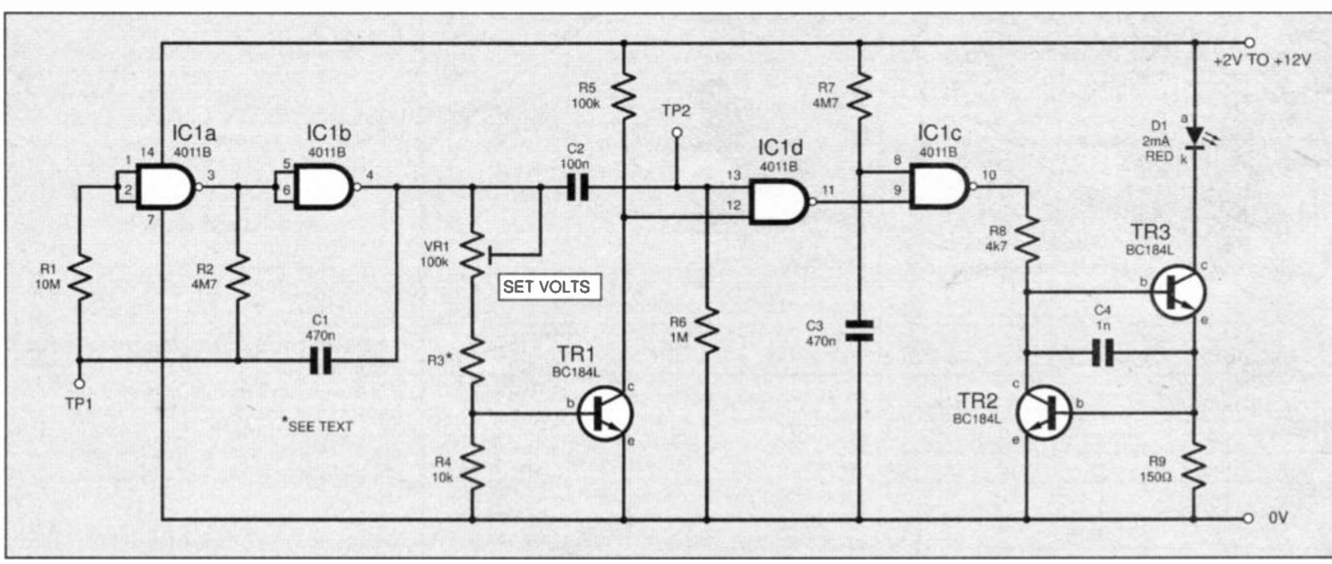


Fig.1. Complete circuit diagram for the Low Battery Indicator. The value of resistor R3 is selected by reference to Table 1.

single long flash from D1. This confirms that the battery is initially present and working.

CONSTANT BRIGHTNESS

The l.e.d. D1 is driven by a "constant current" circuit built with transistors TR2 and TR3. The purpose of this is to ensure almost constant brightness over a wide range of supply voltages and to avoid the need to adjust resistor values in this part of the circuit to suit the voltage to be used. It also gives better results at the extreme low end of the operating supply range, which is around two volts.

A disadvantage of this type of current generator is a tendency to oscillate at high frequencies. During "breadboard" testing of this design oscillation was found to be taking place at about 60MHz, but the addition of capacitor C4 completely eliminated the problem.

For initial adjustment the two test points TP1 and TP2 can be forced high by connecting them directly to the positive supply. This stops the oscillator with pin 4 high, and also holds pin 13 high. The l.e.d. will now illuminate continuously when transistor TR1 is "off" and go out when it "conducts".

ON THE THRESHOLD

If the supply voltage is set to the proposed "battery failure" value, preset VR1 can easily be adjusted to the point where the l.e.d. D1 is on the threshold of operation. The value of resistor R3 must be chosen to suit the supply voltage as shown in Table 1.

A minor disadvantage of using the base-emitter junction voltage of a transistor as a reference is that it varies with temperature at the rate of about 2mV per degree Centigrade. If the operating temperature range is assumed to be zero to 35 degrees, which is probably wider than will be encountered in most applications, this will result in a total change of about 70mV.

The threshold voltage for conduction at normal room temperature is about 550mV, so the overall variation is about 13 per cent. If the unit is set up at mid-temperature this will mean a maximum error of about plus or minus 6·5 per cent.

When applied to a 9V supply, with a "failure" voltage set to 6V the maximum error will be plus or minus 380mV. In practice operation at these temperature extremes is unlikely so the errors encountered will normally be much smaller. For this simple application they should be perfectly acceptable.

CONSTRUCTION

To avoid the need to purchase or make a p.c.b. (printed circuit board) whenever one of these units is required the circuit is constructed on a piece of 0·1in. matrix stripboard with 11 strips of 22 holes. The component layout is shown in Fig.2, together with the copper side showing the breaks required in the copper tracks.

There are nineteen breaks in all. As always, it's a good idea to inspect them carefully with a strong magnifying glass as minute strips of copper sometimes remain around their edges and can subsequently prove difficult to trace.

There are fourteen link wires, all of which are short so they can be made using bare tinned wire for simplicity. A d.i.l. socket is recommended for IC1. Although not essential this will simplify testing if any problems arise at this stage.

The resistors are all placed horizontally to give the unit a low profile. The value of R3 should be chosen from Table 1 for the intended operating voltage. The circuit can be operated with battery voltages from 3V to 12V, with "failure" voltages between around 2V and 9V respectively.

Preset VR1 should be a multi-turn type, the horizontal 18-turn unit shown was chosen mainly for it's low profile compared to the square multi-turn types. Connection pins for the supply, l.e.d. and test points simplify setting up and making the external connections.

COMPONENTS

Resistors

R1	10M
R2, R7	4M7 (2 off)
R3	see text
R4	10k
R5	100k
R6	1M
R8	4k7
R9	150Ω

All 0·6W 1% metal film

See SHOP TALK Page

Potentiometer

VR1 — 100k 18-turn cermet preset, horizontal

Capacitors

C1, C3	470n resin-dipped ceramic (2 off)
C2	100n resin-dipped ceramic
C4	1n resin-dipped ceramic

Semiconductors

D1	2mA red l.e.d.
TR1, TR2, TR3	BC184L *npn* transistors
IC1	4011B CMOS quad 2-input NAND gate

Miscellaneous

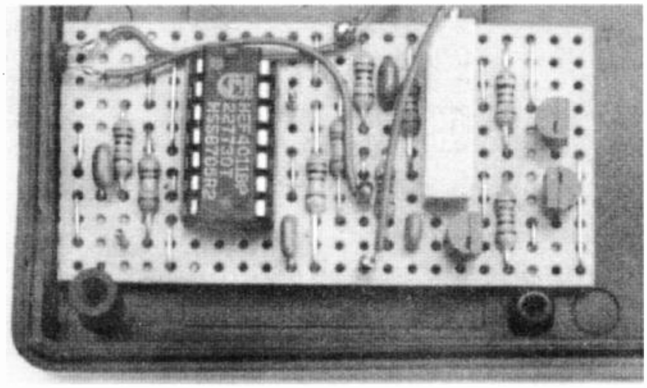
Stripboard, 0·1in. matrix, size 11 strips × 22 holes; 14-pin d.i.l. socket; supply hook-up wire; single-sided solder pins; solder etc.

Approx Cost Guidance Only £6.50

TESTING

Testing is best carried out using a variable voltage bench power supply and ideally should be done at about the normal operating temperature. The two test points, TP1 and TP2, are shorted to the positive supply, l.e.d. D1 is connected to the board, then the supply voltage is set to the proposed "failure" value and preset VR1 is adjusted to the operating point of D1.

To assist in finding this easily it may be helpful to remember that clockwise



Component layout on the completed prototype circuit board.

Table 1: Selection of Failure Voltage resistor

Nominal Voltage	Failure Voltage	R3 Value
3	2	2k2
4·5	3	2k2
6	4	15k
9	6	47k
12	9	100k

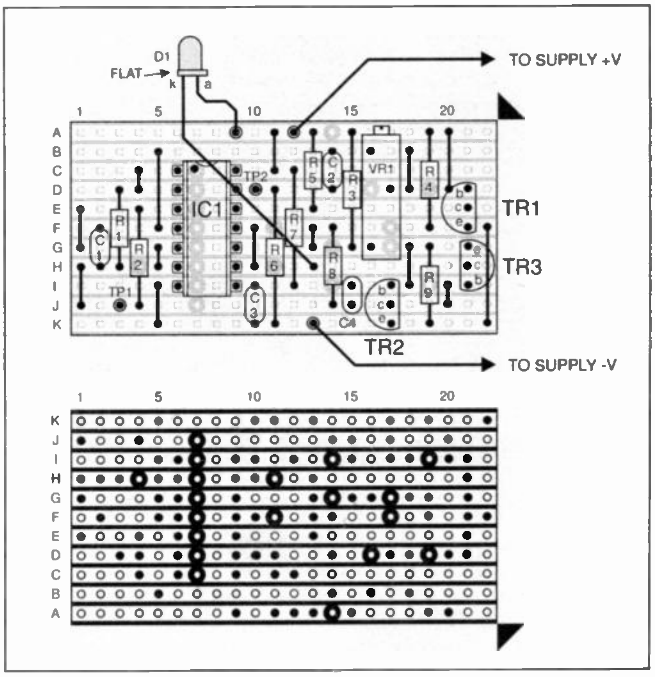


Fig.2. Stripboard component layout, wiring and underside details of breaks required in the copper tracks.

rotation of VR1 lowers the operating point, moving towards turning D1 off, whilst anti-clockwise rotation raises it and moves towards turning D1 on. Once the desired point has been found and set, the connections to the test points can be removed and a final operational check can be made.

FINAL CHECKS

The supply voltage should be raised to the normal operating value. When it is applied to the circuit D1 should give one long flash of about two seconds and then remain "off". If the supply voltage is now gradually reduced, when the "failure" value is reached D1 should begin to flash briefly about once every five seconds.

The operating voltage of a typical red l.e.d. is about 1·5V to 2V. It follows that it may not be possible to set the circuit to operate at 2V so where it is used for monitoring a 3V battery supply it may be necessary to set operation to about 2·25V. This should prove to be acceptable for most applications.

The only other precaution is that the circuit may generate a small amount of local electrical noise since the oscillator produces a square-wave output and has a gradually changing input to one of its two CMOS gates. If use with a radio receiver circuit is planned it would be wise to check first that there will be no problems with this. For most other projects, especially ones using very low supply currents, this should prove a very useful addition. □

With the finished circuit board being small and compact, there should be no problem in finding room for it within the case of most battery driven projects. Here it is installed, using pieces of Blu-Tack, in the lid of last month's EPE Mood Changer project.

Innovations

A roundup of the latest Everyday News from the world of electronics

Listening is a Lost Cause

Packing more data onto audio discs is a desirable objective – but what quality will we accept? asks Barry Fox.

IN AN humiliating climb-down, record industry trade bodies the IFPI (International Federation of the Phonographic Industry) and RIAA (Recording Industry Association of America) have had to abandon the listening tests they promised to choose the best technology for DVD-Audio, the next generation hifi disc. The International Steering Committee set up by the IFPI and RIAA 18 months ago had said it would report to the world's record companies, by the end of 1997. Now the ISC admits it cannot "choose a winning sound format".

DVD, the new digital video disc, already has surround sound to accompany the movie pictures but it is digitally compressed by a "lossy" system which throws away some data on the assumption that the human ear will not notice. The hifi and record companies want to use the full 4·7GB capacity of the disc for lossless surround sound, with nothing thrown away, to give much higher sound quality than a CD.

HOW TO JUDGE?

The ISC underestimated the difficulty of finding a test method that satisfies the hifi industry, which has never been able to agree on the best way to judge sound quality. The Committee did not foresee the heavy political and commercial agendas which create disagreement on what system is best even within record companies and between their own artists. North America's draconian anti-trust laws stop business competitors collaborating. The number of systems on offer is still growing, with disagreements hardening.

Until recently Philips and Sony had been coy about plans for their DSD, Direct Stream Digital, system which codes sound as a very rapid stream of single bits, instead of the long PCM words used by CD and all other proposals for DVD Audio.

Now they are promoting DSD as the "digital Rosetta Stone" and telling consumers they "need to migrate from the Compact Disc". Bob Stuart, founder of hifi industry group the Acoustic Renaissance for Audio, and Managing Director of British hifi company Meridian Audio, has published a paper which attacks DSD technology as "unacceptable".

Dolby Laboratories already provides the lossy compression system, Dolby Digital AC-3, used for DVD movie discs. Now Dolby is licensing a lossless PCM system invented by British engineers Peter Craven and (the late) Michael Gerzon, and owned by Meridian.

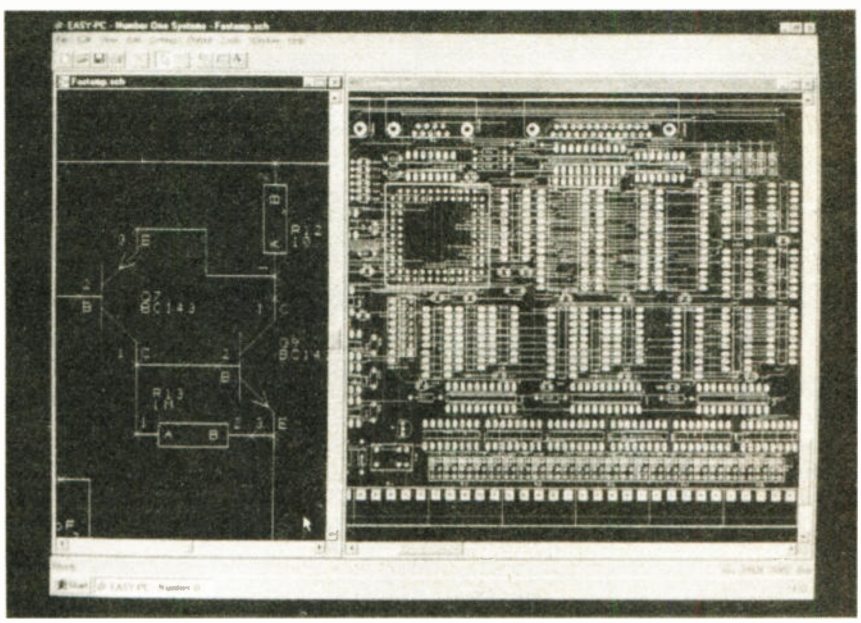
Pioneer, Panasonic and Samsung all have rival PCM systems.

AGAIN A STANDARDS BATTLE

"Abandoning centralised listening tests does not mean that the introduction of DVD Audio will be slowed" say the IFPI and RIAA, hoping that "the availability of a number of sound formats need not result in separate DVD players in the marketplace".

The record companies have unhappy experience of past standards battles, like VHS versus Betamax and Mini Disc versus the Digital Compact Cassette, so they want the ISC to finish the job it started. The ISC says the electronics industry should develop a DVD Audio player that automatically self-adjusts to whatever disc standard the owner tries to play on it.

Says Tony Griffiths, who pioneered digital recording with Decca, "The ISC shouldn't abandon testing, just because it's difficult, they should just alter the time-scale". Bob Stuart believes the ISC has overlooked a simple solution to the whole mess. "If you have a lossless system, you don't need to do a listening test. All you have to do is check what data comes out".



EASY-PC FOR WINDOWS 95

Easy-PC for Windows is the fourth generation Schematic Capture and PCB CAD product from Number One Systems. Many readers, and contributors to *EPE*, use Easy-PC in its various forms and will undoubtedly be pleased to know about this latest product.

The original Easy-PC was introduced ten years ago, winning a British Design Award in 1989. The new product is completely new and has been written to take advantage of the facilities offered by the Windows 32-bit operating system. There are *no limits* to any of the major parameters: no limits to pin counts, net counts, layers, track widths or pad dimensions. "If you run out of capacity anywhere", says Adrian Espin, MD at Number One Systems, "simply add more memory"!

For more information contact Number One Systems Ltd., Dept EPE, Harding Way, St Ives, Cambs PE17 4WR. Tel: 01480 461778. Fax: 01480 494042.
Web: http://www.numberone.com.

Y2K AND MICROSOFT

By Barry Fox

MICROSOFT admits that software released only four years ago cannot cope with the date change from 1999 to 2000. The company is still testing some products and will never test others.

Microsoft has split its products into five categories; fully Year 2000 compliant, compliant with minor problems, not compliant, still under test, and too old to warrant testing. Details are posted in a "resource centre" on the Internet at **www.microsoft.com/year2000**.

Older versions of Windows 3.1 and 95 are not fully compliant. Some dates will have to be entered manually, and by keyboard not mouse. Microsoft is still "investigating" and does not yet have a full set of software fixes which users can download from the Internet.

Seven pages of daunting jargon reveal that Version 2 of Access, Microsoft's database software released in April 1994, will misinterpret 00 as 1900. Version 4.3 of the Office Professional suite of programs will also give problems because it contains Access.

Version 5 of the popular DOS wordprocessor, Word, gives the most serious problems. Documents dated 2000 or later may be corrupted when saved. The PC then freezes and refuses to work until shut down and re-started. Microsoft has not yet been able to produce a fix and suggests that users try updating to Version 5.5 or 6.

Already there is something new for computer users to worry about. The recently announced Euro currency sign is a strange E with two lines added. The European Union says the E was inspired by the Greek letter Epsilon, and is also the first letter of Europe. The lines represent the hoped-for stability of the currency.

"The sign is very convenient and will soon be on every new computer or typewriter keyboard" assures the EU. Maybe. But it is not on any existing keyboard or included in any existing computer character set.

Microsoft pledges that when Windows 98 goes on sale, it will "support the Euro currency symbol". Win 95 can be upgraded but Microsoft is doing nothing about Windows 3 or DOS.

Microsoft recently sent out a four page press release on the Euro sign. But there was no sign of any Euro signs. Microsoft denies that this is because the company cannot yet print them.

700MHz PENTIUM

AT the recent *CeBIT Trade Fair*, Intel demonstrated a Pentium II processor running at 702MHz, which is more than twice as fast as its current production processor, which runs at 333MHz.

Intel's spokesman Michael Sullivan said that "This is still a technology demonstration, but that is where we are going".

The company also demonstrated technology that will be used in its future Merced processor. Michael Sullivan would not say how fast Merced chips would run, but pointed out that they will be based on a more advanced process than the Pentium II. "Past history is that a new process eventually gets you more speed", he said.

Current trends have been for a doubling of computer speeds every 18 months.

Browsing Intel's web site revealed a report which stated that the Merced chip is the first microprocessor based on IA-64 technology and is scheduled for production in 1999.

The report said that last October, Intel and Hewlett Packard revealed the first details of their jointly defined Explicitly Parallel Instruction Computing (EPIC) technology, the foundation for the new 64-bit Instruction Set Architecture (ISA).

EPIC technology breaks through the sequential nature of conventional processor architectures by allowing the software to communicate explicitly to the processor when operations can be done in parallel. Increased performance is realised by reducing the number of branches and branch mis-predicts, and reducing the effects of memory-to-processor latency (the time taken to retrieve data from memory).

The future 64-bit Intel Architecture (IA-64) applies EPIC technology to deliver explicit parallelism, massive resources and inherent scalability not available with conventional RISC (Reduced Instruction Set Computing) architectures.

For more information, browse Intel's web site at http://www.intel.com.

Windows 98

BROWSING the Net recently for information about the forthcoming Windows 98 operating system revealed a news item from Microsoft, of which the following is a precis:

On 7 January '98, Microsoft began a limited Consumer Beta Preview Program, with the goal of letting home users of the Windows 95 operating system get an early experience with Windows 98 Beta 3 before general product availability.

"We developed this program based on feedback from users of Windows 95 who wanted a chance to preview the next version of Windows before release", said Jonathan Roberts, Director of Windows marketing at Microsoft.

Windows 98 has improvements in key areas of overall product quality, Internet functionality, entertainment features, and support for the latest hardware. With Windows 98, users can speed up their system, so programs load faster and hard-drive storage is used more efficiently to gain up to 30 per cent more free hard-drive space without compressing the drive.

Also featured are new desktop navigation options, including single-click program launch, forward and back buttons, and an easier-to-customize Start Menu. The system is intended to make your computer more entertaining with better 3-D support for exciting, immersive gaming, as well as support for DVD drives that provide better sound and video, and can hold 15 times more information than a CD-ROM.

Universal Serial Bus (USB) is broadly supported in Windows 98. With USB you can connect joysticks, video-conferencing cameras, scanners, and more to your PC easily and without rebooting.

The full production version of Windows 98, will allow users of Windows 3.1 and '95 to upgrade their system. Your local Microsoft agent should be able to tell you more. There is also a Microsoft web page with questions and answers about the program and its expansion at: http://www.microsoft.com/windows98/info/preview.htm.

A Few Dates for Your Diary

25-26 Sept '98: *27th Leicester Amateur Radio Show*, Donington International Exhibition Centre, Donington Park, Castle Donington Leics. For stand and table bookings contact John Theodorson, G4MTP, tel/fax 01664 790966, E-mail G4MTP@mail.com. Other enquiries to Geoff Dover, G4AFJ, tel 01455 823344, fax 01455 828273. Also: http://members.aol.com/jtheotlc/LARS.

14 Nov '98: *AMS'98 Computer and Electronics Show*. Bingley Hall, Staffordshire Showground, Weston Road, Stafford. More details from Sharwood Promotions, tel: 01473 741533, fax: 01473 741361, E-mail: services@sharwood.co.uk.

Don't forget that there is now a fast route to finding out about computer fairs via the Net: http://www.computerfairs.co.uk and http://www.netxtra.co.uk. Those we publicise in *EPE* have been advised to us directly by their organisers. If you want to publicise an event, let us know – can't promise to include it, but we'll try.

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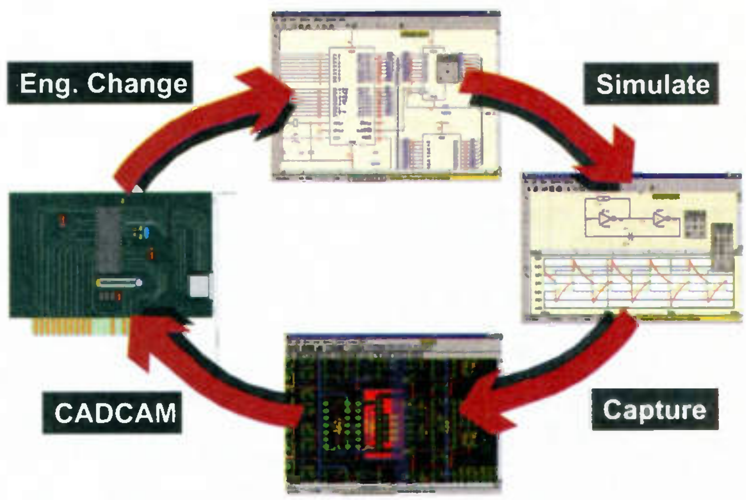

Use the multi layer autorouter, and/or manual routing to complete your PCB together with copper fill, etc as required. Finally print your design, or create CADCAM files suitable for manufacture (we even include a Gerber viewer for checking).

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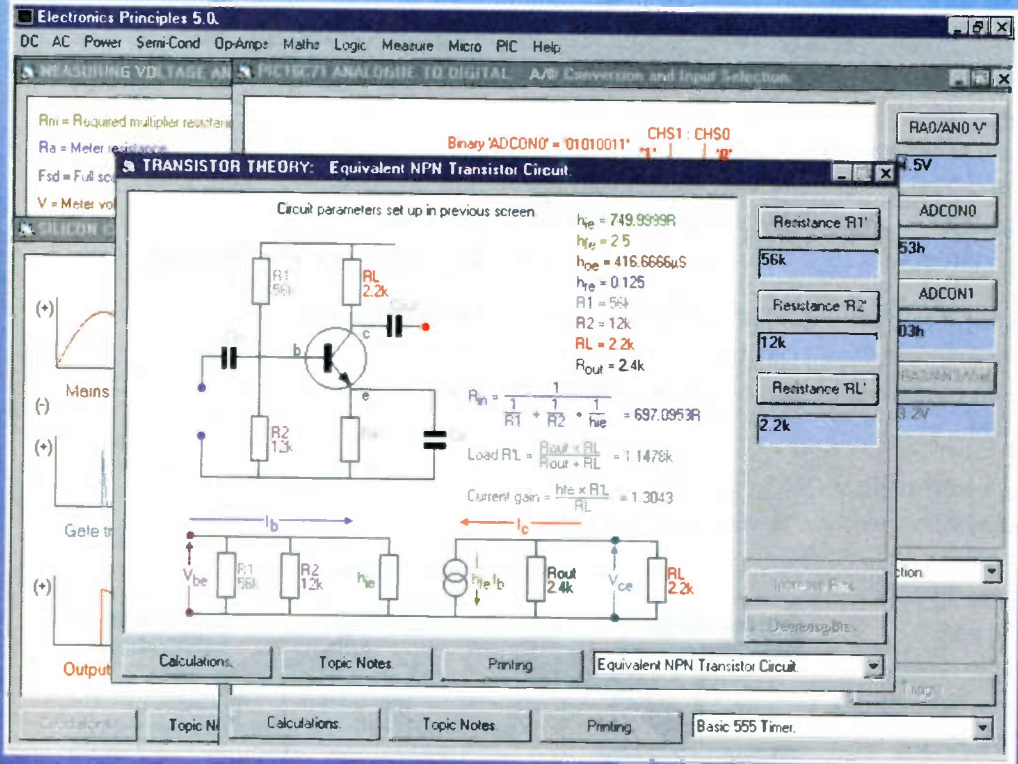

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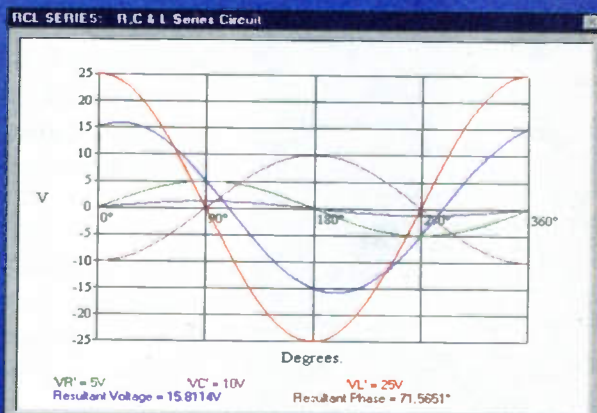
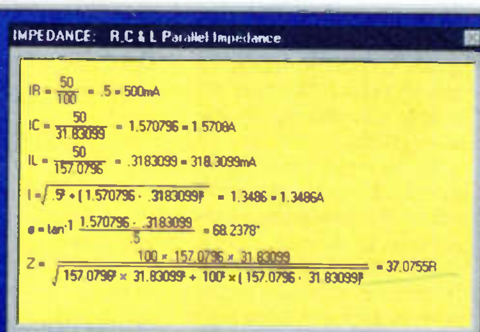
The PIC16C84 microcontroller hardware and instruction set has been introduced and brought to life through colourful interactive graphics where you can study the architecture of this device by changing the data values to simulate all of the registers, direct/indirect addressing, program/data memory and input/output port configuration. Along with those analogue to digital functions of the PIC16C71. If you would like to learn more about the principles of these popular microcontrollers then it could not be made easier.



Electronics Principles software is currently used in hundreds of UK and overseas schools and colleges to support City & Guilds, GCSE, A-Level, BTEC and university foundation courses. Also NVQ's and GNVQ's where students are required to have an understanding of electronics principles.



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New Technology Update

Research into keeping chips cool is hotting-up! Ian Poole reports

ONE of the major problems facing i.c. designers is that of heat dissipation. The increasing complexity of i.c.s means that there are greater amounts of heat generated within them.

The problem has been with designers since the very earliest days of i.c.s. Originally it was thought that the limit for the number of components on a chip would be reached very quickly. Fortunately CMOS technology enabled the brick wall that was being approached to be surmounted. Now i.c.s, in particular some of today's processors, have enormous numbers of transistors.

However, new ideas will shortly be required to enable the levels of heat currently being generated to be easily dissipated if development of i.c.s is not to stop. The problem is highlighted by the fact that the current Pentium processor, which contains around 7·2 million transistors, needs its own fan to remove the heat. This is fine for present technologies but, with ever larger, faster and more complicated i.c.s being devised, new techniques will shortly be required.

The rate of development in this area of technology is very fast. A law has even been devised. Known as Moore's Law, it is named after Dr Gordon Moore, the founder of Intel. It states that semiconductor transistor density, and hence performance, doubles approximately every 18 months. Along with this, there is an increase in the amount of heat generated. He made this prediction in the 1970s and so far he has been proved to be correct.

PC Freezer

There are a number of advantages to be gained in keeping i.c.s cool. Not only does their reliability improve, but it is also found that CMOS devices run faster at lower temperatures. There is a 30 per cent improvement in speed gained by reducing the temperature of a device from about 100°C down to 0°C. If the temperature is reduced still further, much greater gains can be made. The reason arises from the increased carrier mobility and other second order effects.

To achieve this, a company called KryoTech have demonstrated a system where the processor is cooled to a temperature of around −40°C using vapour phase refrigeration. This process is about 50 times as effective as forced air and it is very convenient because it uses a well proven technology.

The temperature reduction to −40°C gives a speed increase of about a third for a processor and can be easily guaranteed. At a recent exhibition the company demonstrated a 300MHz processor running at 400MHz. The temperature of −40°C has been chosen because it is the practical lower limit for this type of refrigeration. If lower temperatures were used then further increases in speed would be possible, but a different cooling technology would have to be used. For example, decreasing the temperature to around −100°C would enable the speed to be doubled.

The technology, which has been patented, uses standard refrigerator parts. The compressor uses an environmentally friendly refrigerant gas and the refrigerant unit is designed to sit under the PC case. A cooler unit is plugged into the processor socket on the motherboard, and then the processor sits in this. A cooler block with the same gas circulating is placed over the processor to ensure the temperature is maintained over the whole of the processor.

Some of the heat extracted from the processor itself is returned to the PC case. This is done to ensure that condensation does not form in the case and cause failures due to moisture formation.

The current technology is well proven and is being used in a variety of products. However, development is ongoing and in a recent announcement a link with another company, MMR Technologies, has been made. Their expertise is with lower temperature refrigeration (down to −123°C) and this will enable further improvements in performance to be obtained.

New I.C. Package

Many forms of i.c. package are now reaching their limits. The requirements for the increased number of connections combined with improved heat dissipation are forcing designers to look for new ideas. Most applications do not require the same amount of heat to be dissipated as in the case of a processor, but even so improvements over existing packages are required.

A new package called a polymer stud grid array (p.s.g.a.) has been produced. Looking like a cross between a conventional pin grid array and a ball grid array it consists of a plastic injection moulded body with a cavity for mounting the chip. The pins which make contact with the p.c.b. are arranged around the cavity and are made of a polymer/metal combination. The pins are referred to as studs and consist of a plastic base with a metallic coating. They measure 400μm in diameter; they are 500μm long; and they are on a 1mm pitch.

The advantage of this type of stud is that it causes less thermal mismatch between the package and the board. This creates less stress between the package and the board that may lead to a reduction in reliability.

The package has a metallised back. This distributes the heat from the chip, giving an improved heat dissipation figure over many existing packages. If further improvements in heat dissipation are required then a full metal insert can be placed into the package moulding onto which the die is placed.

Surface Mount Power Transistors

It is not only in the field of i.c.s that new methods of heat dissipation need to be investigated. With the increasing trend towards surface mount technology, new difficulties are being encountered and overcome, enabling these small components to dissipate much larger amounts of heat.

In view of the reduced size of surface mount components new development is required to enable some of the medium power transistors, or their equivalents, to be transferred to this technology. In past years, the TO220 package has been very popular for transistors and other devices including the famous 78xx series of voltage regulators. Whilst these are still available for the home experimenter or construction enthusiast, surface mount equivalents are required for mass production.

One of the first transistor packages to address this market was the Motorola D²PAK which was introduced in the early 1990s. This provided a replacement for many devices contained in the TO220 package but only allowed dissipation levels up to about 2·5 watts.

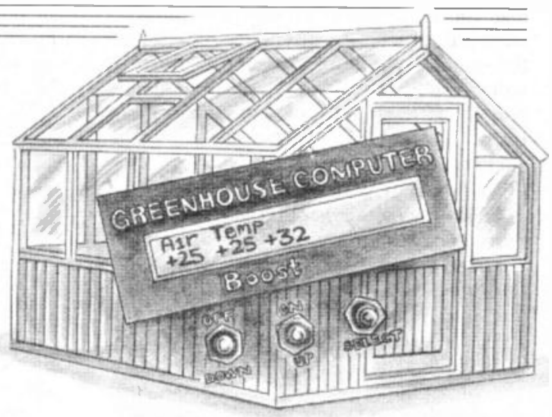
Dissipation levels are being pushed upwards as are the die sizes which require mounting in the packages. As a result of these requirements Motorola developed a new package. Known as their D³PAK, it had a number of advantages over previous offerings. It was a true surface mount package and enabled easier soldering using infra-red reflow and other processes.

The package was targeted at housing power MOSFETs but was equally well suited for a host of other devices including bipolar power transistors, IGBTs and rectifiers.

Unlike many other packages, it can handle high voltages, up to 1kV, and is able to dissipate powers up to four watts when mounted on an ordinary fibreglass board. By using other techniques, including the use of intermetallic substrate materials, the power dissipation can be increased four-fold. However, for normal use the power dissipation can be increased by increasing the p.c.b. copper thickness and/or the area of copper through which heat can be dissipated.

Constructional Project

GREENHOUSE COMPUTER



COLIN MEIKLE

Part 1

Pamper your plants (and yourself) with microcontrolled heating and watering, includes Radio Link.

THIS greenhouse computer was designed to control and monitor a small greenhouse, conservatory or similar. The controller's main function is to attend to the heating and watering requirements of the plants.

An additional feature of this controller is that it has the option of a radio link to a remote display unit, so you can view and log the status of the greenhouse from the comfort of your home.

FEATURES

A typical setup for the main components of the system is shown in Fig.1. Here a heating cable is used to heat a bed of sand, which in turn heats seed trays, pots, etc. The temperature of the sand is monitored and controlled by the microcontroller.

The watering feature is intended for use with plants that require frequent watering, such as tomato plants. This function is separate from the heating. Watering is controlled by measuring the soil moisture, therefore ensuring accurate watering. (Most commercial systems use a timer – which is an inaccurate technique.)

There are two separate temperature sensors, one for monitoring air temperature and one for monitoring soil temperature. Both temperatures, along with the associated minimum and maximum values, are displayed on the l.c.d. separately.

The air temperature is for information purposes only. The soil temperature controls a relay which can switch a soil heating cable on or off, to maintain a constant soil temperature. The temperature at which the heater is switched on and off is user-definable, via a setup menu.

Rather than controlling a soil heating cable, you may wish to control an electric heater to heat the whole greenhouse. Here you could use one temperature channel (previously the soil channel) to control the greenhouse temperature. The other channel would be spare; you could use it to monitor the outside temperature.

The controller has an optional 2-level heating setting (Normal and Boost). For example, you could have a "normal" setting for your heater, say 15°C and a higher "boost" level, say 20°C.

Under normal circumstances, the heating will be maintained at a minimum of 15°C. However, if you temporarily want to boost the temperature to the higher level (20°C), you simply press the Boost On button on the front panel.

This feature saves the trouble of having to alter the temperature setting between two common values. This can be useful if you want to boost the soil temperature for seed germination, or the lower temperature could be a frost prevention level. The Setup section explains how to implement this.

A separate power supply unit contains all the mains voltages and the switching relays. This keeps the potentially dangerous voltages away from the control box, which contains the user interfaces.

Specification

* Two separate channels for monitoring temperature
* Current, minimum and maximum temperature display
* 2-level thermostatic heater control
* Soil moisture monitoring
* Automatic plant watering
* Monitoring of water reservoir level
* 2-line 20-character liquid crystal display
* Optional Radio Link to remote display unit

The power supply box also contains the battery back-up pack, so the controller is unaffected by temporary power loss.

SOIL MOISTURE AND WATERING

Soil moisture monitoring plus automatic plant watering is very useful if you have thirsty plants such as tomatoes.

Two probes placed in the soil monitor its moisture and a number between zero

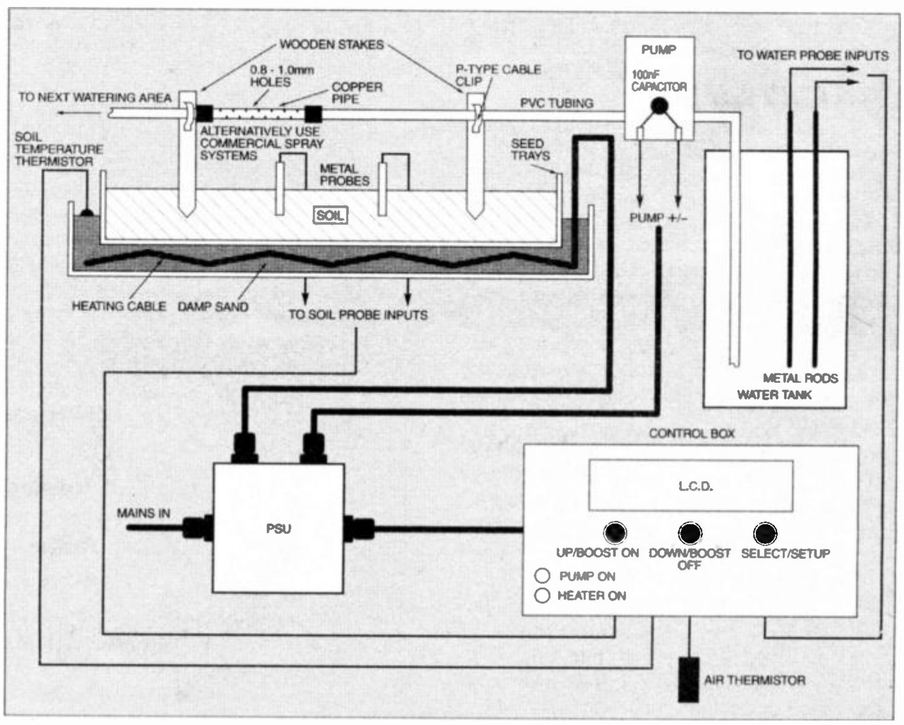


Fig.1. Typical Greenhouse monitoring system setup for the controller.

and 100 is displayed on the l.c.d. to give an indication of the dryness. The higher the number, the drier the soil. The actual value displayed will vary depending on the conditions, e.g. soil type and distance between the probes. Once set up, you will soon be able to relate the number displayed to a moisture level.

When the soil dries out to a preset level, the controller turns on a relay, which in turn can drive a pump or valve to water the plants. The length of time the relay, and hence the pump, is on for is variable, set via the setup procedure. This allows the amount of water delivered in any one watering to be controlled. Once the watering cycle has been activated, it is disabled for four hours, this stops the plants being drowned if a fault occurs.

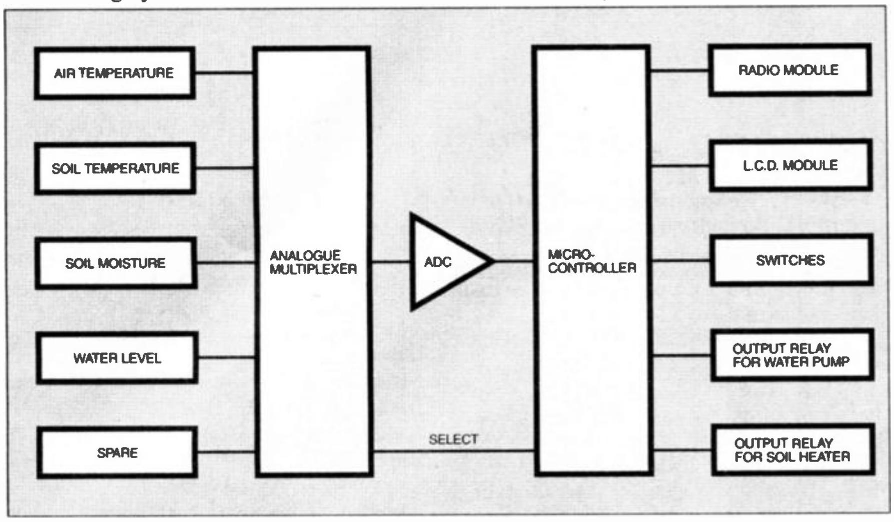


Fig.2. Greenhouse Computer system block diagram.

Water will normally be drawn from a large water storage tank, with a probe in the tank to detect when the water level is low; a warning will be displayed when this occurs.

Note that there is only one watering channel on the controller. As a result, this feature is really only suitable for watering plants with similar watering needs. You can compensate to some extent by using adjustable watering nozzles.

RADIO LINK

A radio link (to be described in the final part) allows you to monitor the status of your greenhouse from another location.

The main controller board has an option to plug in a low power radio module. This module operates on a frequency of 418MHz and is license-exempt in the UK and most of Europe (433MHz in Europe). These small modules require no setting-up or any special r.f. knowledge.

The Transmitter sends the data from the Greenhouse Computer every 10 seconds. This information is picked up by the Receiver, decoded and displayed on the l.c.d. The link has a range of 50 to 100 metres which (for most gardens) is sufficient to transmit from the greenhouse to a nearby house.

The Receiver consists of a small processor board with an RS232 port and an l.c.d. It logs the temperatures into on-board EEPROM at preset intervals, e.g. every 30 minutes. This information can then be periodically uploaded to a PC-computer via the RS232 port, e.g. once a week/month.

The uploaded information is stored in a file along with date and time data. The file can be loaded into a spreadsheet, where the information can be graphed.

The receiver's small size allows for it to be portable, so it does not have to have a fixed location. It can even be battery powered if required.

SPARE CHANNELS

The system has been designed with flexibility in mind. There are three input channels to the analogue-to-digital converter (ADC). Two are spare and could be used for other temperature sensors or a light sensor. The third channel could be used to monitor the input voltage.

When the mains is supplying the PSU, the output voltage will be 14V to 16V d.c. If the mains supply fails, the battery will take over and this voltage will be lower, at 12V. Therefore, by monitoring this channel mains failure could be detected.

These functions are only supported in hardware and the software does not support them. However, the software could be easily changed to make use of the functions, although this would be at the expense of existing functionality, as the available code space has been fully used.

HOW IT WORKS

A block diagram of how the circuit works is shown in Fig.2 and the main Greenhouse Computer circuit (excluding the power supply) is shown in Fig.5.

An Atmel AT89C2051 microcontroller (IC1) is at the heart of the system. This device is a member of the 8051 family of processors (discussed in *EPE* June '98 issue). It has 2K bytes of EEPROM, 128 bytes of RAM and a serial port. Fitting all the functions of the Greenhouse Computer into 2K of ROM was a tight squeeze however, and a few compromises had to be made.

IC1's clock rate is set by a 12MHz crystal, X1, in conjunction with capacitors C4 and C5. On power-up, IC1 is briefly reset by the pulse generated across capacitor C3 and resistor R30.

The main points of the circuit are as follows:

Soil Moisture Monitoring

The principle behind measuring the soil moisture is simple, although its implementation is slightly more complex. To measure the moisture level we simply measure the resistance of the soil; as the soil dries out its resistance will increase. If we use the soil in a simple potential divider, as shown in Fig.3, we can use the output voltage as a measure of the soil moisture.

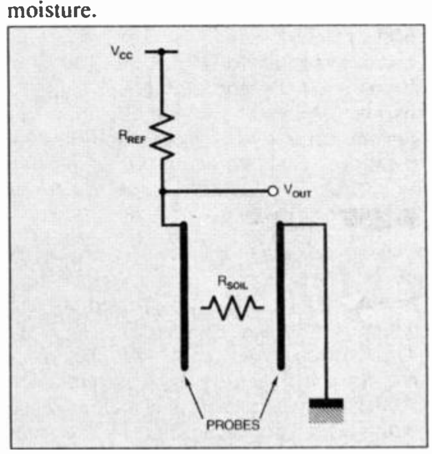
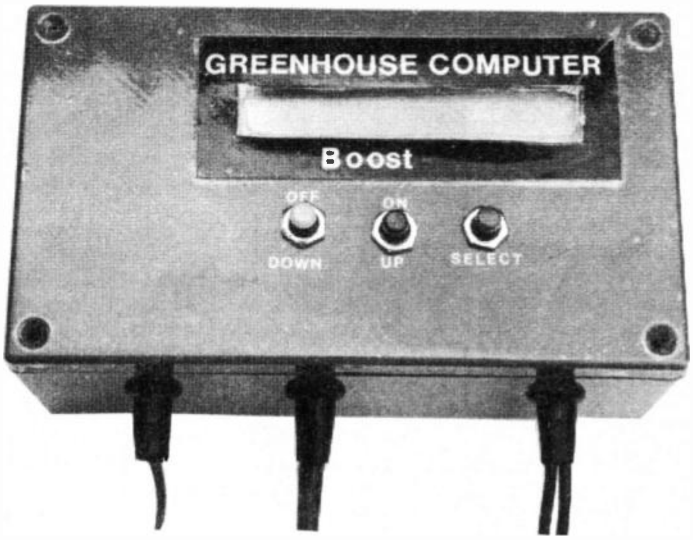
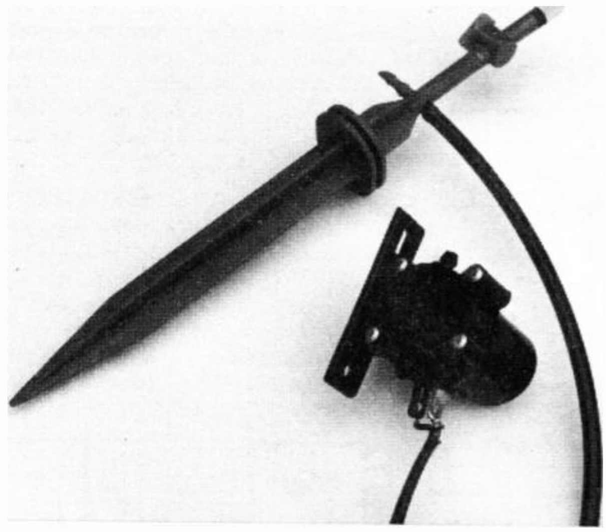


Fig.3. Using the soil in a potential divider network.

The three modules that make up the Greenhouse Computer, (left to right) mains power unit, radio link and greenhouse controller.



Display window on the completed control box.



Water dispenser and pump.

NON-CORROSIVE

The problem with the simple potential divider is that we are passing a direct current (d.c.) through the probes in the soil. Over time, one probe will gather deposits and the other will corrode away, which will give erratic results as well as limited probe life. To avoid this problem, an alternating current (a.c.) is used, which prevents the electrolysis effect. The equivalent circuit is shown in Fig.4.

The practical implementation of Fig.4 is the circuit around IC3a and IC3b in Fig.5. IC3a is configured as an oscillator whose frequency is set at about 4kHz by resistor R23 and capacitor C14.

The resulting a.c. signal is output to the soil moisture probes (P1) via R19 and C13. The value of resistor R19 sets one arm of the potential divider, the other arm being the soil resistance. Discussion of the best value for R19 takes place when setting up is described next month.

From the soil probes, the return signal is buffered by IC3b, rectified by Schottky diode D4, plus C16 and R25. The amplitude of the voltage appearing across C16 thus represents the soil resistance – high voltage when dry, low voltage when wet.

The output voltage is fed to the 8-way multiplexer IC2, into which the output voltages of the other sensors are also fed. The selection of which signal is routed to the microprocessor is determined by the code applied by IC1 to IC2's control pins A, B, C and INH.

Table 1: Relationship between temperature, resistance, voltage and time.

TEMP	R(5K)	Voltage	Time/256	Lookup
-10	27520	3.67	34.2	136.7
-8	24663	3.56	33.2	132.7
-6	22140	3.44	32.1	128.4
-4	19906	3.33	31.0	124.1
-2	17926	3.21	29.9	119.7
0	16168	3.09	28.8	115.2
2	14604	2.97	27.7	110.7
4	13210	2.85	26.5	106.1
6	11967	2.72	25.4	101.6
8	10856	2.60	24.3	97.0
10	9862	2.48	23.1	92.6
12	8971	2.36	22.0	88.2
14	8171	2.25	21.0	83.8
16	7452	2.14	19.9	79.6
18	6805	2.02	18.9	75.5
20	6222	1.92	17.9	71.5
22	5696	1.81	16.9	67.7
24	5220	1.71	16.0	63.9
25	5000	1.67	15.5	62.1
26	4790	1.62	15.1	60.4
28	4400	1.53	14.2	57.0
30	4047	1.44	13.4	53.7

Three switches (S1 to S3) are also connected to the same lines that IC1 uses to control IC2. The switches, though, are not intended to provide additional control over IC2. Rather, they are used to control and set up the various modes of operation via IC1. They have different functions depending on the mode selected, as discussed later. In the set-up procedure, the switch functions are displayed on the bottom line of the l.c.d.

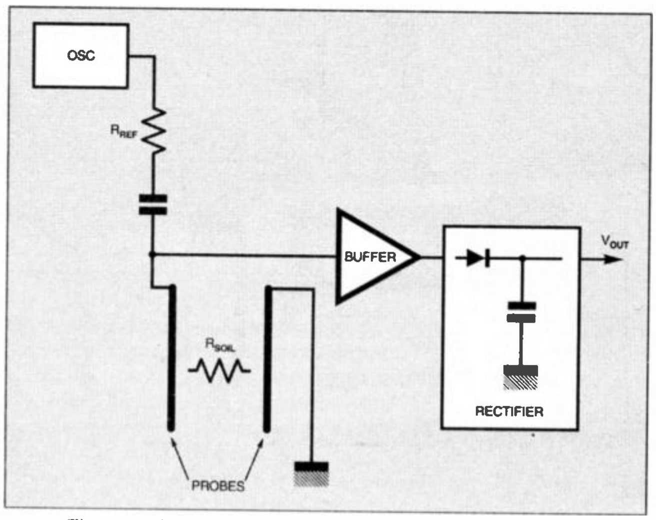


Fig.4. Using a.c. helps to prevent probe corrosion.

Temperature Measurement

There are a number of devices on the market that can make temperature measurement very simple. However, these devices are relatively expensive. In an application such as this, inexpensive ones are preferred as they could get damaged easily in a greenhouse.

The devices used here are NTC thermistors, R26 and R27; these small devices are cheap and reasonably accurate (±2%). The only drawback is that their resistance does not vary linearly with temperature. This is not a great problem, though, since the processor can easily calculate the temperature via a look-up table. The formula for calculating resistance is as follows:

$RT1 = RT2e \times (B/T1 - B/T2)$

where RT = resistance R at Temperature T (in °K), B = characteristic temperature for the thermistor (see comp. list) and e = exponential factor (i.e. 2.718282)

Table 1 shows the relationship between temperature, resistance, voltage and time for the thermistor specified. Column 2 shows the thermistor resistance for various temperatures shown in column 1. Column 3 shows the voltage input to the ADC, i.e. the result of the voltage divider.

Column 4 shows the time taken for the comparator to trip within the ADC function of IC1. A 16-bit timer measures this time, although only the upper eight bits of the timer are used, hence the time is divided by 256. The look-up value is that used by the software and is actually the previous time multiplied by four (this gives better resolution).

Water Level Monitoring

Monitoring of the water level in, say, a rain water butt, is based on a similar principle to soil moisture monitoring, except that only a d.c. voltage is needed across the probes (P2). The amount by which the probes are immersed in water will vary the resistance between them. This forms one arm of another potential divider, the other arm being resistor R9.

DIGITAL CONVERSION

The AT89C2051 microcontroller has built-in analogue processing facilities which make it ideal for use as a sort of analogue-to-digital converter when monitoring sensor voltages, although it is not really an ADC! It's more like a voltage-to-time converter and its operation is quite simple.

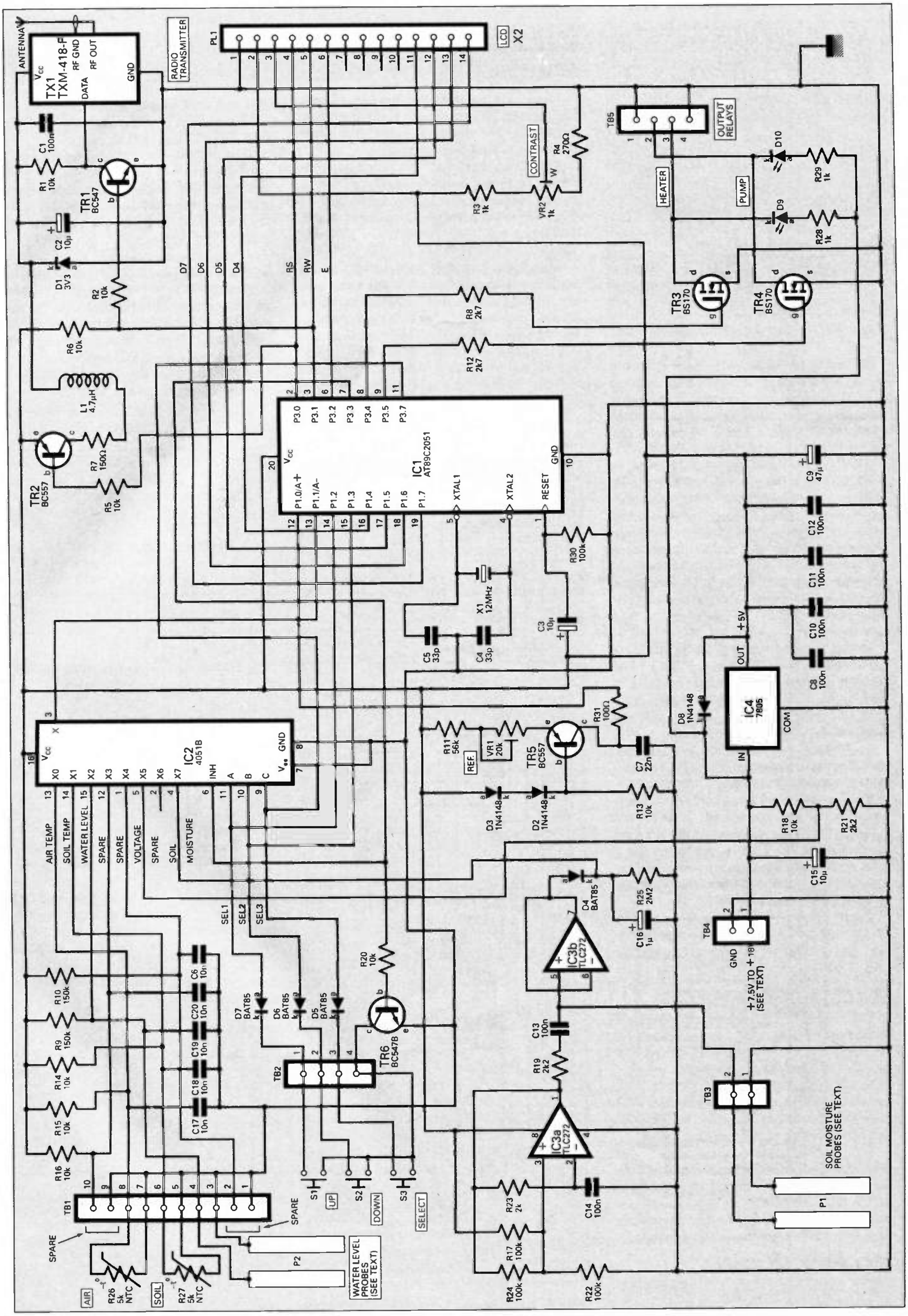


Fig.5. Complete circuit diagram, excluding power supply, for the Greenhouse Computer.

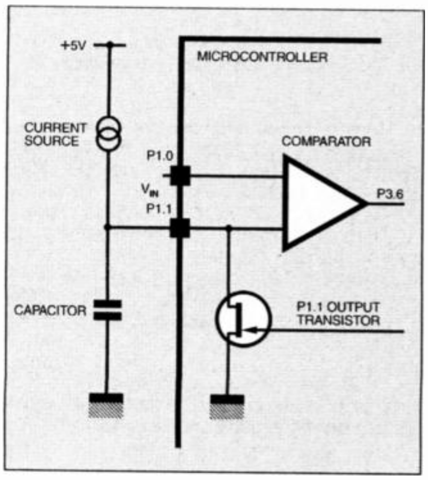


Fig.6. Producing a "reference voltage".

Referring to Fig.6, the voltage from the signal source (V_{in}) is applied to one input (P1.0) of the microcontroller's internal comparator. The other input (P1.1) is supplied by a current-limited reference voltage, which is also coupled to a capacitor.

To obtain a V_{in} voltage value, software first turns on the microcontroller's output transistor connected to P1.1, discharging the capacitor. It then turns off the transistor, allowing the capacitor to begin recharging. Now the software measures the time it takes the capacitor voltage to reach the same level as V_{in} (at which point the comparator output changes state). This time is proportional to the input voltage ($C = dv/dt$).

In Fig.5, the reference voltage is set by the network around transistor TR5. The timing capacitor is C7, and preset VR1 is used to fine-tune the timing/reference rate.

L.C.D. INTERFACE

The display is shown on a 2-line 20-character intelligent l.c.d. (X2), connections to which are via PL1.

The interface will work with most intelligent l.c.d.s that operate off a single 5V supply. Due to the shortage of I/O lines on the processor, the l.c.d. is set up to use a 4-bit data bus rather than its full 8-bit bus. The contrast for the display is controlled by preset potentiometer VR2.

The l.c.d. must be of the single voltage (+5V) supply type, i.e. the type that does not need a negative voltage on its contrast pin.

RADIO INTERFACE

The radio interface uses the processor's serial port to output the current status and setting to the r.f. module. *This design will be explained fully in the final part.*

In a nut-shell, though, data is sent from the controller as a single block every 10 seconds. The link is one-way, so the control board cannot receive any messages.

The receiver decodes the data from processor and displays the information on the l.c.d. It also stores the data in non-volatile memory, so that it can be downloaded to a PC for further processing (e.g. temperature graphs can be generated).

POWER SUPPLY

The controller circuit has its own 5V regulator on board, as shown in Fig.5. It can be fed at between 7·5V and 18V, which is attenuated to 5V by IC4.

Resistors R18 and R21 form a potential divider which supplies a reference voltage which could be read by the microcontroller via IC2, but is not implemented in the prototype.

Diode D8 protects the regulator when the power is removed (i.e. the bulk capacitors are discharged via the diode rather than through the regulator).

The controller can be supplied with power from any suitably rated d.c. power source, although the circuit illustrated in Fig.7 is recommended. The control board consumes less than 100mA; the pump is likely to require between 1A and 3A.

Mains a.c. power is brought into transformer T1 whose dual 12V a.c. output is rectified by diodes D11 and D12, resulting in a d.c. voltage of about 18V at smoothing capacitor C21. This 18V is fed to the 5V regulator on the controller board. Additionally, a 5V6 Zener diode (D15) drops the 18V to 12·4V to supply the relays.

RELAYS

Also shown in Fig.7 is the power circuit for the relays, RLA and RLB. These are responsible for switching the Heater and the Pump. They are controlled from IC1 via f.e.t. power transistors TR3 and TR4 (see Fig.5). Their status is indicated by l.e.d.s D9 and D10.

Returning to Fig.7, rechargeable NiCad batteries are used to provide the power for the pump. The mains power supply keeps the batteries topped up and provides power for the control board, it does not power the pump. The batteries also give backup to the controller, so you will not lose your setting during power interruptions.

Switch S4 is provided to give a choice of charge rates for the batteries. The low rate is set at approximately 7mA and the high rate at 20mA. These rates are controlled by resistors R33 and R32, respectively. If the watering function is not used, the low setting should be selected.

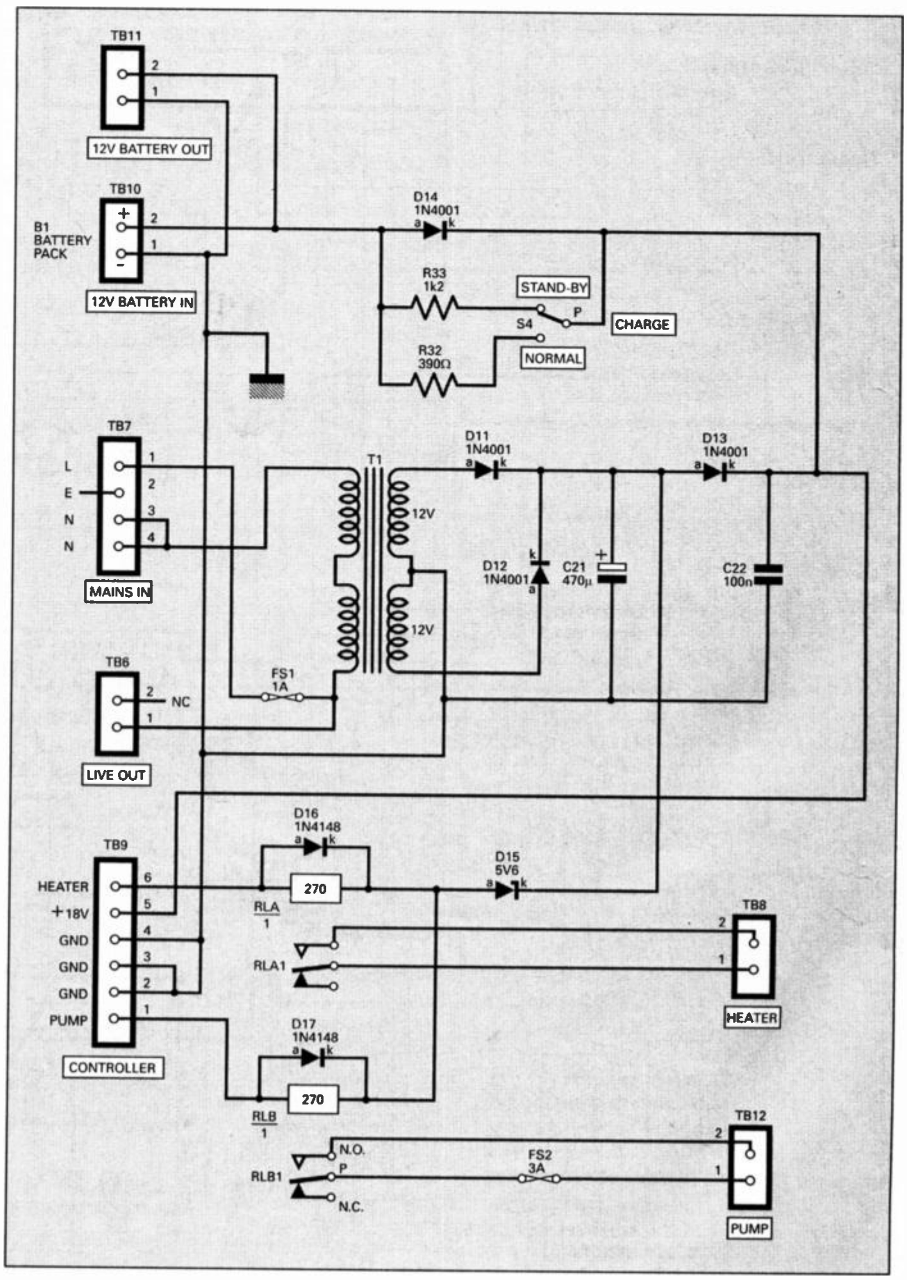


Fig.7. Recommended power supply circuit diagram for the Greenhouse Controller. The legends around the relay contacts indicate the pole or moving contact (p), the normal open (n.o.) and the normal closed (n.c.) terminal.

COMPONENTS

Approx. Cost Guidance Only £65

excluding transmitter and greenhouse hardware

Resistors

Items marked * are for the Radio Transmitter Interface (seetext).

R1*, R2*, R5*, R6*, R13 to R16, R18, R20	10k (10 off)
R3, R28, R29	1k (3 off)
R4	270Ω
R7 *	150Ω
R8, R12	2k7 (2 off)
R9, R10	150k (2 off)
R11	56k
R17, R22, R24, R30	100k (4 off)
R19	2k2 (see text)
R21	2k2
R23	2k
R25	2M2
R26, R27	NTC thermistor, 5k at 25°C, 300Ω at 100°C, B value 4100
R31	100Ω
R32	390Ω
R33	1k2

All 0·25W 5% carbon film unless marked.

Potentiometers

VR1	20k multiturn, top adjust.
VR2	1k multiturn, top adjustable

Capacitors

C1*, C8, C10 to C14, C22	100n ceramic disc (8 off)
C2*, C3, C15	10μ elect. axial, 25V (3 off)
C4, C5	33p ceramic disc (2 off)
C6, C17 to C20	10n ceramic disc (5 off)
C7	22n polystyrene
C9	47μ elect. axial, 16V
C16	1μ tantalum bead, 10V
C21	470μ radial elect., 25V

Semiconductors

D1*	3V3 Zener diode 400mW
D2, D3, D8	1N4148 signal diode (3 off)
D4 to D7	BAT85 Schottky diode (4 off)
D9, D10	red l.e.d.
D11 to D14	1N4001 rect. diode (4 off)
D15	5V6 1W Zener diode
D16, D17	1N4148 signal diode (2 off)
TR1*, TR6	BC547B *npn* transistor (2 off)
TR2*, TR5	BC557 *pnp* transistor (2 off)
TR3, TR4	BS170 MOSFET (2 off)
IC1	AT89C2051 pre-programmed microcontroller (see text)
IC2	4051B 1-of-8 analogue multiplexer
IC3	TLC272 dual op.amp
IC4	7805 5V 1A voltage reg.

Miscellaneous

FS1	1A 20mm fuse, plus p.c.b. mounting clip
FS2	3A 20mm fuse, plus p.c.b. mounting clip and cover
L1	4·7μH inductor, bobbin or axial
PL1	14-way IDC plug
RLA, RLB	s.p.d.t. relay, 12V 10A, p.c.b. mounting (2 off)
S1 to S3	s.p. push-to-make switch (3 off)
S4	s.p.d.t. min. slide switch, p.c.b. mounting
T1	transformer, 12V-0-12V 3VA, p.c.b. mounting
TB1	10-way terminal block, p.c.b. mounting, 0·2in. pitch
TB2, TB5	4-way pin header, 0·1in. pitch (2 off)
TB3, TB4, TB6, TB8, TB10 to TB12	2-way terminal block, p.c.b. mounting, 0·2in. pitch (7 off)
TB7	4-way terminal block, p.c.b. mounting, 0·2in. pitch
TB9	6-way pin header, 0·1in. pitch
TX1	TXM-418-F transmitter module (see text)
X1	12MHz crystal
X2	2-line 20-character l.c.d. module (+5V supply – see text)

Printed circuit boards, available from the *EPE PCB Service*, coded 197 (controller), 198 (power supply); 20-pin d.i.l. socket; 8-pin d.i.l. socket; 14-way IDC connector; plastic case, 154mm × 88mm × 58mm, waterproof; plastic case, 104mm × 104mm × 55mm, waterproof; 12V battery pack, AA-size rechargeable (1·2V cells, 10 off); cable gland, waterproof, locking (3 off); cable grommet, sleeved (3 off); miniature water pump, 12V, e.g. car windscreen washer pump; tubing to suit pump (e.g. 4mm for car washer pump); soil heating cable (see text); connecting wire; solder, etc.

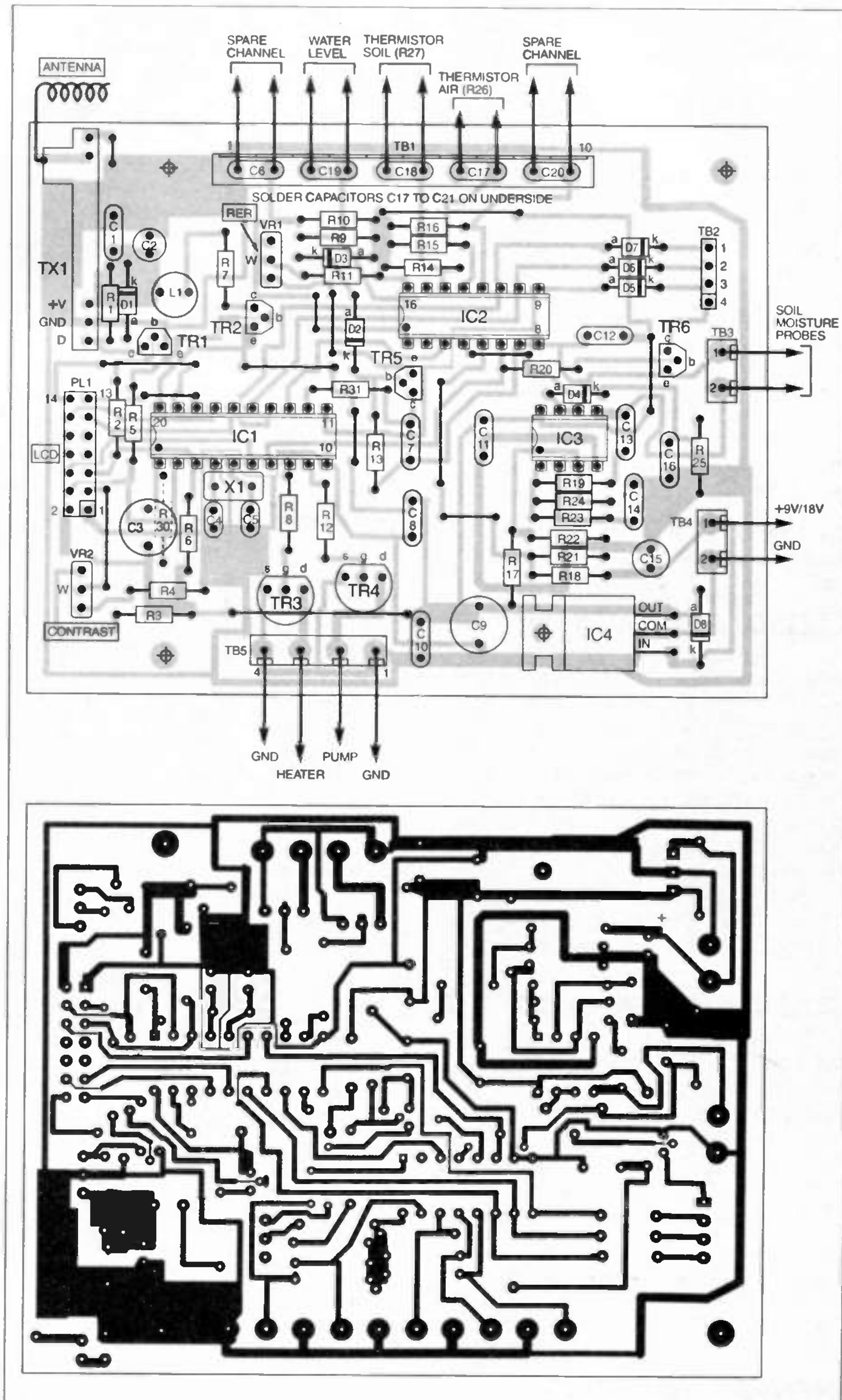


Fig.8. Printed circuit board component layout, wiring details and full size copper track master for the control board. Note R30 is soldered to underside.

CONSTRUCTION

Warning: parts of this circuit carry mains voltage. Take care when constructing and testing the design. If a heating cable is used, ensure it is one with an earth shield (i.e. one meant for this purpose). Remember that greenhouses can be wet, ensure that equipment is suitably protected. It is also advisable that all mains equipment in a greenhouse is protected by an earth leakage breaker (ELB or RCCB).

During assembly, if you have to desolder any components use the minimum amount of heat as tracks will lift easily.

There are two printed circuit boards (p.c.b.s), one for the main circuit and one for the power supply. Both boards are available from the *EPE PCB Service*, codes 197 and 198 respectively.

CONTROL BOARD

Start with the control board, layout and tracking details of which are shown in Fig.8. The usual order of links, resistors, diodes, capacitors etc. should be followed to simplify the assembly. There are a number of polarized components, take care to insert them correctly. Note that capacitors C17 to C21 and resistor R30 are soldered on the rear (trackside) of the board.

Transistors TR3 and TR4 are shown as BS170 MOSFETS, but in fact general purpose *npn* transistors can be used in their place, such as BC547 for example.

Inductor L1 is shown as a bobbin type, but you can use an axial one by standing it on its end. Regulator IC4 should be mounted face up, i.e. metal tab against the board.

Use d.i.l. sockets for IC1 and IC2. Use good quality sockets, especially if you are developing code yourself, as the processor may be in and out a few times. If you are developing your own code, use two sockets for the processor. When removing the processor, remove it in a socket, therefore if you damage a pin, it will be a socket pin, not a processor pin!

If you are going use the radio interface to be described in the last part, it would probably be best to populate all the components now, with the *exception* of the radio module and its antenna. If you are not intending to build it, omit the components associated with it.

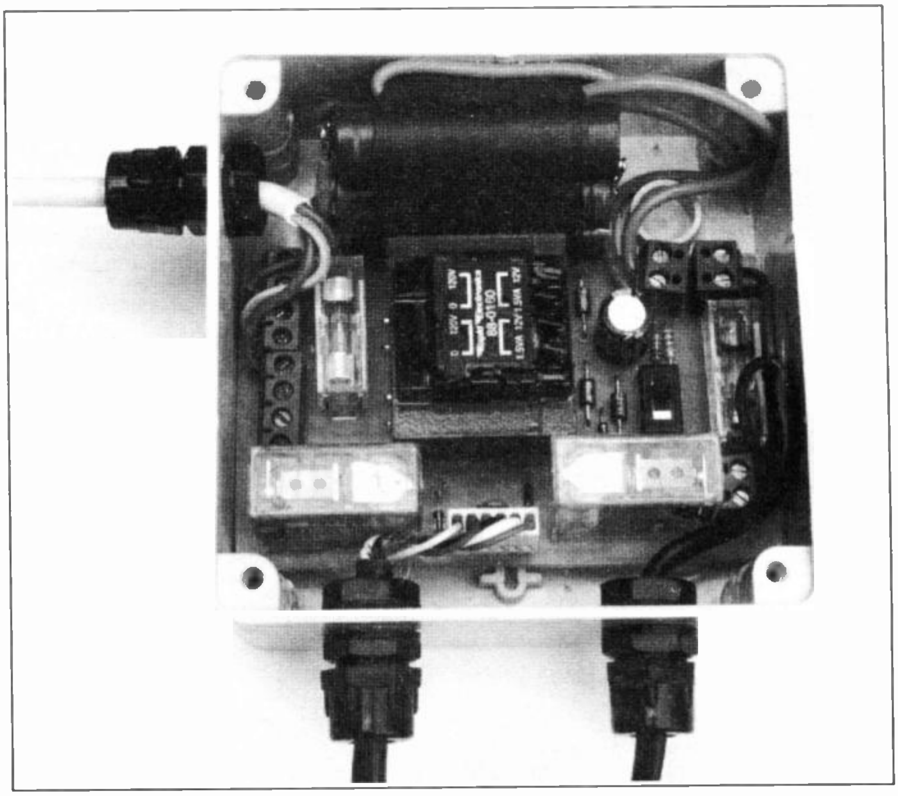
All the off-board connections are made via connectors rather than directly soldering wires to the p.c.b. This adds a little to the cost but makes testing and installation much simpler.

Connection to the l.c.d. is made by a 14-way ribbon cable with an IDC connector at the control board end. The connection at the other end will depend on the l.c.d. used, you may be able to use an IDC connector at the other end too. Some l.c.d. connections are a single row of 14 rather than 2 × 7, but in either case the connection numbering is the same.

PSU ASSEMBLY

For the power supply board (p.s.u.) follow the layout shown in Fig.9. Take care to ensure the diodes are inserted the correct way round.

Pin-outs for the transformer secondary vary between suppliers. The p.c.b. tracks have been laid out so that modifications can be made easily.



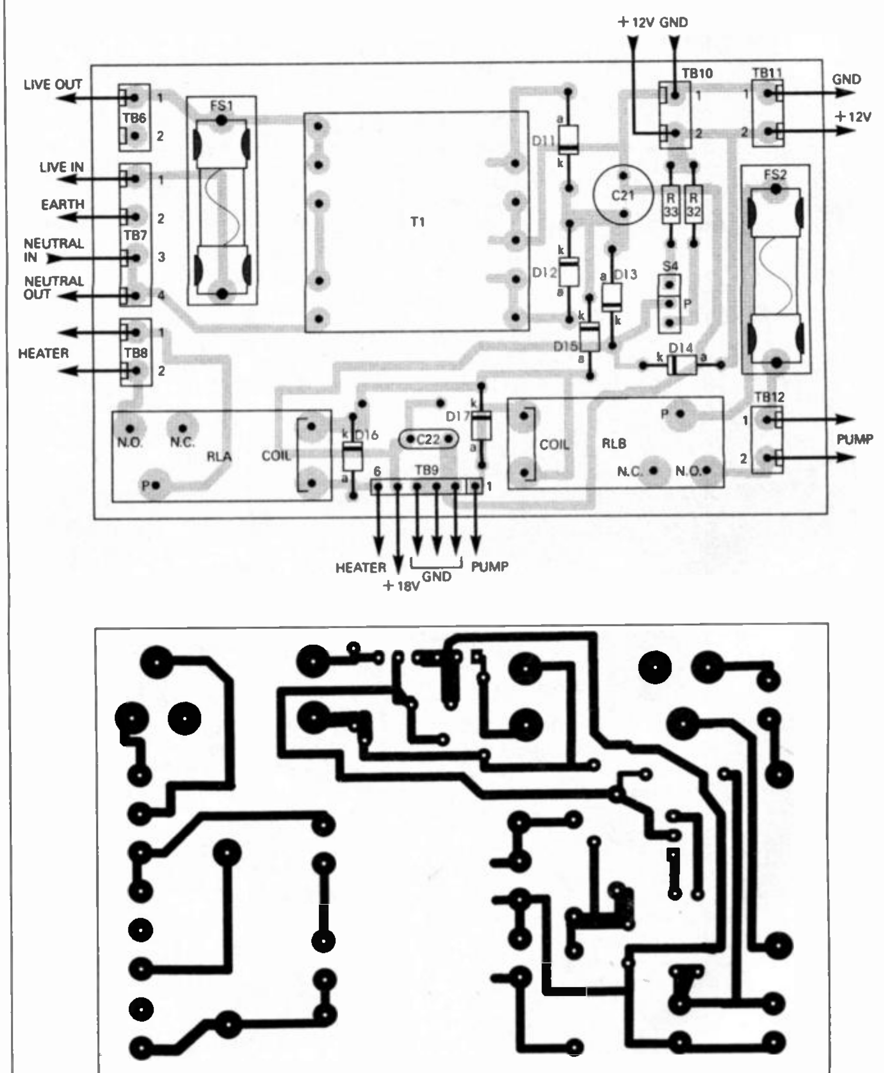


Fig.9. Power supply printed circuit board component layout, wiring details and full size copper foil track master. The completed p.s.u. is shown at the top.

It is suggested that ten rechargeable cells are used for battery back-up. These will produce a total output voltage of 12V to 13V (1·2V apiece). Most pumps will work between 11V and 14V.

For safety purposes, ensure the mains fuse (FS1) has a cover and is not an open type fuseholder.

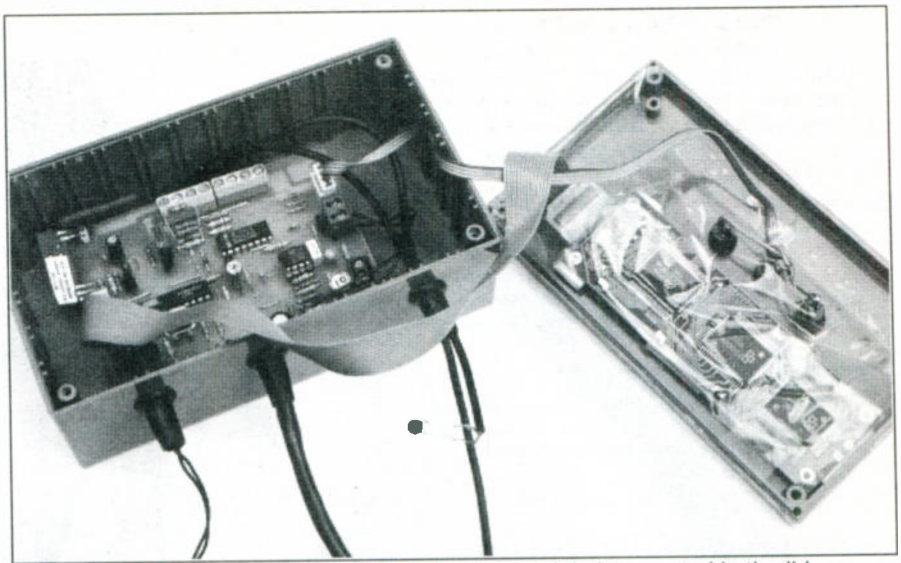
SOFTWARE

The software source code is written in C. The main reason for using C was for speed and maintainability (the original design was experimental and a number of changes were envisaged and implemented).

Despite being written in C, the code is very efficient (few library functions are used to make the code more efficient). Although writing the code in assembler might have resulted in slightly more efficient use of the ROM, the advantages of writing in a high level language often outweigh the disadvantages.

Because it is written in a high level language, the code is much more readable and, therefore, if you want to make changes you should find it reasonably simple (providing you have C facilities, of course).

However, if you want to make changes to the code, some functionality may have to be sacrificed, as every byte in the available code space is currently used! Note that if you do alter the code you *must* keep the variables in the same order if you want to use the Radio Interface.



Completed controller unit. The display module is mounted in the lid.

RESOURCES

Software for the Greenhouse Computer is available from the *EPE* Editorial Office on a 3·5 inch disk, order as PIC-Disk 1. See *EPE PCB Service* page for postage charges.

The software is also available free from our Web site:
ftp://ftp.epemag.wimborne.co.uk/pub/8051/Greenhouse

Controller IC1 is available as a pre-programmed device direct from the author: Colin Meikle, 9 Coldstream Drive, Strathaven, Lanarkshire, ML10 6UD. Make cheques payable to him. The price, inclusive of UK postage is £12 (add £1 for overseas post).

You can also contact the author via E-mail at **colin.meikle@virgin.net**.

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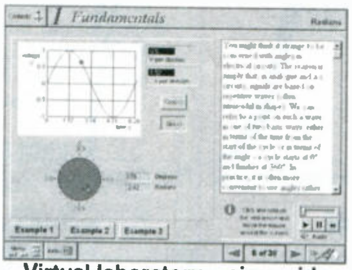

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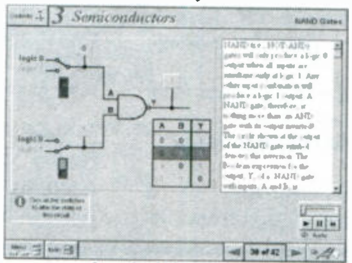

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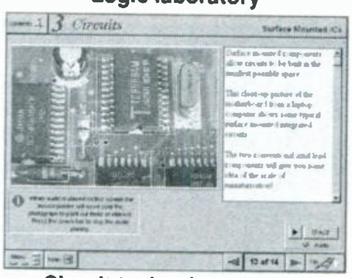

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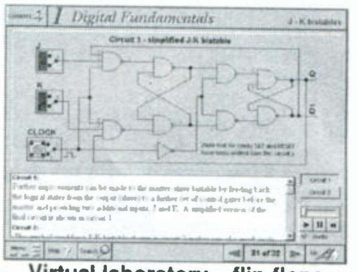

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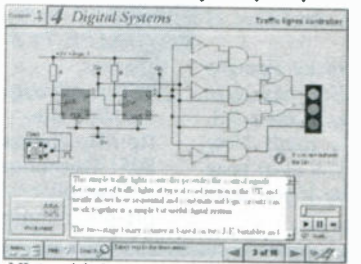

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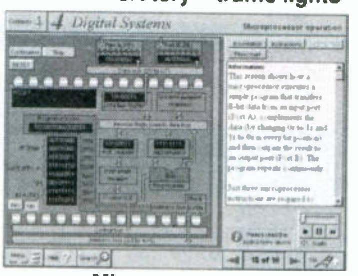

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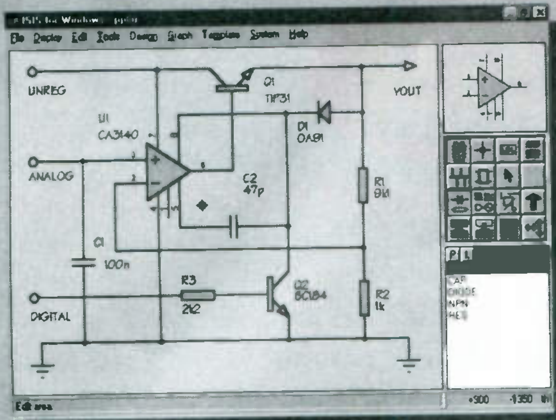

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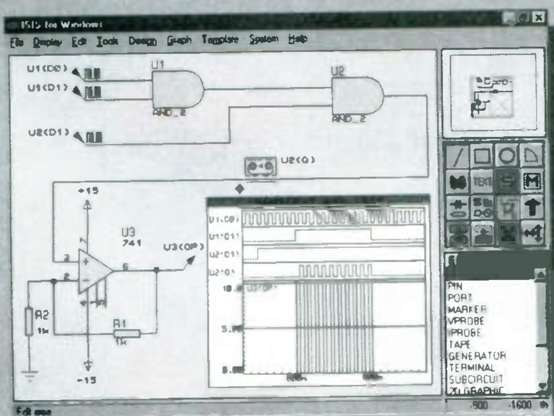

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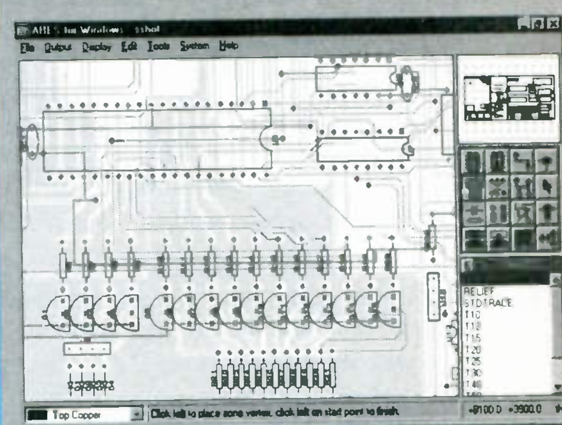

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John Becker addresses some of the general points readers have raised. Have you anything interesting to say? Drop us a line!

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TUT, TRIS AND TASM

Dear EPE,

Nice to see the *PIC Tutorial* in the mag, just what we've been waiting for. I have programmed a few 16C84s but some *EPE* projects have left me a little non-plussed! Like when I bought an l.c.d. module that met all the criteria stated in the *How to Use Intelligent L.C.D.s* article (Feb/Mar '97), but could I get it to work?!

Looking at the code on page 194 March '97, I now understand why this code never worked for me. Where, oh where, is the page switching code to drive and control Port B?

I very much welcome PIC-Tutor, I've already learned something from Part 1 as I didn't realise the significance of PAGE switching for port control and output. Keep up the good work chaps!

Incidentally, I have in fact been using TASM for many years to program the good old Z80 CPU, having developed and built a Z80 development system.

Mel Saunders, Leicester

Your l.c.d. might, perhaps, be failing to initialise correctly when power is first applied and the software run. I favour a different command sequence to that published in March '97 (there are several ways it can be done). Try the sequence published in the Tutorial Part 3.

It is unlikely that Paging is the cause. The use of TRIS in the March '97 code is an alternative to the PAGE instructions I discuss in the Tutorial, and having the same effect.

Command TRIS is one which I felt it best not to include in the Tutorial as Microchip recommend that, although it is available in the PIC16C84 set, it should not be used in order to maintain upward compatibility of code with later devices, which do not include the command.

Whilst I have not used TRIS as a command, the PIC Data Book says that "all Port pins have data direction bits (TRIS registers) which can configure these pins as output or input". The use of TRIS with a Port A or Port B address directly accesses these bits.

The March '97 code you refer to has the following statements (with revised comments from me):

```
CLRF 05      ; clear PORTA
CLRF 06      ; clear PORTB
MOVLW 0F8    ; load W with %11111000
TRIS 05      ; to set RA0 to RA2 as
             ; outputs
             ; and RA3, RA4 as inputs
MOVLW 00     ; load W with 0
TRIS 06      ; to set RB0 to RB7 as
             ; outputs
```

This seems to me to have the same effect as what I would write for the same function (having defined all names in the initialisation heading):

```
CLRF PORTA
CLRF PORTB
PAGE1
MOVLW %11111000
MOVWF TRISA
CLRF TRISB
PAGE0
```

I'm interested to learn of your use of TASM with other processors, it is a versatile assembler.

CHARACTER PIC

Dear EPE,

I am considering using a PIC to control a circuit which generates alphanumeric characters on segmented l.e.d.s. I need to have two digit select lines, six data inputs, eight outputs to l.e.d. segments and four outputs to the l.e.d. common electrodes, a total of 20 lines required to create characters from 0 to 9 and A to Z.

However, the PIC16C84 only has 13 I/O lines and is thus not suited to the design. The next device size up, the PIC16C57 I think, has two 8-bit ports and one 4-bit port, but you have not yet covered this PIC in the same detail as you have the '84 and I am not familiar with its use. Can you help? It would also be useful if you published a table of info on the various PICs.

John Gray, London N10 2NU

First, unless many readers suggest otherwise, we cannot immediately see the benefit of covering non-EEPROM type PICs in the same detail as given to the '84. The '84 justified the coverage because of its ease of immediate reprogrammability. Other PICs are less easy to experiment with as they require time-consuming erasure by UV-light.

The information we gave in the '84 Tutorial, though, is basically applicable in terms of coding to other PIC members and anyone familiar with the '84 should be able to use other PICs in conjunction with their own data sheets. As far as physically programming them is concerned, it is advisable to use Microchip's MPASM/MPLAB hardware/software suite which covers all PIC devices.

Returning to your character drive problem, you are assuming that an '84's 13 lines cannot be used in your 20-line requirement. Not so!

Remember that each line can have its input/output direction changed from within a program, which thus provides you with the equivalent of 26 lines to play with, as long as you take suitable precautions to prevent conflict between the devices on the lines when in bi-directional use. This may be as simple as simply using biasing or current limiting resistors, or may require the addition of external signal routing gates. Your imagination and a data book of logic devices should be used jointly for the latter!

Furthermore, you do not need to control external devices by parallel output data from the PIC. You could consider serial control using just two of the PIC's lines, one for Data, one for Clock. You might need a third as a Latch control, but that's still only three lines, leaving ten available.

This would allow SIPO (serial-in, parallel-out) shift registers to be used in series fed by data from the PIC with their outputs controlling the segments. Some of the other lines could be used to control common electrode multiplexing if desired. For the latter, three lines could control eight common electrodes via a 3-to-8 gate plus transistor drivers.

Obviously, 7-segment displays cannot be used for all the characters you want, but alphanumeric displays are readily available (Maplin, for example), as are matrixed multi-l.e.d. modules.

Regarding PIC info tables, you appear to have missed our giant PIC Data Chart given away free as part of the Jan '98 issue – we still have some back issues available (see Back Issues page).

Complete PIC data is available from Arizona Microchip Technology Ltd., Microchip House, 505 Eskdale Road, Winnersh Triangle, Woking, Berks RG41 5TU. Tel: 0118 921 5800. Fax 0118 921 4820. Web: http://www.microchip.com.

TEN CHEERS

Dear EPE,

I have just seen your web site support for PIC projects, and thanks very much!

Now I have ordered three PICs after studying many of your past PIC projects. I have electronics experience and some programming ability too, so, together with your excellent tutorial/intro projects and articles, am confident of many happy hours fiddling with PICs.

I also intend making your *Simple Dual Output TENS Unit* (March '97) for my sister and I appreciate the info you've put on your web site. I'll be directing her to the site to read for herself too.

Thanks very much, it's magazines like yours that keep electronics alive, may you be most successful.

David Vandenberg, via the Net

Thanks. PICs and TENS projects have proved incredibly popular.

★ LETTER OF THE MONTH ★

REVERSING THE TIDE

Dear EPE,

I sympathise with Mark McGuinness in his sadness over the (apparent) decline of electronics as a hobby (*Readout* April '98), but wonder whether his culprits (PC simulations and low cost consumer electronics products) are the whole of the reason. He has concentrated on the education of electronics, and there are a lot of hobbyists like me who only got interested in electronics after finishing formal education.

I followed an arts course at school, so I only had a rudimentary exposure to physics and that was in the early 1960s: I learned Ohm's Law, how to determine which magnetic pole would appear at which end of a coil when current was passed through it, and which way the current had to flow to electroplate something. All good stuff, but hardly a complete foundation for electronics.

What got me interested in electronics was an aunt buying me a build your own transistor radio kit for a Christmas present just after I left school. It was Medium Wave only, had only a handful of components and needed an aerial the length of a washing line for a reasonable reception, but it did have a circuit diagram as well as wiring instructions. I got curious about how these components could produce music, but only when they were wired up the way the instructions said.

At that time all the books in the public library and the hobby magazines available described valve circuits and, whilst I was interested, it was not until I encountered transistor circuits and discovered Veroboard that I constructed anything. It became a real challenge to lay out components on Veroboard within the limits of the wires on the components, yet cutting the least number of tracks.

I also learned to improvise on circuits provided for other purposes. When I slowed down an oscillator of a tone generator to one cycle a minute and used it to switch an SCR my battered Ford Cortina had an intermittent wipe facility!

Bigger and better things followed and I also learned Murphy's Law: that if there is a construction fault, the component ruined is either the most expensive or the most difficult to get a replacement for, and that the only dry joint in a circuit is the one you forget to check. Computer simulations can't provide that sort of education!

The pinnacle of my hobby was probably the solid state room thermostat with 15 transistors to generate a variable mark/space ratio according to the temperature differential, and providing zero voltage switching of a SCR man enough for a 2kW electric fire.

Then suddenly everything published was using integrated circuits. Circuits became a few passive components surrounding a mystery with a dual-in-line pin layout, and they only make sense once it is established from data sheets whether "IC1" is a timer, a NAND gate, an op.amp or whatever. The hobbyist is provided with pre-designed circuit boards and is deprived of the underlying basic principles of a circuit and so the fascination is lost.

I can understand why interest in electronics might be waning: I have constructed very little recently. I can also understand why PIC projects have reversed the tide. I have been following the Tutorials avidly, because once again I can see, instruction by instruction, why a circuit works, and the potential for variants of the basic idea.

For the non-PIC projects, I have a suggestion. Patents and copyrights permitting, why not show one circuit occasionally with the equivalent of the resistor, transistor, capacitor internals of the i.c.s, so that it is possible to see both what a circuit does, and why it does it. And by building a component equivalent of an i.c., the hobbyist can not only appreciate the complexity inside an i.c. but can test voltages, currents, etc. at intermediate points to aid understanding. Chips with everything is not good for anyone.

J.F. Warren, Bath

It is the fascination with "how and why things work" that has been the inspiration for many who have taken up electronics as a hobby and/or career. There does seem, though, to be a general malaise amongst the UK public in an apparent unwillingness to question or delve into the nature of such things. Indeed it almost seems to be a proud claim amongst some that they do not understand technology and have no wish to do so. I am frequently left fuming by some media personalities, and politicians, who seem to boast about having this attitude.

It is a lamentable outlook that is in danger of keeping us on the path towards becoming a mere service-providing nation rather than one that is a technological innovator and producer. Whatever has happened to the enquiring attitudes that prevailed in the days of Brunel, Stevenson, Babbidge and Faraday, and even more recently with figures like Frank Whittle, Alan Turing, Clive Sinclair and Trevor Baylis? (Readers, who are your recent British heros/notables in science and technology?)

To return to immediate practicalities, it is gratifying that the PIC Tutorials should provide you with insights that you have found missing. We do try to explain how things work in many other ways as well. However, the state of electronic technology has now reached the point at which demonstrating exactly how a modern device such as a simple logic chip or a complex microprocessor works in terms of individual transistors etc. has become impossible.

It would also be meaningless at the very least, and incomprehensible at the most (even if one could actually draw it on a large enough sheet of paper). The sheer quantities of transistor-like components in a modern digital chip (7·5 million in the Pentium II processor) prohibit simple illustration of current and voltage flows and their effects.

It's not like the days of the Eagle *comic that I was brought up on in the 1950s – it used to show cut-away illustrations of how all sorts of things worked. You can't slice open a microprocessor to reveal how it works. Sometime, though, we might try to give a hint of the complexity – if we can find something simple enough!*

To begin to understand modern electronics, you have to start well down the ladder of sophistication. To this end we publish such series as Teach-In *and* PIC Tutorials *from which we hope readers will grasp the fundamentals, and can then begin to comprehend how the basic principles might be expanded to achieve such things as simple wipe devices at one end, to sophisticated microcontrolled marvels at the other.*

Irrespective of what non-technophiles might believe, to me two things continue to remain clear: that technology is a fascinating subject, and that its basic principles can be understood if one has the inclination to look into them. Always encourage an enquiring mind!

CHARGING THE FENCE

Dear EPE,

I have been a reader and user of your top rate magazine for 15 years and have never seen a design for an electric fence charger/energiser. Have you a circuit diagram using, perhaps, an automobile coil for the charge oscillator?

Peter Thorpe, via the Net

Following our E-mailed reply to Peter that it was not something we had come across, he responded:

That's rather disappointing. I would have thought that a magazine with your stature would have direct access to electronics engineers who could provide the relevant info.

Whilst we do have access to designers, the cost of supplying individual designs to meet the needs of readers is excessive, and an electric fence charger is not a project that would have wide appeal. When we have already published a design, then we can obviously supply information, but we cannot offer a design service.

However, if quite a few readers ask for a particular design, we do take steps to try and satisfy that need, suggesting to some of our regular contributors that they might consider doing a project. It's up to them, though, as to whether or not they follow up our suggestion.

Also (and not many readers know this, perhaps), many larger reference libraries might well be able to help. Where a design concept and its possible solutions are within the public domain, the information is often available in published form and held at selected libraries (they tend to specialise in subjects). It's a facility well worth researching.

Returning to fences, can any readers help on this design problem?

EVERYDAY PRACTICAL ELECTRONICS BACK ISSUES

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DID YOU MISS THESE?

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PROJECTS ● Pacific Waves ● How To Use Intelligent L.C.D.s, Part 1 ● PsiCom Experimental Controller ● Earth Resistivity Meter, Part 2 ● Theremin MIDI/CV Interface, Part 2.
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MARCH '97

PROJECTS ● Simple Dual-Output TENS Unit ● Video Negative Viewer ● Tri-Colour NiCad Checker ● How To Use Intelligent L.C.D.s – 2 ● Oil Check Reminder.
FEATURES ● Interface ● Ingenuity Unlimited ● Build Your Own Projects, Part 5 ● Digital TV – The Reality ● Circuit Surgery ● Net Work.

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FEATURES ● Interface ● Ingenuity Unlimited ● Digital TV and MPEG2 ● EDWin NC Software Review ● Circuit Surgery ● Net Work.

MAY '97

PROJECTS ● 2 Metre F.M. Receiver ● EPE PIC-A-Tuner ● Alarm Operated Car Window Winder ● Quasi-Bell Door Alert ● PIC-Agoras – 2.
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JUNE '97

PROJECTS ● PIC Digilogue Clock ● Child Minder Protection Zone ● Pyrotechnic Controller ● Narrow Range Thermometer.
FEATURES ● Great Experimenters – 2 ● Circuit Surgery ● Interface ● Reactobot and Virtual Reality ● Ingenuity Unlimited ● Net Work.

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PROJECTS ● Micro PEsT Scarer ● Karaoke Echo Unit ● Infra-Red Remote Repeater ● Computer Dual User Interface ● Micropower PIR Detector – 1.
FEATURES ● Ingenuity Unlimited ●Techniques – Actually Doing It ● Circuit Surgery ● Great Experimenters – 3 ● Electronics Workbench V5.0 Review ● Net Work.

AUG. '97

PROJECTS ● Variable Bench Power Supply ● PIC-olo Music Maker ● Universal Input Amplifier ● Micropower PIR Detector – 2.
FEATURES ● Interface ● Ingenuity Unlimited ● Colossus Recreated ● Circuit Surgery ● Great Experimenters – 4 ● Net Work.

SEPT '97

PROJECTS ● PIC-Noughts & Crosses Game ● Ironing Safety Device ● Active Receiving Antenna ● Soldering Iron Controller ● Micropower PIR Detector – 3.
FEATURES ● Ingenuity Unlimited ● Raising the Pressure – RC4190 Switch-Mode I.C. ● Circuit Surgery ● Techniques – Actually Doing It ● Great Experimenters – 5 ● Net Work.

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PROJECTS ● Safe and Sound – Security Bleeper ● Active Microphone ● Car Immobiliser ● Mini Organ.
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FEATURES ● TEACH-IN '98 – An Introduction to Digital Electronics–3 ● Circuit Surgery ● Ingenuity Unlimited ● Alternative and Future Technologies–2 ● Net Work – The Internet ● *Free* – Giant PIC Data Chart.

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M7/98

INTERFACE

Robert Penfold

TEAM QUIZ MONITORING VIA THE PRINTER PORT

I HAVE noticed over the years, that for every project you design there is always at least one reader who requires a slightly modified version. It could simply be that some *EPE* readers like being awkward, but the more likely reason is that most projects can be used in a variety of ways, and it is tempting to customise them to precisely match your requirements.

One of the main advantages of do-it-yourself electronics is that you can tinker with the designs in an attempt to make your ideal gadget. Sometimes a simple modification is all that is needed in order to make a project operate in the fashion required by the reader. In other cases a totally different approach is needed.

Pressing Needs

A recent reader's letter inquired about a quiz monitor. A conventional four-station device of this type was described in a recent issue of *EPE* (Oct '97), and a multi-station PC based system was featured some time ago in an *Interface* article. In both cases they were designed for standard television style quizzes where the first person to press their pushbutton switch gets the opportunity to answer the question.

The reader required something rather more sophisticated than this, with the monitor indicating who pressed first, second, third and fourth. Presumably, if the first contestant answered the question incorrectly, or was unable to answer it at all, whoever pressed second would be given a chance, then whoever pressed third and fourth.

This may seem to be simple enough, but it cannot be implemented as simply as a basic "first past the post" quiz monitor. Well, this is certainly true of the system based on conventional logic circuits, but it can be implemented quite simply using some form of computer-based system. The hardware can then be kept to the minimum, with the complexities being handled by the software.

The hardware for a PC-based system of this type can consist of little more than the four pushbutton switches themselves. The system I devised uses the ultra-simple circuit of Fig.1.

Four pushbutton switches (S1 to S4) are connected to data lines D0 to D3 (pins 2 to 5) of the PC printer port. The printer port must be capable of bi-directional operation because the data lines are used as inputs. Internal pull-up resistors take the inputs high under standby conditions, but operating one of the switches takes the relevant input low.

At switch-on, the data lines will default to the output mode. Protection resistors R1 to R4 provide current limiting if someone should operate one of the switches while data lines are in the output mode.

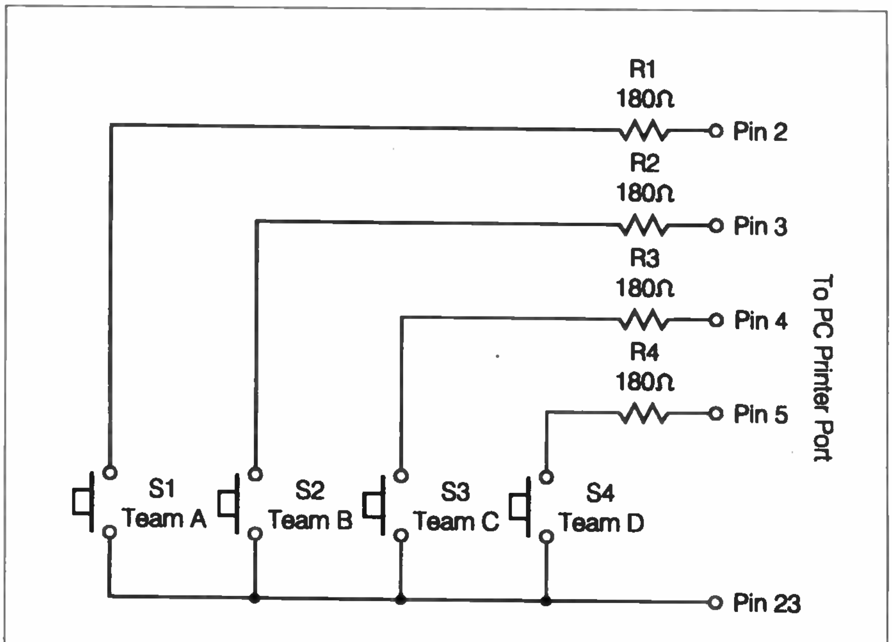


Fig.1. Circuit diagram for the Quiz Monitor interface.

Quiz monitors are mainly used for teams rather than individual competitors, and it will normally be more convenient to have an individual switch for each team member rather than just a single switch for each team. This is easily achieved, and it is just a matter of replacing the individual switches with banks of pushbutton switches wired in parallel.

The circuit diagram in Fig.2 shows how the single switch for team A can be replaced by a bank of four pushbutton switches. Operating any of these switches pulls the relevant data line low and activates the system. In theory at any rate, any number of switches can be used. Of course, all four stations would have to be modified in the same way.

The connections to the printer port are made by way of a 25-way male D-type connector (Fig.3). As this project uses very few components there is probably no point in bothering with a circuit board. The four resistors can simply be hard wired to the D-connector.

The switches are mounted in individual cases, and a project of this type inevitably has a lot of cables. The most practical approach would probably be to have the printer port connected to a sort of junction box, with the switches connecting to the junction unit via something like 3·5mm jack plugs and sockets.

Software

The accompanying program listing will run under GW-BASIC or QBasic. Lines 20 and 30 set variables PORT1 and PORT2 at the appropriate values for the printer port addresses. Where appropriate, these addresses should be changed to &H378 and &H37A or

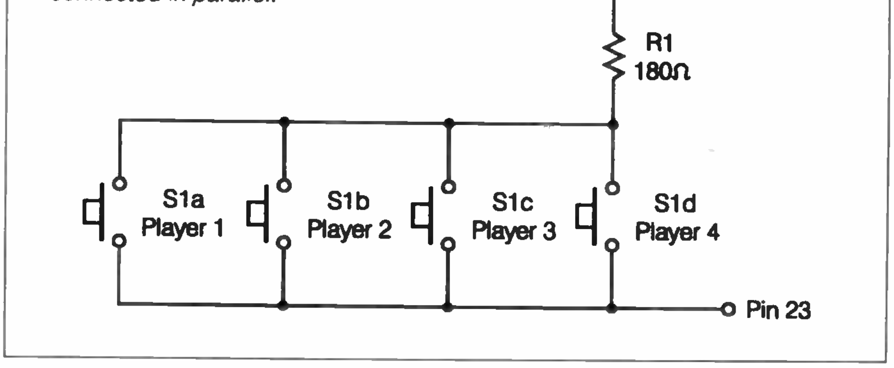
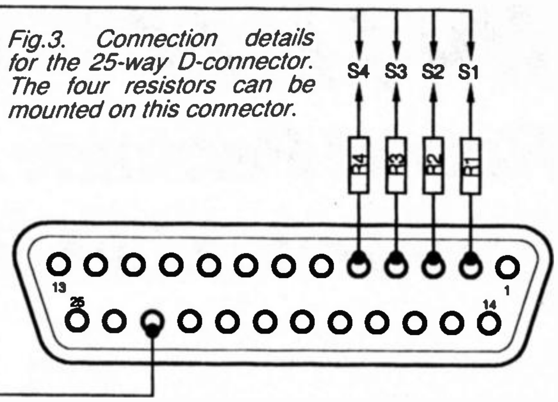


Fig.2. Each team can have several switches connected in parallel.

Listing 1

```
10 REM 1st, 2nd, 3rd, 4th Press Quiz Monitor Prog
20 PORT1 = &H278
30 PORT2 = &H27A
40 OUT PORT2,32
50 CLS
60 LOCATE 1,10
70 PRINT "PRESS R KEY TO RESET OR S KEY TO
STOP PROGRAM"
80 LOCATE 5,10
90 PRINT "FIRST TO PRESS IS                "
100 LOCATE 10,10
110 PRINT "SECOND TO PRESS IS              "
120 LOCATE 15,10
130 PRINT "THIRD TO PRESS IS               "
140 LOCATE 20,10
150 PRINT "FOURTH TO PRESS IS              "
160 A = 1
170 B = 1
180 C = 1
190 D = 1
200 P = 1
210 X = INP(PORT1)
220 IF (X AND 1) = 0 THEN GOSUB 290
230 IF (X AND 2) = 0 THEN GOSUB 380
240 IF (X AND 4) = 0 THEN GOSUB 470
250 IF (X AND 8) = 0 THEN GOSUB 560
260 IF INKEY$ = "r" THEN GOTO 80
270 IF INKEY$ = "s" THEN END
280 GOTO 210
290 IF A = 2 THEN RETURN
300 IF P = 1 THEN LOCATE 5,32
310 IF P = 2 THEN LOCATE 10,32
320 IF P = 3 THEN LOCATE 15,32
330 IF P = 4 THEN LOCATE 20,32
340 PRINT "TEAM A"
350 A = 2
360 P = P + 1
370 RETURN
380 IF B = 2 THEN RETURN
390 IF P = 1 THEN LOCATE 5,32
400 IF P = 2 THEN LOCATE 10,32
410 IF P = 3 THEN LOCATE 15,32
420 IF P = 4 THEN LOCATE 20,32
430 PRINT "TEAM B"
440 B = 2
450 P = P + 1
460 RETURN
470 IF C = 2 THEN RETURN
480 IF P = 1 THEN LOCATE 5,32
490 IF P = 2 THEN LOCATE 10,32
500 IF P = 3 THEN LOCATE 15,32
510 IF P = 4 THEN LOCATE 20,32
520 PRINT "TEAM C"
530 C = 2
540 P = P + 1
550 RETURN
560 IF D = 2 THEN RETURN
570 IF P = 1 THEN LOCATE 5,32
580 IF P = 2 THEN LOCATE 10,32
590 IF P = 3 THEN LOCATE 15,32
600 IF P = 4 THEN LOCATE 20,32
610 PRINT "TEAM D"
620 D = 2
630 P = P + 1
640 RETURN
```

Fig.3. Connection details for the 25-way D-connector. The four resistors can be mounted on this connector.



&H3BC and &H3BE (see *Interface* May '98). The next two lines set the printer port to input operation and clear the screen.

After this, some simple instructions are printed at the top of the screen. Below this, on separate lines and well spaced out, the program prints "FIRST TO PRESS IS", "SECOND TO PRESS IS", and so on. If team C is the first to respond to a question, the program will print "TEAM C' immediately after "FIRST TO PRESS IS". If team A is the next to respond, the program prints "TEAM A" immediately to the right of "SECOND TO PRESS IS", and so on.

One slight problem the software must overcome is that once a switch has been activated and read, it will not be released immediately. Therefore, once a switch has been read and the appropriate message has been printed on the screen, that switch must be ignored until another round of questioning is commenced. This is achieved by giving each switch a variable (variables A to D), and starting that variable with a value of 1.

The routines that write "TEAM A", etc. on the screen check that the appropriate variable is at 1, and only proceed if it is. At the end of the routine the variable is set at 2, thus ensuring that multiple operations of the routine are avoided.

Obviously the system will only perform correctly if the routines print the team identifications in the correct places on the screen, and variable P controls this function. Initially this is set at 1, but it is incremented by 1 each time a switch is operated and a message is printed on the screen. A series of conditional instructions print the message on the screen at a point that is dependent on the value of P.

For example, by the time the third switch is operated variable P will have been augmented to a value of 3. This results in the message being printed on line 15, to the right of the "THIRD TO PRESS" message.

Port Reading

The input port is read at line 210, and the next four lines check inputs D0 to D3, one-by-one. If a switch has been operated, the program branches to the appropriate subroutine, the correct response is printed on the screen, two of the variables are incremented, and the program then returns to the main loop.

Once the switches have been operated, pressing the "R" key resets the program. This is detected at line 260, and from here the program branches back to line 80. Lines 80 to 150 then return the screen to its original state by overwriting the appropriate areas with spaces. The variables are returned to their original values and the program functions as before.

Pressing the "S" key exits the program (line 270), or the usual CONTROL-BREAK combination has the same affect.

TEACH-IN '98

An Introduction to DIGITAL ELECTRONICS

Ian Bell, Rob Miles, Dr. Tony Wilkinson, Alan Winstanley

TEACH-IN is a series designed to support candidates following City and Guilds (C&G) 726 Information Technology, with reference to the following specific syllabuses: ***7261/301 Introductory Digital Electronics, *726/321 Elementary Digital Electronics, *726/341 Intermediate Digital Electronics.**

Even if you are not undertaking the City and Guilds syllabus, there is much to be learned from *Teach-In*.

Lab Work

Throughout *Teach-In*, attempts are made to involve the student with practical "Lab Work" experiments and demonstrations, and complex mathematics will be avoided unless really necessary – and even then, plenty of help is to hand! We make a point of identifying practical components in special sections of *Teach-In*, so that you will learn to recognise parts.

Part Nine: COUNTERS AND SHIFTERS

IN PART 8 we designed a number of 3-bit binary counters, both asynchronous and synchronous. We have used an intuitive approach (this means that we make up the designs as we go along) looking at the patterns of 1s and 0s in the binary count sequence to derive rules about how they changed and hence the logic we required.

A combination of intuition, reasoning and experience often serves a designer well, but there are always problems which due to their size, complexity or simple lack of obvious patterns defeat this approach. In such cases we need more systematic techniques if we are to obtain the circuit required. To illustrate this we will show how you can design a simple 3-bit counter using a systematic approach.

Recall our introduction to sequential logic in Part 6, where we described a traffic light control circuit in which combinational logic was used to work out what the next pattern of lights in the sequence was to be. Fig.9.1 shows our counter drawn in the same form, and in fact any synchronous logic circuit can be drawn in a similar way.

We need to design the combination circuit which works out the next number in the count sequence from the current one. We can start by writing out the Truth Table for the "Next Value" in terms of the "Current Value". Each value has three bits in our counter so we effectively need three truth tables, one for each bit of the next value. We will label the current bits C2, C1 and C0 and the next value bits N2, N1 and N0. A combined truth table is given in Table 9.1.

Now we can use any combinational logic design technique we like to obtain the circuits for getting N2, N1 and N0 from C2, C1 and C0.

Looking at the truth tables it is obvious that $N0=\overline{C0}$ but N1 and N2 need a bit more work. We can use K-maps for N1 and N2 as shown in Fig.9.2.

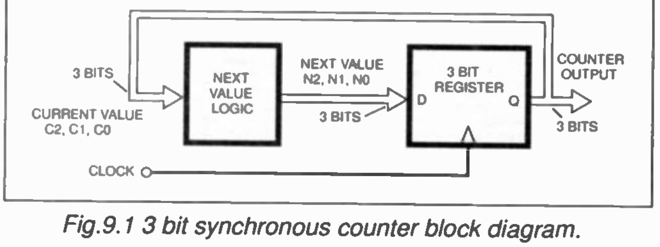


Fig.9.1 3 bit synchronous counter block diagram.

Table 9.1 Truth table for next value logic for 3-bit binary up counter

CURRENT VALUE			NEXT VALUE		
C2	C1	C0	N2	N1	N0
0	0	0	0	0	1
0	0	1	0	1	0
0	1	0	0	1	1
0	1	1	1	0	0
1	0	0	1	0	1
1	0	1	1	1	0
1	1	0	1	1	1
1	1	1	0	0	0

From the K-maps for N1(a) we see two loops. Loop 1 is $\overline{C1}\cdot C0$ and loop 2 is $C1\cdot\overline{C0}$. So we get $N1=\overline{C1}\cdot C0+C1\cdot\overline{C0}$ which is the XOR function, i.e. $N1=C1\oplus C0$. Experienced designers may have spotted the XOR function directly from the Truth Table or K-maps.

From the K-map for N2 (b) we see three loops. Loop 3 is $\overline{C2}\cdot C0\cdot C1$, loop 2 is $C2\cdot\overline{C0}$ and loop 1 is $C2\cdot\overline{C1}$. So for N2 we get:

$$N2=C2\cdot\overline{C0}+C2\cdot\overline{C1}+\overline{C2}\cdot C0\cdot C1 \quad (1)$$
$$=C2\cdot(\overline{C0}+\overline{C1})+\overline{C2}\cdot(C0\cdot C1) \quad (2)$$
$$=C2\cdot(\overline{C0\cdot C1})+\overline{C2}\cdot(C0\cdot C1) \quad (3)$$
$$=C2\oplus(C0\cdot C1) \quad (4)$$

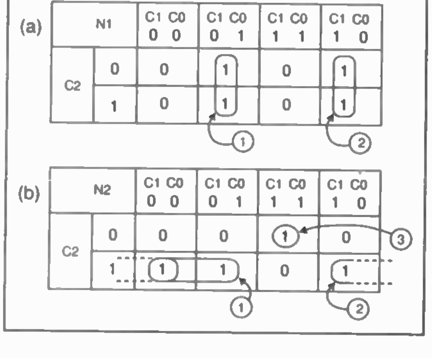


Fig.9.2 (left) K-maps for 3-bit binary synchronous up counter

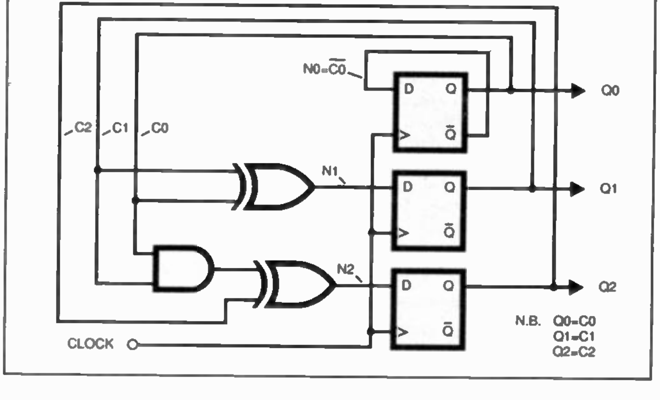


Fig.9.3 (right) 3-bit binary synchronous up counter.

We could use any form of the N2 equation to build the circuit. The XOR form we derived above corresponds with Fig.8.16. The third version of the N2 equation corresponds with Fig.8.14. The final circuit developed from these equations is given in Fig.9.3.

Ups and Downs of Counters

So far all the counters have been 3-bit up counters which have served well to illustrate most of the design issues, but in reality we often need more bits and additional features such as count/inhibit controls. Perhaps one immediate question is how do we count *down*.

If we repeat our observation of patterns in the binary numbers we find that an asynchronous down counter is obtained simply by using positive edge clocks instead of negative. This is shown in Fig.9.4, in which the toggle flip flop can be either form as for the up counter shown in Fig.8.9 of the previous part.

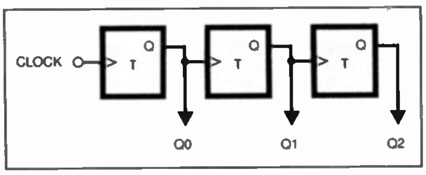


Fig.9.4. A 3-bit binary asynchronous down counter.

If availability of either positive and negative edge clocked flip-flops is limited the $\overline{Q}$ outputs of the flip-flop can be used to give the same effect as the opposite clock edge. An inverter will also be needed at the input if the counter itself requires the opposite clock edge. The use of $\overline{Q}$ and negative edge clocks to form a down counter is shown in Fig.9.5.

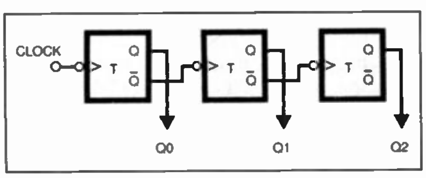


Fig.9.5. A 3-bit binary asynchronous down counter using negative edge triggered flip-flops.

We can use the fact that choosing between Q and $\overline{Q}$ to drive the next clock alters the direction of counting to obtain an up/down counter. The circuit is shown in Fig.9.6 and consists of an asynchronous counter with a multiplexer to select the clock source for each flip-flop.

The circuit used in Fig.9.6 is actually rather difficult to use because the control logic is connected to the flip-flop clocks. Any glitches (tiny pulses caused by timing problems in the logic) on the up/down selector will clock part of the counter. Furthermore, simply changing direction may also cause unwanted changes in the counter's flip-flops.

Synchronous up/down counters do not suffer from this problem. To obtain a synchronous down counter we could either observe that a bit changes when all lesser bits are zero or use a systematic design technique. Either way we can arrive at the circuit shown in Fig.9.7.

You should be able to see the symmetry between Fig. 8.13 and Fig.9.7, noting that the control logic has shifted across to the $\overline{Q}$ outputs. We can obtain a synchronous up/down counter by using multiplexers connected to the JK inputs which select between the up and down control logic.

Since the flip-flops are not clocked by the JK inputs glitches or changes in the up/down control cannot directly affect the state of the counters. The circuit is shown in Fig.9.8.

It's Size that Counts

How do we make counters larger than 3-bits? Basically it's more of the same. The asynchronous counter is just a chain of flip-flops. You can make it as long as you like but you must remember the "ripple" delay and the intermediate outputs.

For a synchronous counter it is simply a matter of designing the next value logic, intuitively or systematically. However, from the patterns we have discussed so far it should be clear that a 4-bit counter requires a 3-input AND gate connected to the three least significant bits to control the fourth bit. By logical extension a 24-bit counter would require a 23-input AND gate for the most significant bit. This gets rather cumbersome but fortunately is not necessary.

We noted in Part 5 that a large AND or OR gate could be built from a set of smaller ones, and in the counter we already have the AND function for the previous stages. All we have to do is add a two input AND gate to add the next stage to the existing AND function. This is illustrated in Fig.9.9 which shows a five-bit synchronous up counter.

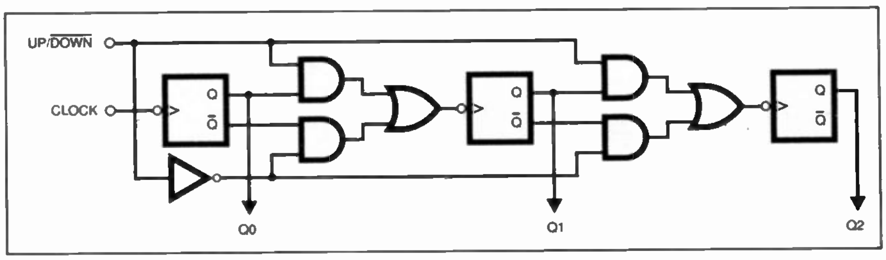


Fig.9.6. A 3-bit binary asynchronous up/down counter.

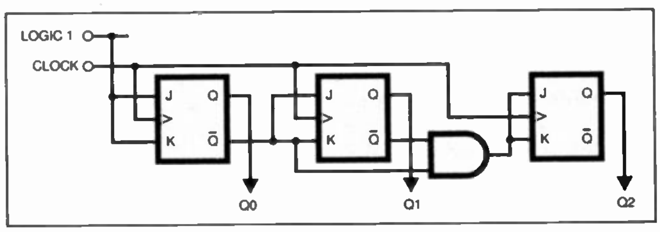


Fig.9.7. A 3-bit binary synchronous down counter.

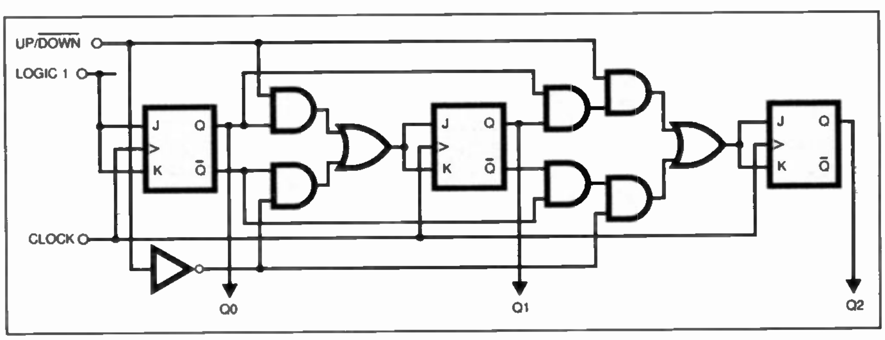


Fig.9.8. A 3-bit binary synchronous up/down counter.

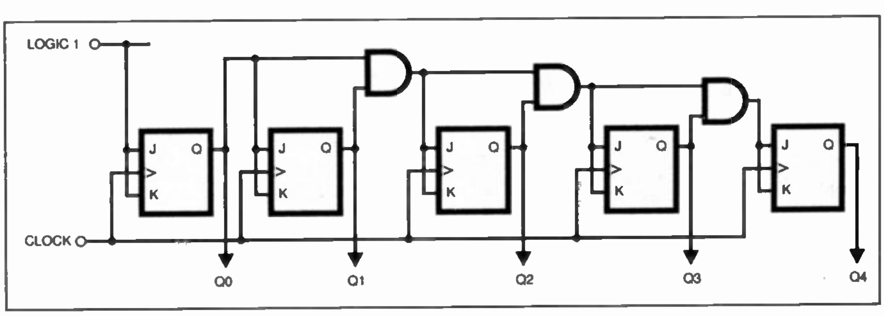


Fig.9.9. A 5-bit synchronous up counter.

If we extend the circuit in Fig.9.9 to a large number of stages we get a problem with the chain of AND gates slowing the circuit down. For example, the clock to a 24-bit counter would have to be slower than 23 gate delays plus one flip-flop delay.

A compromise between the multi-input AND and AND chain approaches provides the best solution. It also helps us build counter blocks which are readily cascaded to form larger counters.

You will find that 7400 and 4000 series synchronous counter i.c.s are often 4-bit but can be connected together to form larger counters. To form cascadable counter "blocks" we need to be able to inhibit the counter (so that a given counter block can stop subsequent blocks when required).

A synchronously controlled inhibit input is generally useful as it provides a means of stopping the counter without having to gate the clock (gating the clock is susceptible to glitches). We also need an output to indicate when the counter block has reached full *count* – which is when the next block needs to count.

A 4-bit counter with an inhibit ($\overline{INH}$) input and a *terminal count* (TC) output is shown in Fig.9.10. (Note that the terminal count is also called the *carry-out* on some counters). These four-bit counter blocks can be cascaded to form larger counters as shown in Fig.9.11.

Synchronous Counter Chips

The 40163 and 74163 i.c.s are examples of 4-bit cascadable synchronous counters. The inhibit circuitry in these circuits is slightly different from that in Fig.9.10. These chips have two enable inputs, both of which must be high for the counter to count. One of the enables connects directly to the TC logic. The two inputs are ANDed together to provide control of the count.

This idea is illustrated in Fig.9.12a, but note this is not a full schematic of these chips (check the databooks for the full story). Fig.9.12b shows how these chips are cascaded.

The 74193 is a synchronous up/down counter which has two clocks – one for up and one for down. For the circuit to function correctly, the clock input which is not being used must be high.

For example, to count down the up clock is set high and the down clock is pulsed. The two clocks must never change at the same instant.

The circuitry used by the 74913 to achieve dual clocking is shown in Fig.9.13, this can be connected to an up/down counter like the one shown in Fig.9.8.

Loaded Counters

It is sometimes useful to be able to load a particular number into a counter, for example so that we can count down from any value to zero. To do this we need a *presettable counter*.

There are a couple of ways of doing this and we will be discussing this in more detail in the context of shift registers later (the basic principles are the same). For the moment let's consider Fig.9.14, this shows a block diagram of a presettable counter.

The multiplexer (MUX) is used to select whether the count logic outputs or the data inputs are loaded into the counter's flip-flops when they are clocked. The 40163 and 74163 i.c.s are presettable using an active low load enable control which is independent of the count enables.

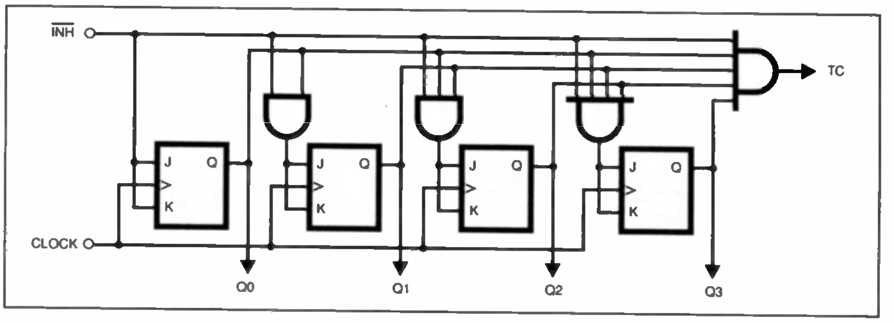
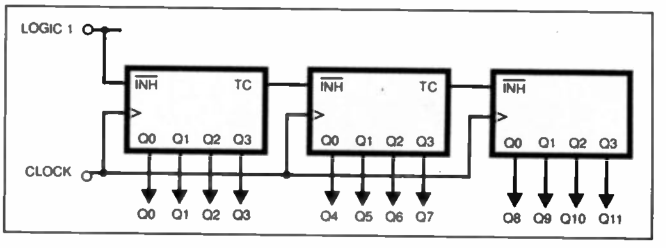


Fig.9.10. Cascadable 4-bit binary synchronous up counter.

Fig.9.11. A 12-bit binary synchronous up counter using three copies of the circuit from Fig.9.10.



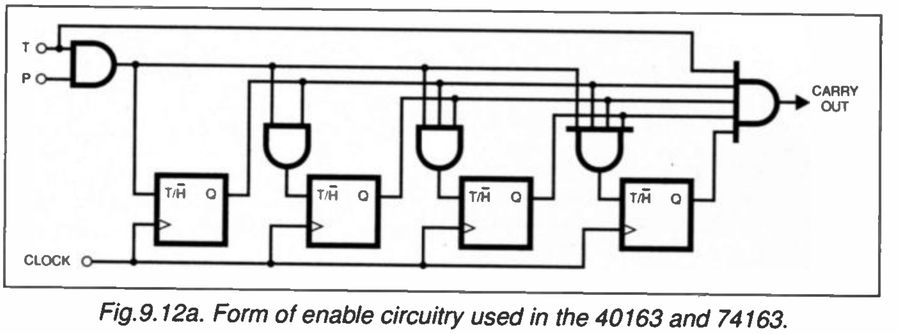


Fig.9.12a. Form of enable circuitry used in the 40163 and 74163.

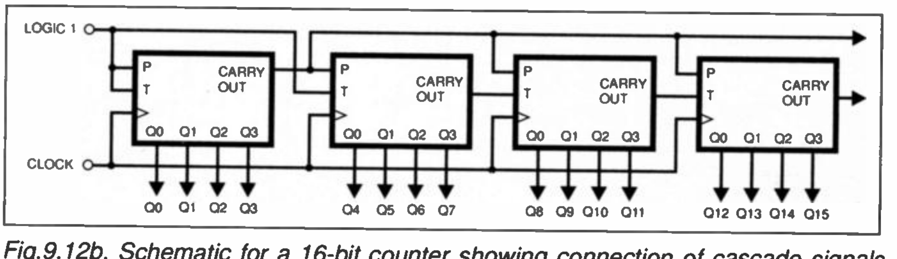


Fig.9.12b. Schematic for a 16-bit counter showing connection of cascade signals for 40163 and 74163 i.c.s. Not all the chip pins/functions are shown.

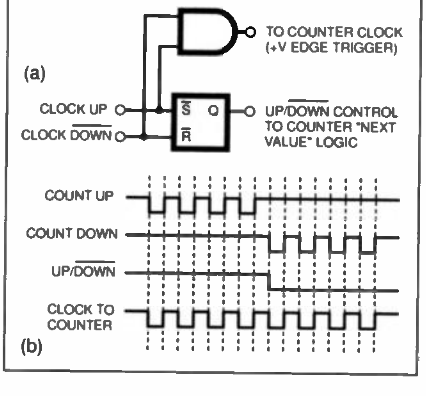


Fig.9.13 (left). Circuit to provide a dual clock for a synchronous up/down counter, (a) schematic and (b) timing diagram. As used in the 74193 i.c.

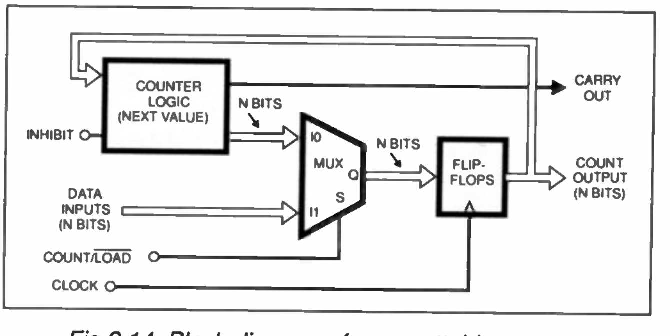


Fig.9.14. Block diagram of a presettable counter.

Any Number You Like

All the counters so far have been binary, but we may require other counter types, for example BCD (Binary Coded Decimal). A BCD counter has 4-bits and counts from 0000 (0) to 1001 (9) and then returns to 0.

There are a number of ways of achieving this. First, we can use a binary counter with a combinational circuit to detect when the counter's output is 10 (1010) and use this to activate the asynchronous reset. This is illustrated in Fig.9.15 together with its timing diagram.

The timing diagram illustrates the problem with this approach – the output of the counter is 10 briefly before the reset takes effect. This problem can be overcome by using a synchronously reset counter. Such a counter could use the synchronously resettable flip-flop described in the previous part.

The reset is applied when the count occurs and takes effect on the following clock pulse. The schematic and timing diagram are shown in Fig.9.16.

An alternative approach would be to use the systematic design technique described earlier and design the BCD counter from scratch. You could use this technique to design counters which not only count a limited range of numbers, but also circuits which produce output sequences other than straightforward binary counting.

For example, you could design a circuit to count in steps of three rather than one (why not have a go!). In fact with the appropriate logic in the "next value" box in Fig.9.14 or Fig.9.1 you can produce any arbitrary "count" sequence. Just write down the list of current and next values and churn out the circuits using K-maps.

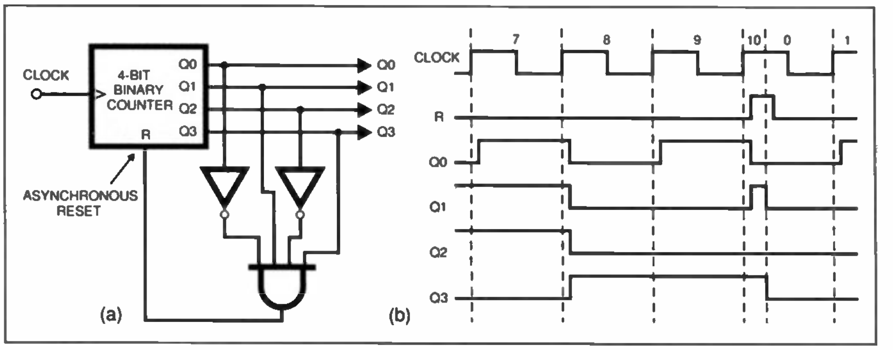


Fig.9.15. BCD Counter (a) schematic representation (b) timing diagram.

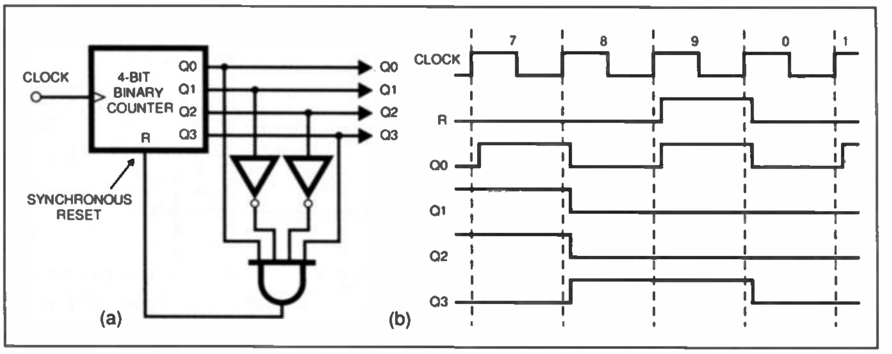


Fig.9.16. BCD Counter without false output (a) schematic (b) timing diagram.

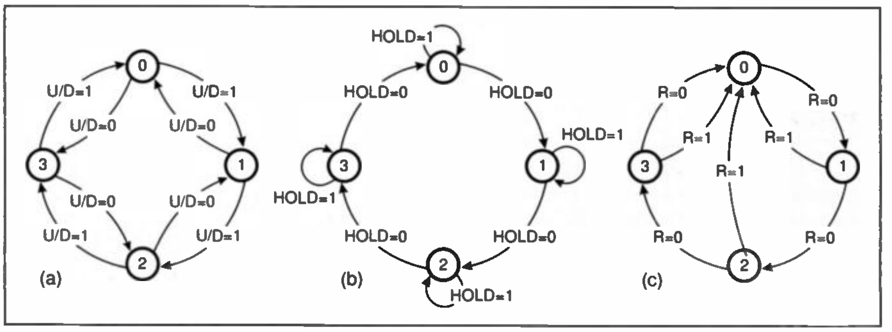


Fig.9.17. State diagrams for 2-bit binary counters: (a) up/down counter which counts up with UD = 1 and down when UD = 0 counter with enable/inhibit input. (b) Counts when hold = 0 counter with synchronous reset. (c) When R = 1 the counter is reset on the next clock edge.

Getting Into a State

At the start of our discussion on counters we showed you a state diagram for a 3-bit binary up counter (Fig.8.6). Diagrams like this become extremely useful when you want to display how control inputs can change the way that a counter behaves. They provide a good way of defining and visualising what the counter will do when it gets a clock pulse in any of its states.

For each state we draw a circle, with an arrow leaving that state for each possible next state. We can then label each arrow with the logical condition which will send it down that particular path. Fig.9.17 shows the behaviour of an up/down counter (a), a counter with a hold control (b) and a synchronously re-settable counter (c).

Serial Data

The registers we have met so far load all their bits simultaneously from a set of *parallel* inputs. Similarly, all bits are available in parallel at the outputs. To transfer data from one register to another we need one wire per bit.

This is simple, fast and very convenient, as long as the distances involved are not too great, so within chips and equipment we find parallel multi-bit buses as we have previously described. Over longer distances the cost of the cable becomes prohibitive and if we wanted to use radio we would have to use eight different channels (frequencies) to send 8-bit data.

Sending 32-bit values down phone lines in parallel would require 32 telephones! In such situations we must send the data *one bit at a time* in what is called *serial* data transfer. At any given instant the signal will reflect the state of one-bit of the parallel data you want to send. Parallel data is often converted into serial data for transmission, and then re-constructed at the receiving end.

One way of getting serial data from a parallel source is to use a multiplexer as in Fig.9.18a. A multiplexer lets you select one of several inputs as its output. The input that you want the multiplexer to send out is selected by a number of control lines. By selecting each input in turn the parallel data bits appear in sequence on the multiplexer's output as shown on the timing diagram in Fig.9.18b.

The select signals could be obtained from a two-bit binary counter synchronised to count through a complete cycle for each input data word. Each bit would be sent out in turn and received by a complementary circuit at the other end of the serial connection.

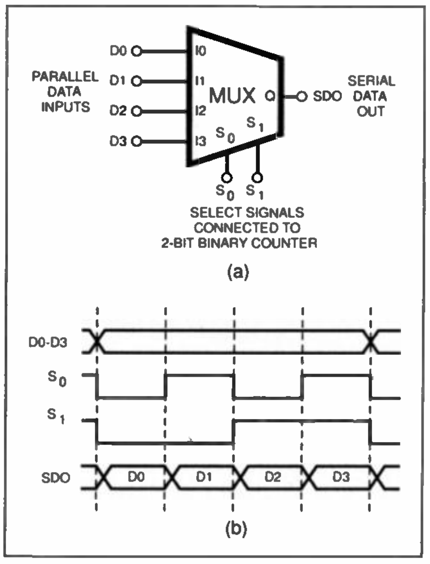


Fig.9.18a. Creating Serial Data with a multiplexer. (b) Timing diagram for data transfer.

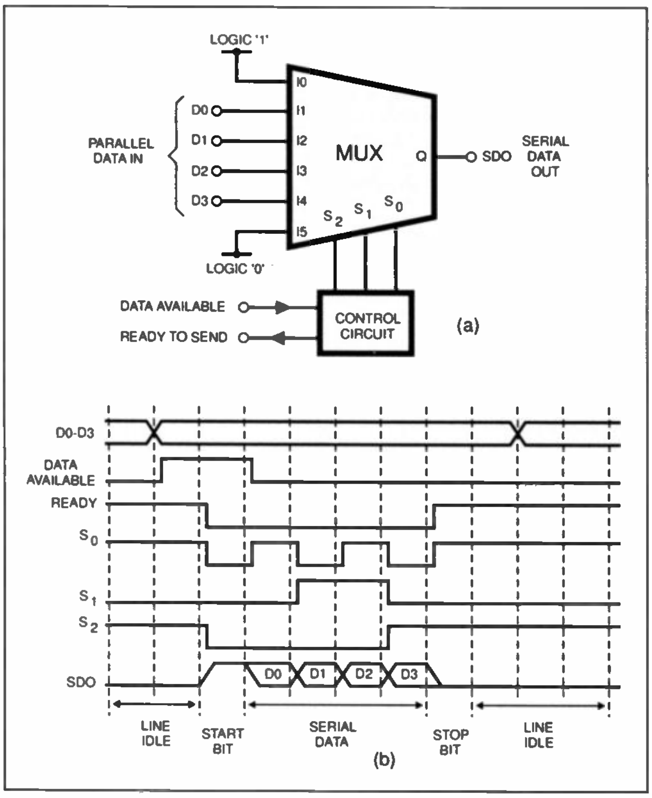


Fig.9.19. Improved serial multiplexer which adds start and stop bits needed for synchronous transfer. (a) schematic (note inputs I5 and I7 of 8-input multiplexer not used). (b) timing diagram.

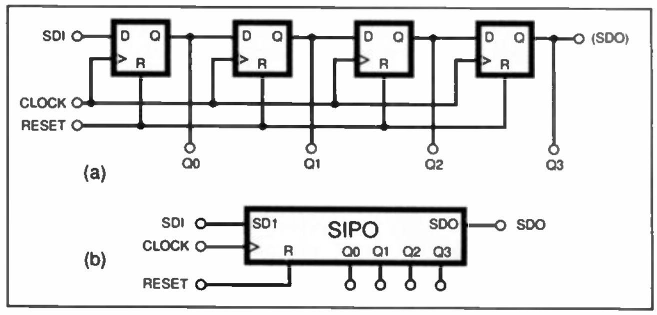


Fig.9.21 Serial In Parallel Out shift register.

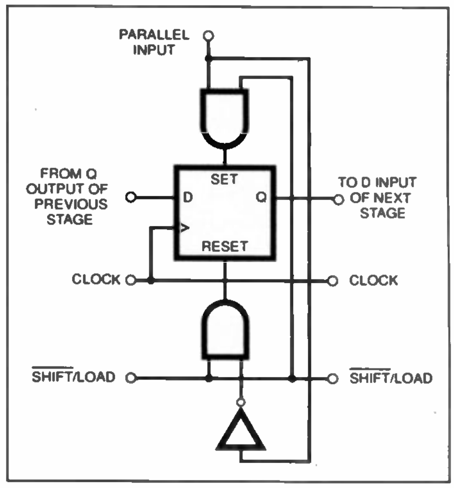


Fig.9.22. One stage of a parallel (PISO) load shift register.

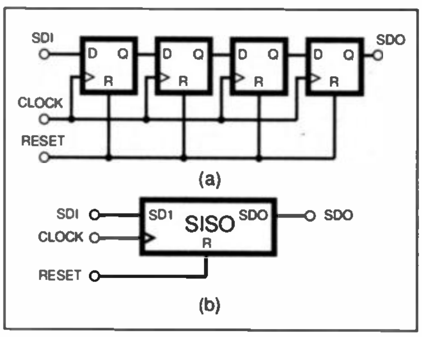


Fig.9.20. Shift Register implemented as a chain of flip-flops (a) schematic (b) symbol.

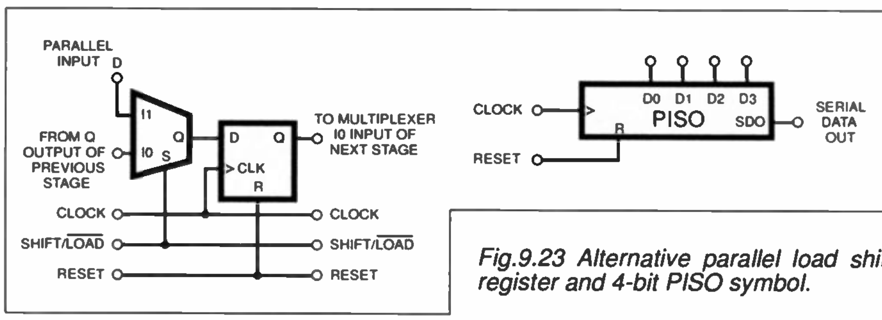


Fig.9.23 Alternative parallel load shift register and 4-bit PISO symbol.

Package Deal

A problem with the circuit in Fig.9.18 is that it is impossible to know when one data word ends and the next starts simply by looking at the serial data. We need to send the S0 and S1 signals too. This means that the simple system in Fig.9.18 needs at least three signals (plus a ground) to transmit the data.

This problem is overcome by creating a recognisable start and end to each block of parallel data on the serial output. This forms what is called a ***data packet***. The simplest way of doing this is to put an extra bit at each end, say a 1 at the start and a 0 at the end. These are called ***start*** and ***stop*** bits.

This is illustrated in Fig.9.19 which is similar to Fig.9.18a but with two extra inputs to the multiplexer. To convert the data from the parallel inputs to serial form, the multiplexer select lines count through the sequence from 0 to 5. This causes a 1 (start bit) to be output followed by 4 data bits and then a zero (the stop bit). The select lines are then held at 5 until the next parallel data is to be transmitted so that the send line remains at 0.

The select lines connected to a control circuit are shown in Fig.9.19. This receives a signal indicating that parallel data is awaiting transmission. When it is ready the controller counts through 0 to 5 on the select lines as described. When it has finished it outputs a signal to indicate it is ready to send the next data packet.

With the lines at zero when no data is present the receiver simply looks for a 1 which will be the start bit of a packet. As long as the speed at which the data is sent (baud rate, in bits per second) is known at the receiver there is no need to transmit select signals or clocks.

All the receiver has to do is look for the start bit and wait the appropriate time before reading the data bits. The stop bit ensures that the line is idle for a short while so that the receiver can detect the 0 to 1 (in this case) transition which indicates the start of the next data packet, even if it follows immediately.

The fact that the transmitter and receiver have separate clocks which they use to send and receive the data (i.e. they are not synchronised together) means that we refer to this form of data transfer as *asynchronous*.

Shifting Data with Shift Registers

To convert data from serial to parallel we could use a de-multiplexer and a set of independently controlled latches, however an alternative approach is to use a ***shift register***, which can be loaded using serial data. We can also use shift registers to convert parallel data to serial by loading the data in parallel (as in a normal register) and shifting out in serial form.

The most basic form of the shift register is simply a "chain" of D-type flip-flops as shown in Fig.9.20. On each positive clock edge (in our example) data is passed from each flip-flop to the next one in the chain. The data in the final flip-flop is "lost" unless it is stored elsewhere.

The first flip-flop is connected to the *serial input* (labelled ***SDI*** – Serial Data In) in Fig.9.20, and the last flip-flop is the *serial output* (labelled ***SDO***). This type of shift register is called a **SISO** (***Serial In Serial Out***) shift register.

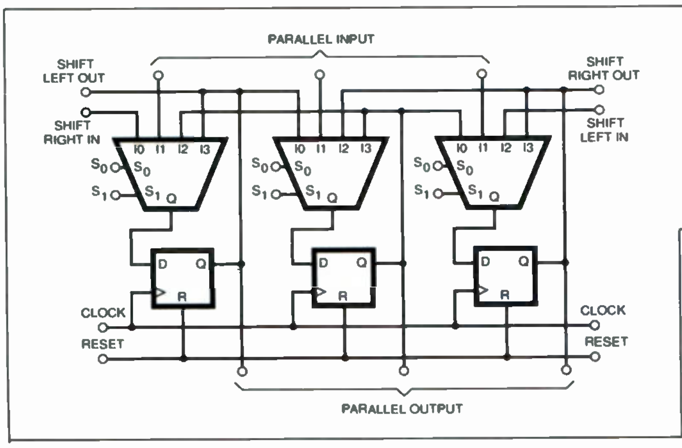


Fig.9.24. Three-stage (parallel/serial, in/out, left/right), four mode shift register.

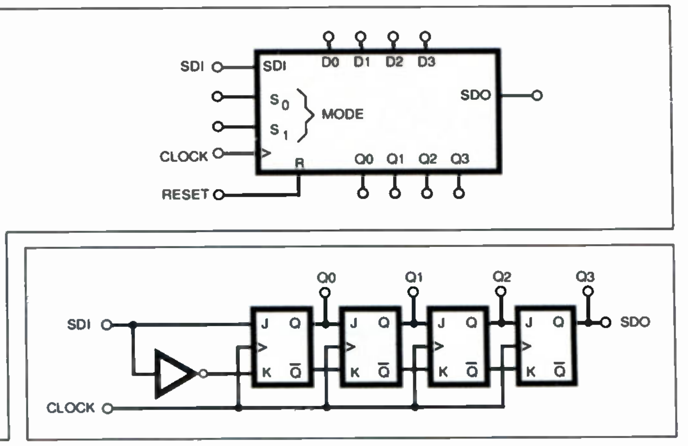


Fig.9.25. Shift register from JK Flip-Flops.

It is easy to obtain a parallel output from a shift register simply by using the Q outputs from all of the flip-flops, giving us a Serial In Parallel Out or *SIPO* shift register. This is shown in Fig.9.21.

Shift registers may also have parallel inputs (so that we get **PISO** and **PIPO** shift registers), but this requires some extra circuitry. There are two basic approaches to this. The first is shown in Fig.9.22 which is one stage of a parallel-load shift register.

If the shift/load line is low the circuit acts as a shift register, shifting data on the clock edge. When the shift/load line is high the parallel input directly influences the asynchronous set/reset inputs of the flip-flops. On the negative transition of the shift/load the data at the parallel inputs is latched into the shift register irrespective of the state of the clock input.

Thus, for Fig.9.22 shift/load acts as an asynchronous parallel load clock. The 74165 8-bit shift register's internal circuitry is based on this design.

Multiplexed

Another approach to parallel loading, and that most commonly used in the 4000 and 7400 series of i.c.s is to use a multiplexer on the D input of each flip-flop. This is shown in Fig.9.23 where shift/load selects either the previous stage (when it is high) or the parallel input (when it is low) for connection to the flip-flop's input.

Unlike Fig.9.22 the load operation for Fig.9.23 is synchronous. When shift/load is low data is loaded on the clock edge. The internal circuitry of the 7495 and 4035 i.c.s (both 4-bit) are based on this approach. The TTL 7495 uses a logic gate (similar to Fig.5.4a) multiplexer and the 4035 uses transmission gates (similar to Fig.5.4b).

So far we have described all our shift registers as moving data in one direction (left to right across the page in our schematics). Sometimes we may want to shift in both directions using the same register. This is easily achieved by using an extension of the multiplexer arrangement used for parallel load in Fig.9.23. Three stages of a shift register which has four modes of operation are shown in Fig.9.24.

The four modes correspond to the four inputs of the multiplexers connected to the flip-flops' inputs. The multiplexer select inputs are all connected together but this is not drawn on the diagram to prevent crowding it too much. The modes of operation are as follows:

S0	S1	Operation	Multiplexer Input Used
0	0	Shift Right	I0
0	1	Parallel Load	I1
1	0	Shift Left	I2
1	1	Hold	I3

You should be able to confirm these operations by tracing the multiplexer input wires on the schematic. This type of multi-function shift register is sometimes called a ***universal shift register***.

All the shift registers we have encountered so far have been made using D-type flip-flops. We can use JK flip-flops by connecting the Q of one stage to the J of the following stage and the $\overline{Q}$ to the K. This is shown in Fig.9.25.

Shifting for Fun and Profit

We have described serial data transfer and this is obviously a potential use for the shift register, however they have many other uses. Shifting a binary number left and right by one bit is equivalent to multiplying or dividing it by two. Shift registers therefore find uses in arithmetic calculations. Most microprocessors have "shift" instructions allowing data to be shifted left or right.

If we are not dealing with a serial stream of input data the question arises as to what to shift into the register. In practice this may be a fixed "0" or "1" or we may loop the shift register back on itself (i.e. connect SDI to SDO) so that the data is re-circulated.

In the next *Teach-In* we ring the changes and look at ring counters, opto-electronics and serial comms (memories). Now have a look at the **Lab Work** section and build an 8-bit Synchronous Up/Down Counter demonstration circuit.

The *Teach-In* writers are delighted to receive your comments, feedback and queries. You can write to us at *Teach-In* c/o the Editorial address, or E-mail **Teach_In98@epemag.demon.co.uk.**

TEACH-IN MEET

A DAY OUT TO MEET THE EXPERTS!

Following on from the success of *Teach-In 98*, the **University of Hull** and **EPE** are organising a *Teach-In 98 Meet* which (subject to response) will take place early in September this year in Hull. Followers of the series will be able to meet up with the writers of *Teach-In*, including a special guest appearance of Lord Faversham Wills.

Hull will be presenting some *Teach-In* related material and making space in their hardware laboratories for you to "bring out your dead" in the form of labs which might not have worked quite right!

If you are interested in attending our *Teach-In Meet* send your name and address to:

Rob Miles
Department of Electronic Engineering
The University of Hull
Cottingham Road
HULL
HU6 7RX

Or you can register your interest via the *EPE* web page:
http://www.epemag.wimborne.co.uk

TEACH-IN '98

LAB WORK 9

Objectives: Build a clock pulse generator. Assemble an 8-bit up/down counter and parallel-load numbers into it. Cascade two 4-bit universal shift registers. Experiment with pseudo-random sequences.

Lab 9.1 Construct a Clock

INTRODUCING an interesting device: the 4046 chip. This is described as a "phase-locked loop" chip which is used for detecting the frequency of an applied signal, and "locking" on to it.

All we are interested in, though, is the voltage-controlled oscillator (VCO) built into a 4046. They can be used to generate a highly stable clock signal.

There are many other ways of generating a clock signal, including the venerable 555 timer i.c., and there is nothing preventing you using such an alternative if desired. All we want is a source of square wave clock signals.

A 4046 configured as a simple but highly stable clock pulse generator is shown in Fig.9.26. You can use any family of device, depending on price and availability. We tested with a cheap 4046 and with a very expensive 74HCT4046, without problems.

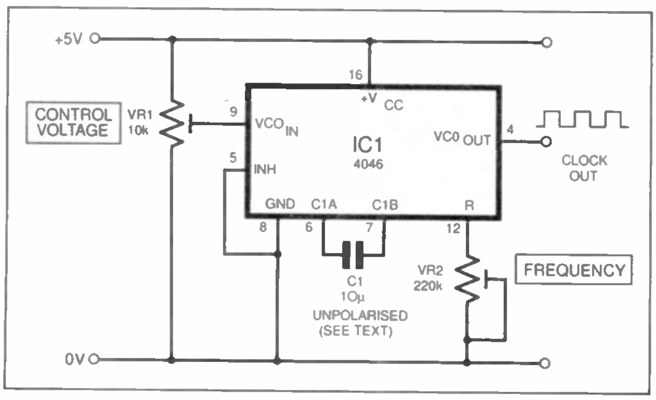


Fig.9.26. Clock pulse generator using a 4046 phase-locked loop i.c.

Using the first 20 rows of contacts and observing the usual anti-static precautions, construct this circuit on the breadboard. The two variable resistors VR1 and VR2 are "trimmer" preset potentiometers which will push-fit directly onto the breadboard: these are used to alter the frequency. (Check the size before you buy.) The timing capacitor C1 should preferably be a 10µF non-polarised type, although in this low energy circuit we used an ordinary electrolytic for 24 hours without any concerns. Test the circuit by applying an l.e.d. with series resistor to pin 4.

Adjusting the preset trimmers VR1 and VR2 will adjust the frequency of the clock pulses displayed by the l.e.d.

Lab 9.2 Programmable Counters

The 74LS193 is a synchronous up/down 4-bit counter chip. It is reversible, so it counts up or down and each of its internal flip-flops is clocked simultaneously, so this synchronous counter avoids any problems with glitches caused by delays rippling along the flip-flops.

It also has a programmable input, where a 4-bit binary number can be applied to the pins D0-D3, and this will be loaded on to the corresponding outputs when the parallel load pin (11) goes low. The chip is designed to be cascaded and is good for up to 32MHz or so!

The chip has two clock inputs, for count up or for count down. The "unused" clock input is pulled high. The purpose of the next lab demonstration is to produce an 8-bit counter. IC1 and IC3 (Fig.9.27) are two 4-bit 74LS193 chips which have been cascaded together: pin 12 of IC1 (Terminal Count Up) drives the Clock Up of IC3, and the Terminal Count Down (pin 13) of IC1 causes IC3 to clock down instead.

The demo circuit of Fig 9.27 can be built on the remainder of the breadboard using 74LS193 chips (or equivalents from other families), and is driven by the clock circuit of Fig.9.26. You should be able to assemble this circuit without any problems (use fine-pointed pliers to grip wires).

The circuit will fill the rest of the breadboard and we found it best to use 3mm miniature high-efficiency l.e.d.s for the indicators to save space. Also, use pull-up resistors on the inputs of unused buffers on the 74LS04 inverter chip IC2.

You Will Need

Resistors
- 330 ohm (10 off)
- 10k (4 off)

All 0·25W 5% carbon film

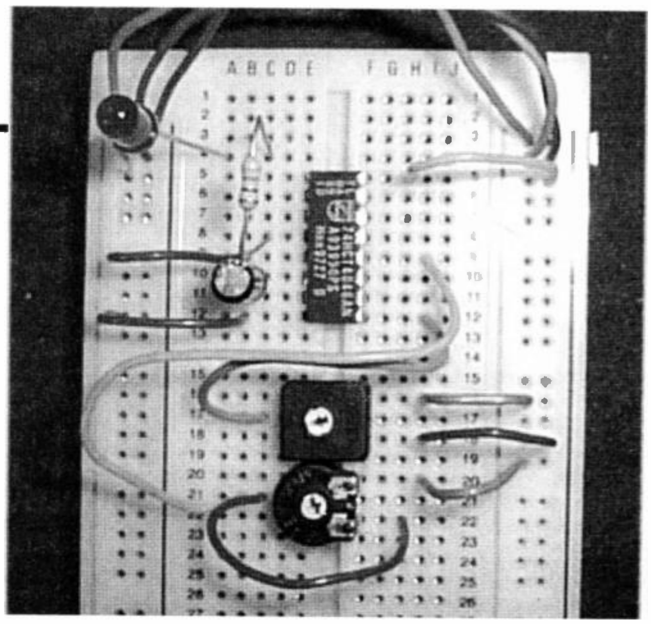
Potentiometers
- 10k miniature enclosed preset (to fit breadboard)
- 220k miniature enclosed preset (to fit breadboard)

Capacitor
- 10µF non-polarised capacitor (see text)

Semiconductors
- 4046 or 74HCT4046 phase-locked loop
- 74LS193 4-bit synchronous up/down counter (2 off)
- 74LS04 or 74HCT04 hex inverter buffer
- 74LS194 4-bit universal shift register (2 off)
- 74LS86 quad XOR (optional)
- 3mm high-efficiency l.e.d. (10 off)

Miscellaneous

Solderless breadboard; 5V d.c. regulated power supply unit (p.s.u.); hook-up wire.

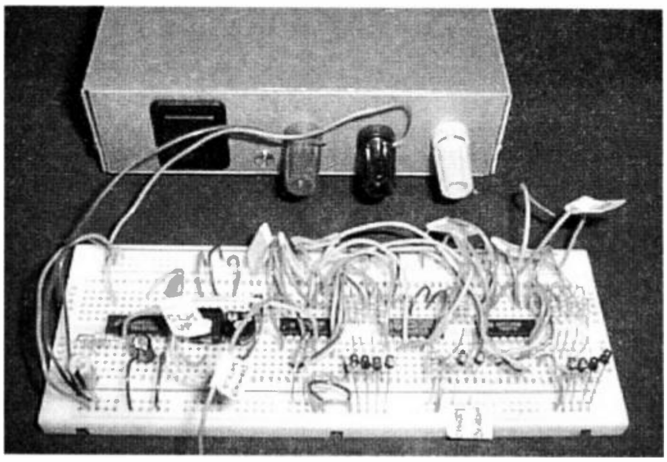


A clock circuit constructed from a 4046. Note the two trimmer resistors which fit directly onto the breadboard.

Each counter has two sets of data inputs (D0-D3) and these can simply be short flying leads, hooked to either the low or the high rails (or a mixture of both) with a total of eight jumper leads. We found it useful to label all the flying leads accordingly. Finally, the Reset/Clear (pin 14) is a flying lead which is taken low in order that the chips may count. When high, the counter output clears and resets to zero.

Connect the 4046 clock signal to the Clock Up input of the counter. A binary count sequence will appear across l.e.d.s D1 to D4, and after 1111 is displayed, the Carry l.e.d. D5 will blink, to signify a carry output from IC1 to IC3. D7 will light so the counter has now incremented to 10000 and will continue. Use the presets of the Clock circuit to adjust the clock speed as necessary.

- Notice that the duration of the carry l.e.d. D5 is the same length as the clock pulse's input. This is how synchronous counters maintain synchronisation – by using the same clock pulse through the entire circuit.
- As you can see, the 74LS193 can be cascaded very easily by feeding the Carry and Borrow outputs of one chip into the count-up (CPU) and count-down (CPD) inputs of the next.



An 8-bit synchronous counter with l.e.d. display, driven by the clock circuit of Fig.9.26.

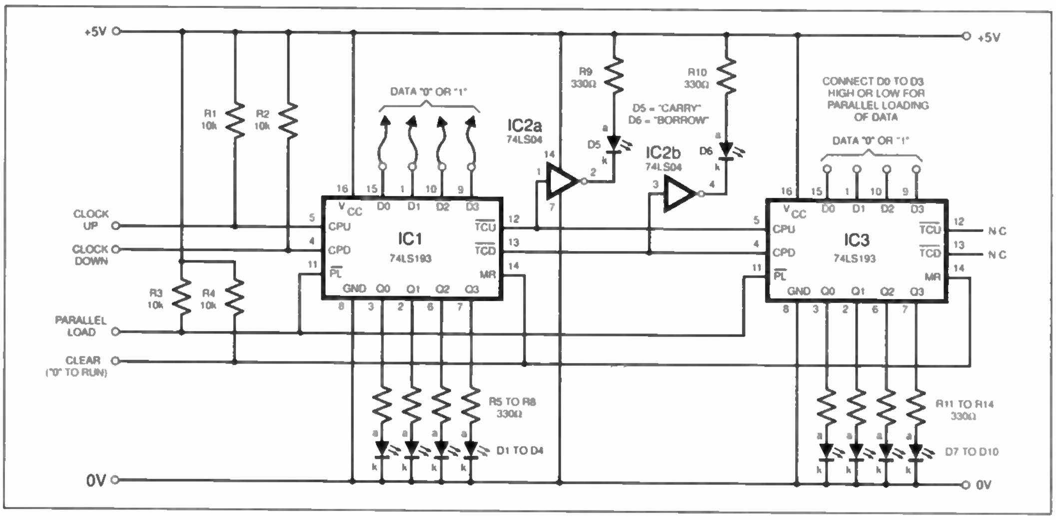


Fig.9.27. Demonstration circuit diagram for an 8-bit synchronous up/down counter. Diodes D5 and D6 (l.e.d.s) signify "carry" or "borrow". Take the "CLEAR" terminal low ("0") to run.

- If you have a logic probe (see the previous part of *Teach-In*), you can monitor the clock pulse audibly, whilst watching the display.

Watch the entire 8-bit sequence count up and repeat. Now put the clock signal on the Clock Down input instead, and the counter will count backwards from 11111111, this time with the "Borrow" l.e.d. pulsing to indicate an "underflow" into IC1.

With the clock input disconnected from the counter, briefly touch the parallel load wire (pin 11) to 0V. Notice that the combination of eight data inputs (both high and low) on the D0-D3 links has now been copied to or loaded onto the outputs on each counter. Unhook the reset (pin 14) from ground (0V) to clear the display again. You can load different numbers by re-configuring the eight jumper link wires from the data inputs to either the 5V rail or 0V as desired, then send the parallel load low again.

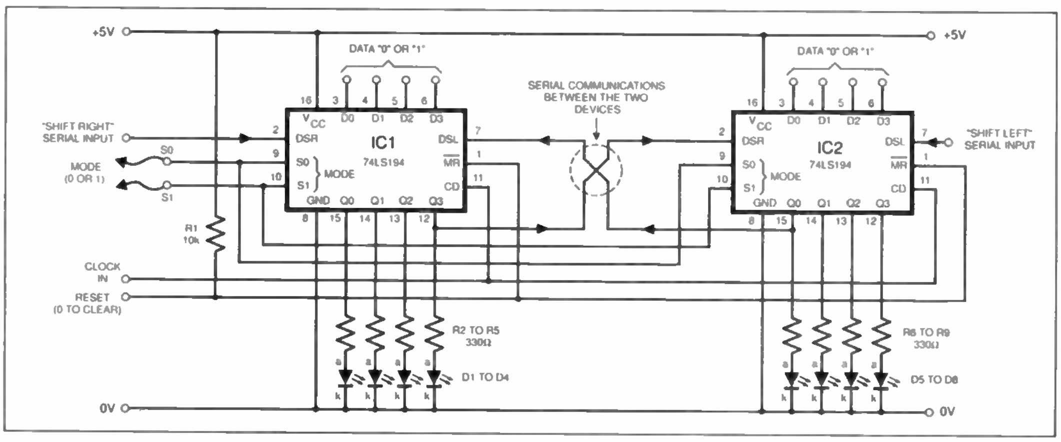


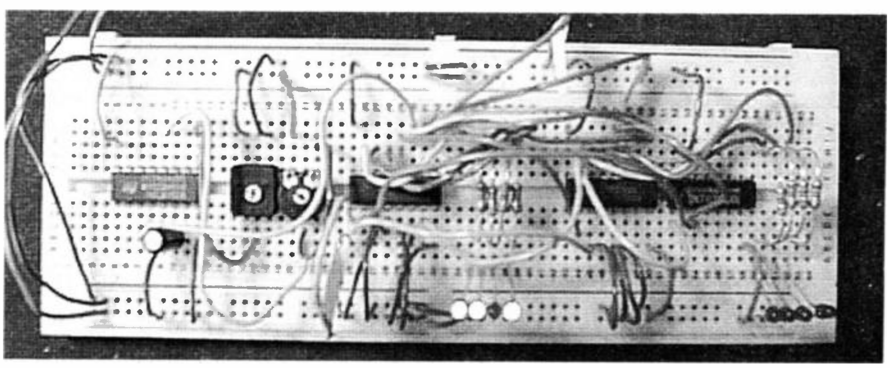
Fig.9.28. Universal shift-register demonstration of serial communications.

Lab 9.3
Universal Shift Register

A universal shift register is simply a series of latches or flip-flops, the outputs of which can be "shifted" in a variety of ways, depending on the design of chip. The 74LS194 i.c. is described as a 4-bit bi-directional universal shift register.

Containing no less than 46 gates, each chip has parallel inputs (D0-D3) and parallel outputs (Q0-Q3), plus left-shift (pin 7) and right-shift (pin 2) serial inputs. Two "mode control" pins S0 and S1 determine how the shift register functions. A brief logic 0 on the reset pin (pin 1) clears the shift register to zero.

A demo circuit containing two '194 universal



The universal shift register of Fig.9.28 with XOR chip included to create a pseudo-random sequence generator.

shift registers is depicted in Fig.9.28. It is easy to construct on the solderless breadboard.

Connect the clock circuit of Fig.9.26 to pin 11 of both chips. A binary number can be set on the parallel data inputs D0-3 of each chip as in the previous demonstration, using eight jumper wires as before. Build this circuit and explore its functions as follows (to reset the Q0-Q3 outputs to low, briefly touch reset input (pin 1) to 0V):

If S0 and S1 are *low*, the outputs will do nothing. The count is inhibited and the display will freeze.

If S0 and S1 are *high*, the shift register will parallel load (or "broadside" load), i.e. the binary number on the inputs D0-D3 will be loaded to the corresponding outputs Q0-Q3 on the next positive-going clock edge.

If S0 is high and S1 is low, the 74LS194 is set in **"shift right" serial mode**: with each successive positive clock input, the data on pin 2 (shift right serial input) is loaded onto Q0, Q0 is copied onto Q1, and Q2 is loaded onto Q3. This will be reflected in the pattern of l.e.d.s, until the display fills with logic 1s.

Finally, if S0 is low and S1 is high, the circuit is set in **"shift left" serial mode**. Q1 is copied onto Q0, Q2 is copied onto Q1, Q3 is copied onto Q2, and pin 7 (shift left serial input) is copied onto Q3.

• The "shift" operations between the two registers can be viewed as the essence of **serial communication**, with one chip transmitting data serially to the other.

Lab 9.4 Pseudo-Random Sequences

This Lab experiment is for the more adventurous. By adding an EXOR gate between various output pins and the serial input of the shift register, a pseudo-random binary logic sequence can be generated, Fig.9.29 shows how.

Use an XOR (e.g. a 74LS86 i.c.) and connect to the universal shift registers as shown. Select S0 high and S1 low, so that the registers shift right.

However, we need to load a "1" somewhere into the register first, or the sequence will "stick" as a series of zeros and nothing will be seen. Simply parallel-load any number (except 00000000) by making S1 high. Then make S1 low, and a pseudo-random sequence will be generated. Increase the clock frequency as desired, and try to observe how many different patterns there are before the sequence repeats.

• Observing one l.e.d. in isolation helps highlight the pseudo-random nature of the sequence.

• You can change the length of the sequence by selecting different outputs from IC1 and/or IC2. A 3-input XOR gate (or a combination of XORs) would need to be used on Q4, Q5 and Q6 of the 8-bit sequence, to generate the maximum possible length of 255 steps.

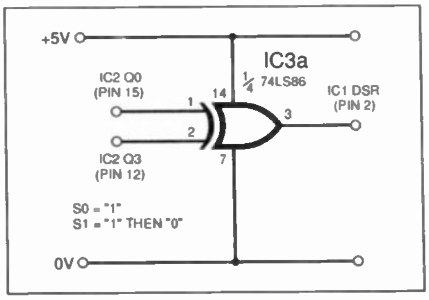


Fig.9.29. Adding XOR feedback to Fig.9.28 will generate pseudo-random sequences (see text).

• Pseudo-random sequencing is a fascinating area to explore. See if you can work out a simple Truth Table for all eight outputs, applying XOR feedback on selected outputs to generate the next digit of the serial input.

• Thought for the day: a 36-bit shift-register can generate a pseudo-random sequence of 68,000,000,000 steps before it repeats! By increasing the clock frequency greatly, a source of digital "noise" can be created.

In the next part of *Teach-In*, we delve further into the field of shift registers and their applications, also looking at data communications standards and a simple fibre-optical experiment.

In **Lab Work 10:** We look at opto-electronics and serial communications.

NOISE CANCELLING UNIT

ROBERT PENFOLD

Enjoy your hi-fi without hearing the neighbours' music, lawnmower or children!

THE SUBJECT of electronic noise cancelling has been covered before (*Experimental Noise Cancelling Unit*, August 1994 issue), but the circuits featured in that article were somewhat of an experimental nature. The device featured here is fully tried and tested, and is primarily for those who prefer to make an exact copy of a project, rather than doing "their own thing" with some basic circuits.

Provided the specified microphones and headset are used the system should perform to quite high standards. Good results cannot be guaranteed if alternative microphones and (or) headphones are used.

The performance of the unit is to a large extent dependent on the quality of the microphones used, and it does not seem to be possible to obtain worthwhile results using inexpensive microphones. The quality of the headphones seems to be less important, but these must also be of *reasonably* high quality.

FAIR POINT

It is only fair to point out that a unit of this kind is not 100 per cent effective, and it is not just a matter of switching on and listening to total silence. When used in its normal mode the unit will provide a reasonably high degree of attenuation over the lower and middle parts of the audio spectrum.

It is difficult to make precise measurements on this type of equipment, but subjectively the estimated reduction in noise is around 20 to 30 decibels. In other words, the amplitude of the sound is reduced by a factor of around 10 to 30.

Performance at the extremes of the audio range tends to suffer due to inadequacies in the phase and frequency responses of the microphones and headphones. There will inevitably be some variations in performance over the middle frequency range where the unit performs well.

A second mode enables the unit to operate with very high efficiency, but only over a very narrow range of frequency. Obviously this mode is of little use when combating most sounds, but it can be very effective at dealing with something like an annoying whine from a computer's cooling fan.

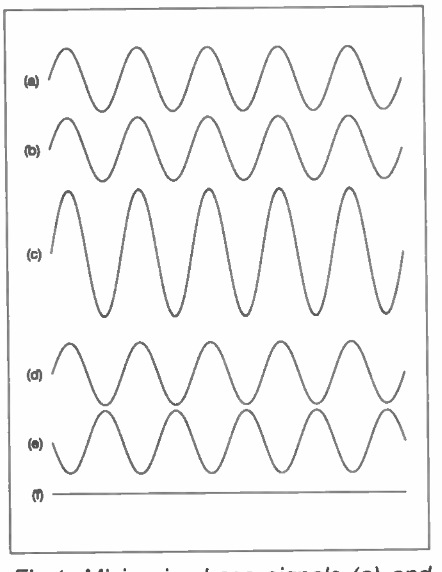


Fig.1. Mixing in-phase signals (a) and (b) gives a gain (c), and mixing identical out of phase signals (d) and (e) produces a zero (f).

Again, it is difficult to put a precise figure on the noise reduction obtained, but with careful adjustment it is certainly possible to obtain something like 40 decibels or more of attenuation at a single frequency in the middle part of audio range. This means the reduction is a factor of 100 or more.

The unit has stereo audio inputs so that it can be fed from a Walkman, TV, Hi-Fi System, etc. This enables the user to listen to music, television programmes, etc. while enjoying the noise reduction provided by the unit.

This is one of the primary advantages of electronic noise cancelling systems. With most mechanical means of combating noise such as earplugs, the user is prevented from hearing any sounds at all. With electronic noise cancelling it is possible for the user to listen to any sounds that can be fed into the system as an electronic signal.

TWO-PHASED

Electronic noise-cancelling systems rely on the use of so-called "anti-sound". In other words, the system generates sound that is equal to the sound that must be removed, but of opposite polarity to it.

We are not sure if polarity is the correct term in this case, but what we are talking about is using an increase in sound pressure to counteract a decrease, and vice versa. The effect of mixing together two equal-amplitude signals that are in-phase (top) and out of phase (bottom) is shown in Fig.1. It does not matter whether the signals are sound waves, electrical signals, or whatever, the same mixing action is always obtained.

The two signals add together, which in the case of the in-phase signals means that they produce an output signal that is double the amplitude of each input signal. The situation is very different with the two out of phase signals. As the upper waveform becomes more positive the lower waveform becomes more negative, and the signals are always equal but opposite. Adding them together therefore produces a result that is always zero.

In this example we are dealing with simple sinewaves, but the same principle applies no matter how complex or simple the signal. Provided the two signals are precisely out of phase and of equal amplitude they will always be cancelled out perfectly to produce zero output.

NO PROBLEM

This phase cancelling technique is commonly used in electronics, and at audio frequencies there is no problem in obtaining a high degree of cancelling. On the face of it, there should be no problem in making a sound cancelling device that produces a high level of attenuation, but in reality things are not that simple.

Electronically inverting the audio signal is extremely simple and simply connecting the headphones "the wrong way round" gives the desired effect. An electronic inverter presents no technical problem anyway, and a signal inversion is a natural feature of many amplifiers.

ACOUSTIC PROBLEM

Obtaining a high degree of sound cancelling is not difficult from the electronic point of view, it is the acoustics that present the real problem. Audio circuits are not perfect, but using modern components it is possible to obtain extremely low levels of phase and amplitude distortion.

A virtually flat frequency response across the entire audio range is something we take for granted. The same is not true of audio transducers such as headphones and loudspeakers, which produce significant amounts of amplitude distortion and have far from flat frequency responses.

Also, they do not normally have linear phase responses. Thus, although the electronics may be very simple and provide almost perfect performance, a noise cancelling system will have very poor performance unless the transducers perform reasonably well.

Many inexpensive headphones seem to provide quite respectable levels of performance, and there would seem to be relatively little to gain by opting for up-market headphones. Using cheap microphones is a very different matter though, and all attempts at using inexpensive units of various types failed to give worthwhile results. In some cases no perceptible reduction in sound could be detected at all!

The microphones used in this sound cancelling system are quite expensive (see *Shoptalk*), but unless you are prepared to pay for microphones of this quality the unit is unlikely to give satisfactory results. A good quality electret microphone seems to be the minimum requirement for worthwhile performance.

Experiment with other types of microphone by all means, but please do not write to complain if you use inexpensive dynamic microphones and the unit fails to work at all.

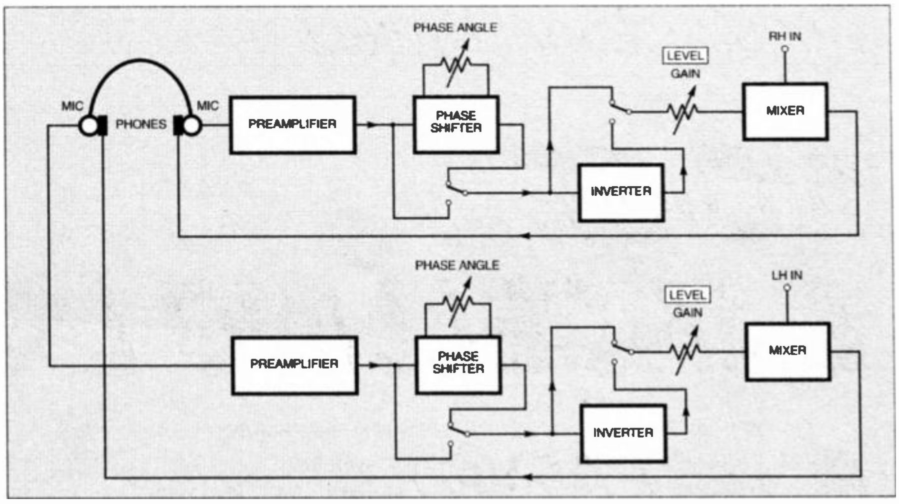


Fig.2. Block diagram for the sound cancelling system.

For reasons explained below, the microphones are mounted on the earphones. The unit is not very practical if you have to walk around with a large stick microphone perched on each ear! The specified microphones are extremely small and light, and it is the cables connected to them that represent the main encumbrance.

MIND THE GAP

The block diagram of Fig. 2 shows the general arrangement used in this Noise Cancelling Unit. The system is based on a pair of headphones which has a microphone mounted on each earphone.

It might seem better to base the system on a loudspeaker. This would certainly be more convenient for the user, but there are practical problems in doing so.

The headphone approach keeps things simple and efficient. Each ear is very close to the transducers that process the sound it receives. Using a loudspeaker inevitably places a significant amount of distance between the user's ears and loudspeaker itself. The salient point here is that sound does not travel instantly and effectively travels at approximately one metre every three milliseconds.

Even with a gap of just a metre or two between the loudspeaker and the user there would be a significant mismatch in the signal heard by the user and that produced by the loudspeaker. It has to be borne in mind here, that a delay of just 0·5ms is sufficient to bring a one kilohertz (1kHz) signal in-phase where it was previously precisely out of phase.

As can be seen from Fig. 3, the effect a delay has on the phasing of two signals depends on the signal frequency. In the upper waveform the signal frequency is relatively low, and the delay has left the two signals to some extent still in-phase. In the middle waveform the signal frequency is twice as high, and the delay has brought the signals precisely out of phase. The frequency in the bottom waveform is twice as high again, and the phase shift is now so great that it has brought the signals back in-phase once again.

The problem in using a system based on a loudspeaker is that the sounds and anti-sounds tend to end up in-phase at some frequencies and out of phase at others. A delay circuit can be used to compensate for the time taken for the sound to travel from the loudspeaker to the user, but this complicates matters and does not seem to work very well in practice anyway.

One problem is that the sound from the loudspeaker will travel direct to the user, but is also likely to be reflected via the walls, ceiling, etc. The reflected sounds take longer to reach the user and will therefore been randomly phased with both the original sound and the anti-sound.

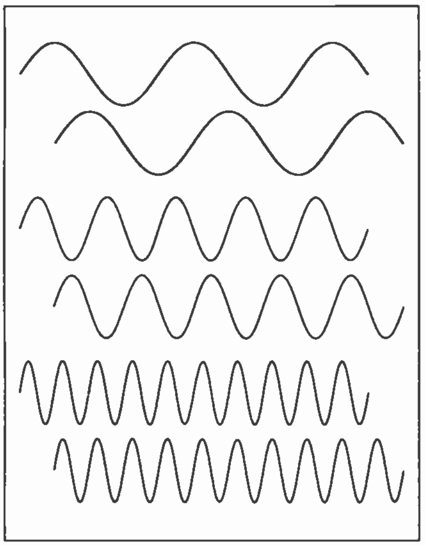


Fig.3. The effect of a delay on phasing is frequency dependent.

EAR EAR

Another problem in using a loudspeaker is that it does not allow for the fact that we have two ears, and that the sounds they receive are slightly different. Although any differences are usually quite small, this application requires such a high degree of precision that these small differences are very significant.

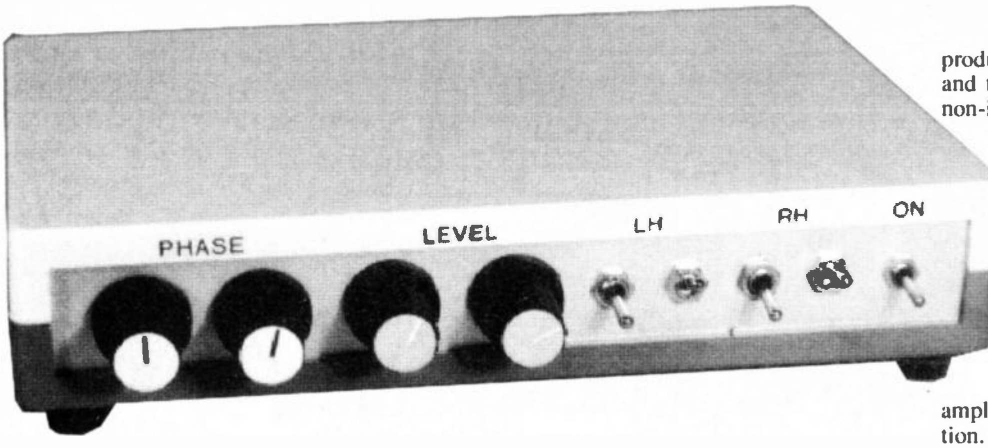
By using headphones it is possible to generate separate anti-sound for each ear, which seems to produce much better results than using the same in-between sound for both ears. By having the microphone and headphone very close together it is possible to generate very accurate anti-sound without having to resort to delay circuits. In order to avoid acoustic feedback and resultant oscillation there must still be some gap between the headphone and the microphone, but it seems to be possible to use a very small gap without any feedback problems occurring.

HOW IT WORKS

Returning to Fig. 2, there are two identical sets of signal processing stages, one for each ear. This description applies equally to each channel of the unit.

The output signal from the microphone will be at an extremely low level, and a low noise preamplifier is therefore used to boost the signal to a suitable amplitude. A phase shift circuit can be used to provide precise cancelling over a narrow band of frequencies, and a Phase Angle control enables the unit to be adjusted for optimum cancelling. This stage can be bypassed if the unit must operate over the widest possible frequency span.

The next stage is a simple inverter. The sound from the headphones might produce anti-sound, or it might produce sound that is in-phase with the normal sound, effectively making it louder rather than quieter. If necessary, the inverter can be switched into circuit so that the unit



Completed Noise Cancelling Unit showing pairing of front panel controls.

produces anti-sound and gives the required cancelling effect.

A Level control enables the volume from the headphones to be adjusted to match the sound being cancelled so that optimum results are obtained. Finally, a mixer stage drives the headphone and combines the anti-sound signal with an external signal source from a hi-fi system, personal stereo unit, etc.

CIRCUIT OPERATION

The full circuit diagram for the Noise Cancelling Unit is shown in Fig.4. The two channels are identical, and only the left-hand channel will be described here.

In this circuit the preamplifier is based on IC1, which is an operational amplifier that is specifically intended for use in low noise and distortion audio stages. It is used as a standard non-inverting amplifier having a close loop voltage gain of about 27.

The input circuit may look a little strange, but it is intended for use with an electret microphone that has a built-in preamplifier. Most microphones of this type have quite long cables together with a large jack plug that contains the battery to power the preamplifier.

In this application only a short microphone cable is required, and the bulk of two long cables and two large plugs is best avoided. With the specified microphones there is an easy solution to the problem, and this is to cut the cables short and fit them with miniature 3·5mm jack plugs. The microphones' built-in preamplifiers are then powered from the main unit, and this is the purpose of resistors R1 to R3 and capacitor C2.

If you would prefer not to modify the microphones, which would almost certainly invalidate their guarantees, they can be left with their original plugs and can be powered from their own batteries. Resistors R1 to R3, R20 to R22 and capacitor C2 and C13 should then be omitted.

PHASE SHIFTER

The output from IC1 at pin 6 is coupled to a conventional phase shifter circuit based on IC2. This circuit is a modified version of an inverting mode amplifier. Resistors R8 and R12 form the negative feedback network, and they set the voltage gain at unity.

Capacitor C5 couples the input signal to the non-inverting input of IC2, but at low frequencies this has very little effect on the circuit which therefore operates as an ordinary inverting buffer stage. At higher input frequencies a stronger coupling is produced due to the lower reactance of C5, and the circuit gradually switches over to non-inverting operation.

It therefore provides the phase shift that varies from 180 degrees to zero degrees as the input frequency is increased. The amount of phase shift produced at a given frequency can be varied by means of Phase control VR1.

The variable phase shifter circuit is followed by a straightforward unity gain, inverting amplifier, which uses operational amplifier IC3 in the standard configuration. With IC3 switched into circuit the total phase shift is from 180 degrees to 360 degrees.

By switching the inverter in or out of circuit using switch S2 it is possible to obtain a phase shift of between zero and 360 degrees. When the phase shifter is not required it can be bypassed using switch S1.

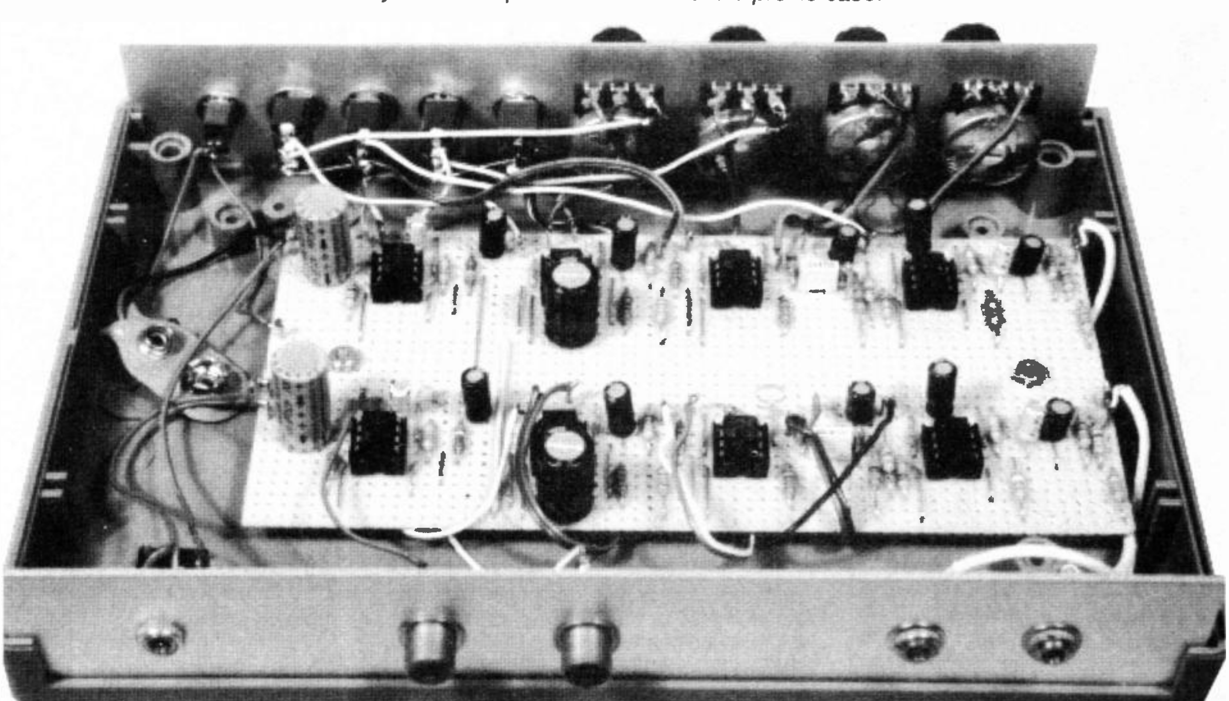
Potentiometer VR3 is the gain or Level control, and from here the signal is fed to a conventional summing mode mixer circuit based on IC4. This circuit is basically just an inverting mode amplifier, but it has two sets of input resistors so that it can accommodate two input signals.

The virtual earth formed at the non-inverting input (pin 3) of IC4 ensures that the two signal sources are totally isolated from one another. Capacitor C11 couples the output of IC4 to the headphones (via SK5) which must be a medium impedance type having an impedance of about 35 ohms.

The total current consumption for both channels of the circuit is about 18mA. In order to make the unit reasonably small and light it is preferable to use a small battery, such as a PP3 type. Due to the fairly high current consumption of the circuit it is preferable to use a *high power* type, as a "bog standard" PP3 could have a short operating life.

Alternatively, the unit can be powered from a battery pack consisting of six AA

Layout of components inside the low-profile case.



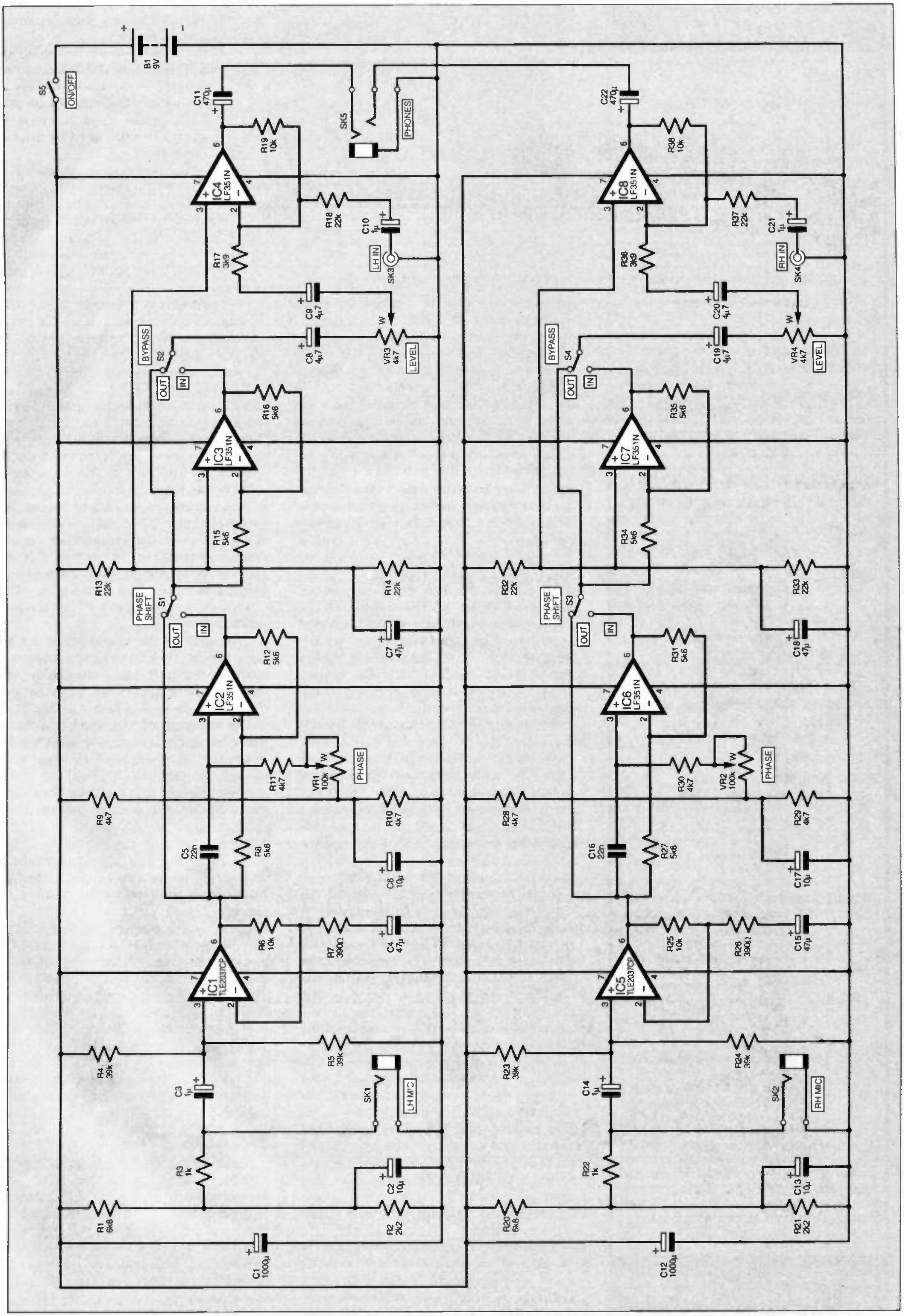


Fig.4. Complete circuit diagram for the Noise Cancelling Unit.

COMPONENTS

Resistors

R1, R20	6k8 (2 off)
R2, R21	2k2 (2 off)
R3, R22	1k (2 off)
R4, R5, R23, R24	39k (4 off)
R6, R19, R25, R38	10k (4 off)
R7, R26	390Ω (2 off)
R8, R12, R15, R16, R27, R31, R34, R35	5k6 (8 off)
R9, R10, R11, R28, R29, R30	4k7 (6 off)
R13, R14, R18, R32, R33, R37	22k (6 off)
R17, R36	3k9 (2 off)

All 0·25W 5% carbon film

See SHOP TALK Page

Potentiometers

VR1, VR2	100k, rotary carbon lin (2 off)
VR3, VR4	4k7, rotary carbon log (2 off)

Capacitors

C1, C12	1000μ radial elect. 10V (2 off)
C2, C6, C13, C17	10μ radial elect. 25V (4 off)
C3, C10, C14, C21	1μ radial elect. 50V (4 off)
C4, C7, C15, C18	47μ radial elect. 16V (4 off)
C5, C16	22n polyester, 5mm lead spacing (2 off)
C8, C9, C19, C20	4μ7 radial elect. 50V (4 off)
C11, C22	470μ radial elect. 10V (2 off)

Semiconductors

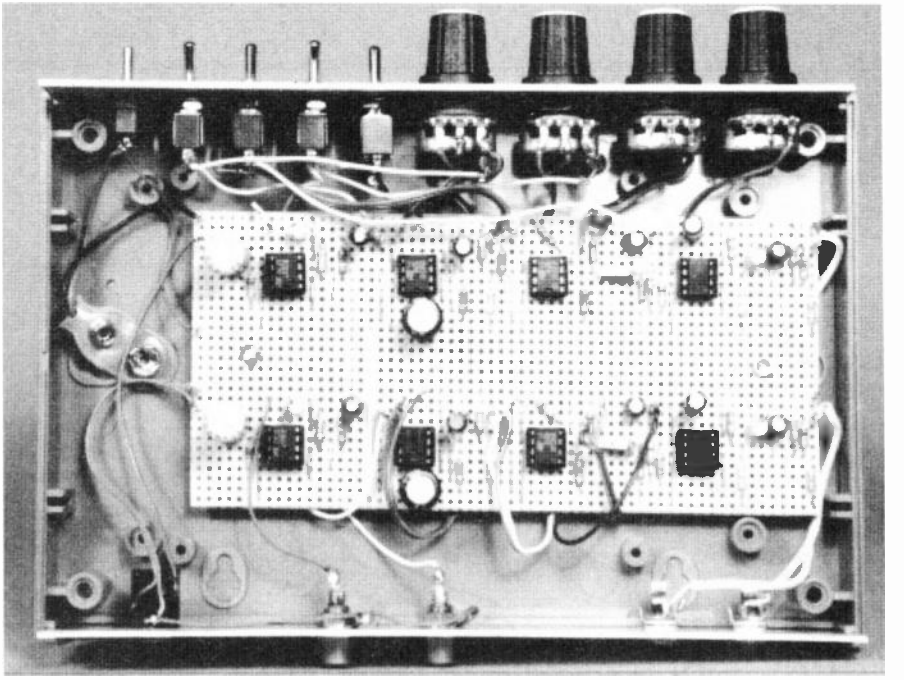
IC1, IC5	TLE2037CP low noise op.amp (2 off)
IC2, IC3, IC4, IC6, IC7, IC8	LF351N bifet op.amp (6 off)

Miscellaneous

MIC1, MIC2	min. electret microphone (Maplin 600 ohm ultra miniature or tie-clip type – see text) (2 off)
SK1, SK2	3·5mm mono jack socket – see text (2 off)
SK3, SK4	phono socket, chassis mounting (2 off)
SK5	3·5mm stereo jack socket
S1 to S4	s.p.d.t. min. toggle switch (4 off)
S5	s.p.s.t. min. toggle switch
B1	9V battery (PP3 size – see text)

Case, size about 200mm × 140mm × 45mm; 0·1 inch pitch stripboard having 62 holes by 29 strips; stereo headphones (22 to 32 ohm impedance), with headband; 8-pin d.i.l. socket (8 off); battery connector; control knob (4 off); multistrand connecting wire; single-sided solder pins; solder, etc.

Approx Cost Guidance Only £40
excl. Microphones & Headphones



Internal wiring to front and rear mounted components.

size cells in a plastic holder. This option is much heavier and bulkier, but represents a much cheaper way of powering the unit.

CONSTRUCTION

A piece of 0·1 inch pitch stripboard, having 62 holes by 29 copper strips, accommodates both channels of the Noise Cancelling Unit. The component layout, together with wiring and details of the cuts required in the underside copper strips are shown in Fig.5. A board of the required size is easily cut from a standard board measuring 62 holes by 39 copper strips.

Once the breaks in the strips have been made drill the two 3·2mm diameter mounting holes for the board. These will accept either metric M3 or 6BA mounting bolts. Most plastic stand-offs do not work well with stripboard, and with a fairly large board such as this one it is probably better to use mounting bolts and spacers.

None of the integrated circuits are static-sensitive, but it is still advisable to fit them all in holders. This is especially important for the TLE2037CP used for IC1 and IC5, as this is not a particularly cheap device. Less expensive operational amplifiers can be used in place of the TLE2037CP, but this would almost certainly result in a *severe* degradation of the signal-to-noise ratio.

In most respects construction of the board is perfectly straightforward, but with any fairly complex stripboard layout it is essential to proceed very carefully making sure that every component is positioned correctly. Also, be careful not to omit any of the link-wires. There is no need to insulate the short links, but short circuits are likely to occur unless the longer link wires are fitted with pieces of p.v.c. sleeving.

In order to fit into this layout properly the electrolytic capacitors must be miniature printed circuit mounting types. Similarly, C5 and C16 must be miniature printed circuit mounting capacitors having 5mm lead spacing.

Fit single-sided solder-pins to the board at the numerous points where connections to the controls and sockets will be made. Note that electrolytic capacitors C8 and C19 are mounted directly on the controls and not on the circuit board. Do not forget to check their polarities.

ASSEMBLY

The width of the circuit board and the large number of controls and sockets preclude the use of a really small case. The unit can still be made quite small and neat if a low-profile case is used.

Due to lack of panel space, on the prototype the controls are mounted on the front panel and the sockets are relegated to the rear of the unit. The general layout of the unit is not unduly critical and any sensible layout can be used, see photographs.

Details of the interwiring are also provided in Fig.5. It is probably best to start by fitting the two capacitors and the few connections between the controls and sockets.

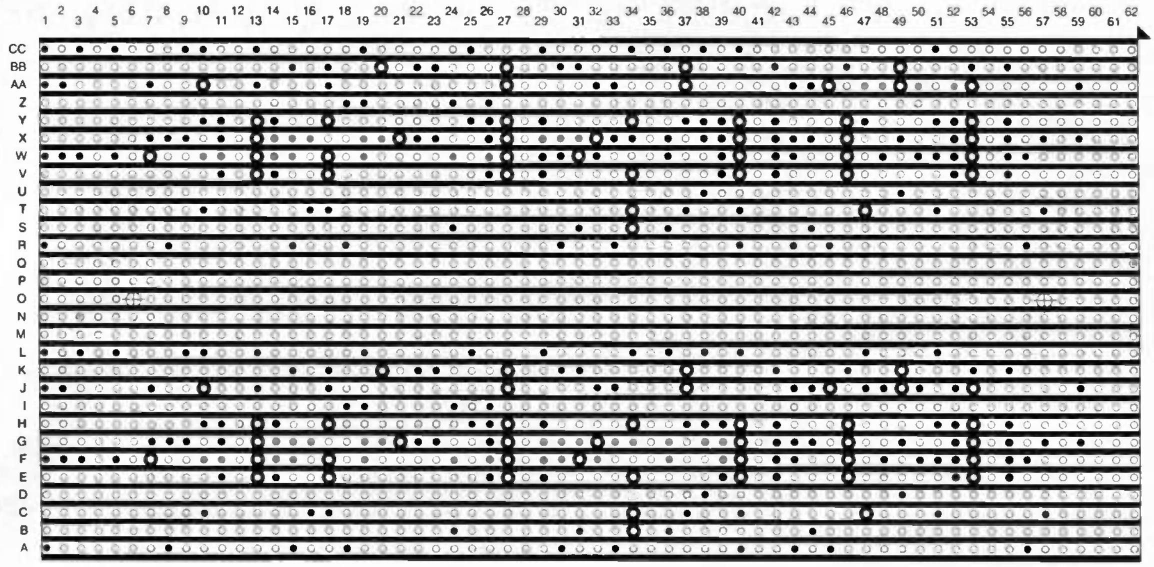
Probably, the best way to deal with the two electrolytic capacitors, C8 and C19, is to cut their leadout wires short and then mount them on controls VR3 and VR4. Their positive (+) leads can then be soldered to switches S2 and S4 using pieces of ordinary insulated connecting wire. It is not essential to use screened cable to connect jack sockets SK1 and SK2 to the circuit board, but this helps to minimise stray pickup of mains "hum" and other electrical noise.

HEADSET

Some types of headphone are better suited to this application than others, and experience would suggest that the best type to choose is the lightweight variety having an adjustable headband. The specified headphones (see *Shoptalk*) are quite inexpensive, and probably represent the cheapest headphones that will work well in this application.

If you have a pair of headphones of the correct type there is no harm in trying

NOISE CANCELLING UNIT



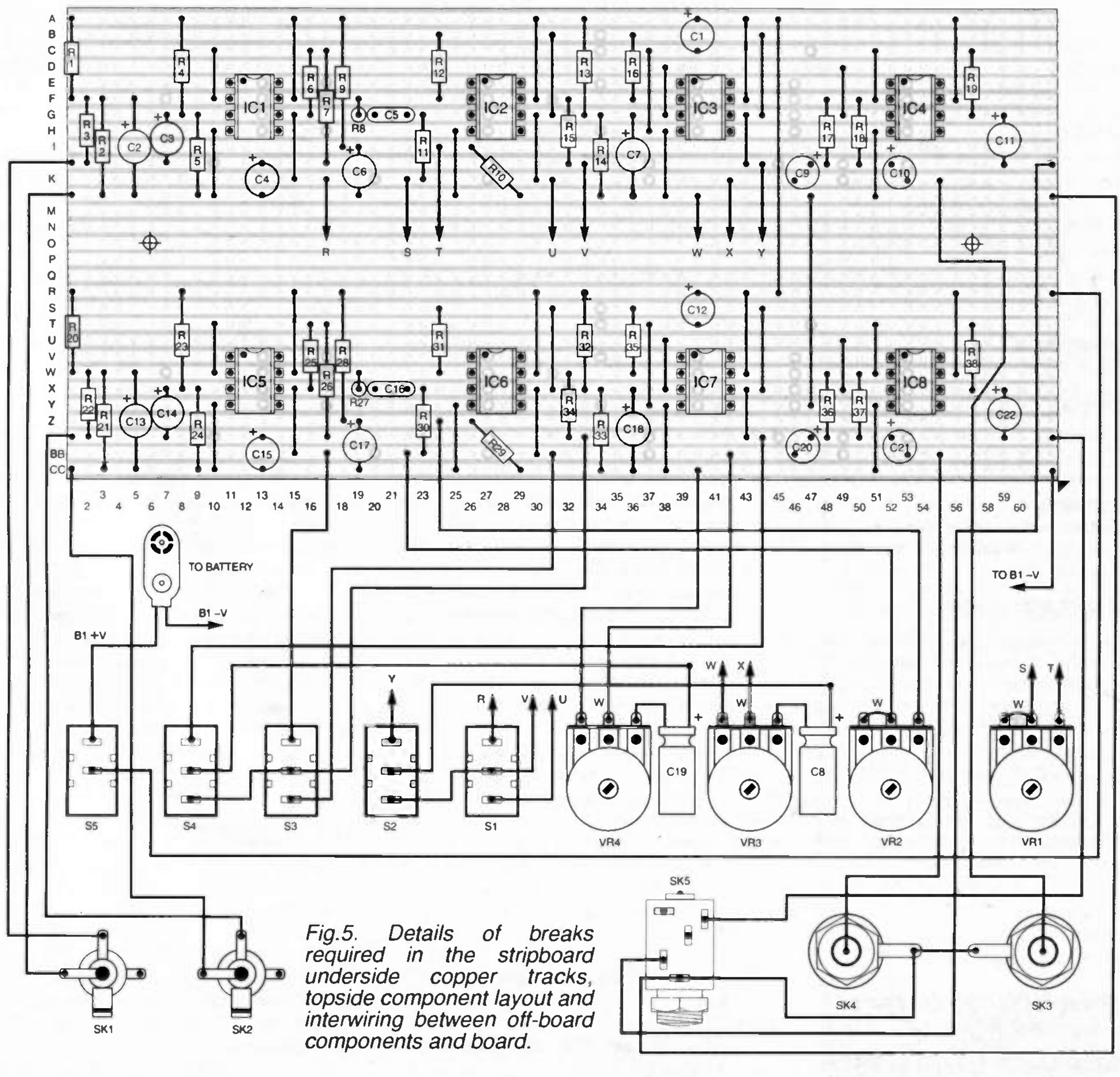
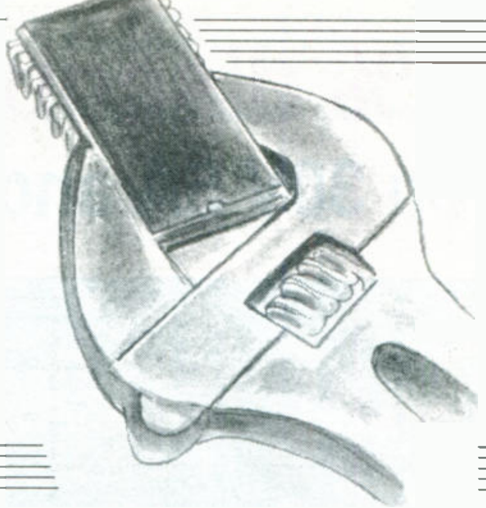


Fig.5. Details of breaks required in the stripboard underside copper tracks, topside component layout and interwiring between off-board components and board.



PIC16x84 TOOLKIT

JOHN BECKER

At last, TASM and MPASM compatibility for PIC16C84 and PIC16F84 users!

VERSATILITY and high speed were the two chief design objectives for this PIC16x84 Toolkit. It can be used in conjunction with both TASM and MPASM source codes and is three tools in one: a programmer, a program disassembler, and a bilingual translator between the two assembly languages.

The Toolkit is for use with PIC16C84 and PIC16F84 microcontrollers (jointly referred to as PIC16C84 within this text). The following options are available:

1. Configure PIC16C84 factors
2. Program PIC16C84 with TASM binary code
3. Program PIC16C84 with MPASM hex code
4. Translate MPASM hex code to TASM binary code
5. Translate TASM binary code to MPASM hex code
6. Disassemble PIC16C84 to TASM source code
7. Disassemble PIC16C84 to MPASM source code
8. Translate TASM source code to MPASM source code
9. Translate MPASM source code to TASM source code

All modes and external switching operations are controlled directly by a PC-compatible computer ('386 and above, with or without Windows). No manual intervention via hardware switches is needed. The computer must have either QBasic or QuickBASIC already installed.

The design may be used as a stand-alone unit, or interfaced with the *EPE PIC Tutorial* printed circuit board (March '98), replacing the latter's switches S1 to S4.

The software can be used directly with the Tutorial board without using the Toolkit board. In this case, though, setting of the program control switches S1 to S4 is still required to be done manually.

Alternatively, the software can be used on its own purely as a "language translator" (menu items 4, 5, 8 and 9), without the Toolkit or Tutorial boards.

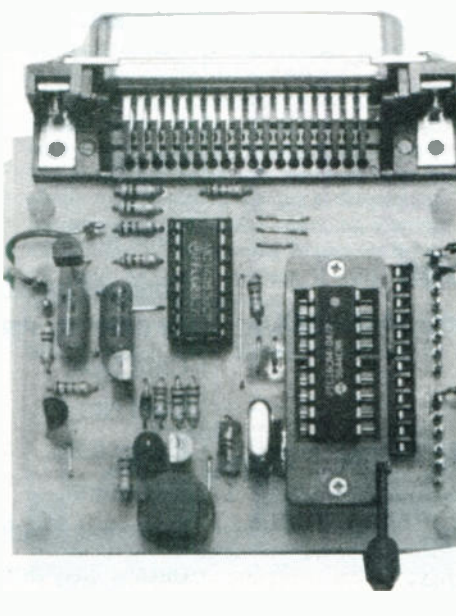
MOTIVATION

EPE's introduction to PIC16C84 microcontrollers was effectively in 1995 when Derren Crome offered us his *Simple PIC16C84 Programmer*, which we published in our February '96 issue. The information and the programming software which came with that design, the TASM and SEND programs, have helped open the eyes of many readers to the benefits of PIC microcontrollers.

The popularity of our PIC-based constructional projects has been immense. Even so, the resounding response to our three recent *EPE PIC Tutorial* Supplements (March to May '98) exceeded all expectations! Obviously, many readers want to know more about programming PICs for themselves.

In this context, the term *programming* can be split into two definitions: actually writing the software, and then down-loading it into the PIC. The aim of the Toolkit is to simplify the latter.

Until now, though, we have been confronted by a compatibility problem, that of there being two principal languages in which the PIC program can be written – TASM and MPASM. Let's first explain this situation and its implications.



TASM ASSEMBLER

TASM is a "universal" Table Assembly language which originated as a shareware product through the Public Domain Shareware Library (PDSL). It is extremely easy to use and can be user-modified to assemble the source code for *any* microprocessor or microcontroller, translating it from "English-like" command structures into the binary or hexadecimal codes which the chosen micro can accept. It does not include facilities to send the assembled code to the micro.

To allow TASM to be used for programming the PIC16C84, a special table file and SEND program were written. The file (.OBJ) generated by TASM in this application is in a linear binary coded format suited to the SEND program. MPASM cannot use this file.

Nor can MPASM use the hex file (.HEX) which TASM can be instructed to produce (**-h** in the command line instead of **-b**) since the hex byte pairs are in the reverse order of those used by MPASM.

Operation of the *Simple PIC16C84 Programmer* is via switches. The simplicity of the programming technique is such that the few components involved can be designed into any other PIC16C84-based circuit, should the designer wish to do so (*EPE* has published several examples of this technique).

This basic switched programming control was used in the *EPE PIC Tutorial*, although two additional computer-isolating switches were also added. It is a very simple and straightforward technique to use. Indeed, an enormous benefit of both TASM and SEND is that they *are* so simple, and are far quicker to load and use than MPASM.

The SEND program, however, has four limitations that restrict its use by many PIC program designers: it can only accept a TASM binary file for sending to the PIC; it cannot verify the programmed code; it cannot disassemble the code from the PIC back into a source code structure; the use of manually operated switches can be an inconvenience.

Additionally, the programming algorithms used in SEND limit the speed at which the code can be loaded into the PIC (taking about one minute 20 seconds for a full 1024 byte transfer).

The Toolkit overcomes all four limitations, and speeds the transfer rate to about 12 seconds for 1024 bytes.

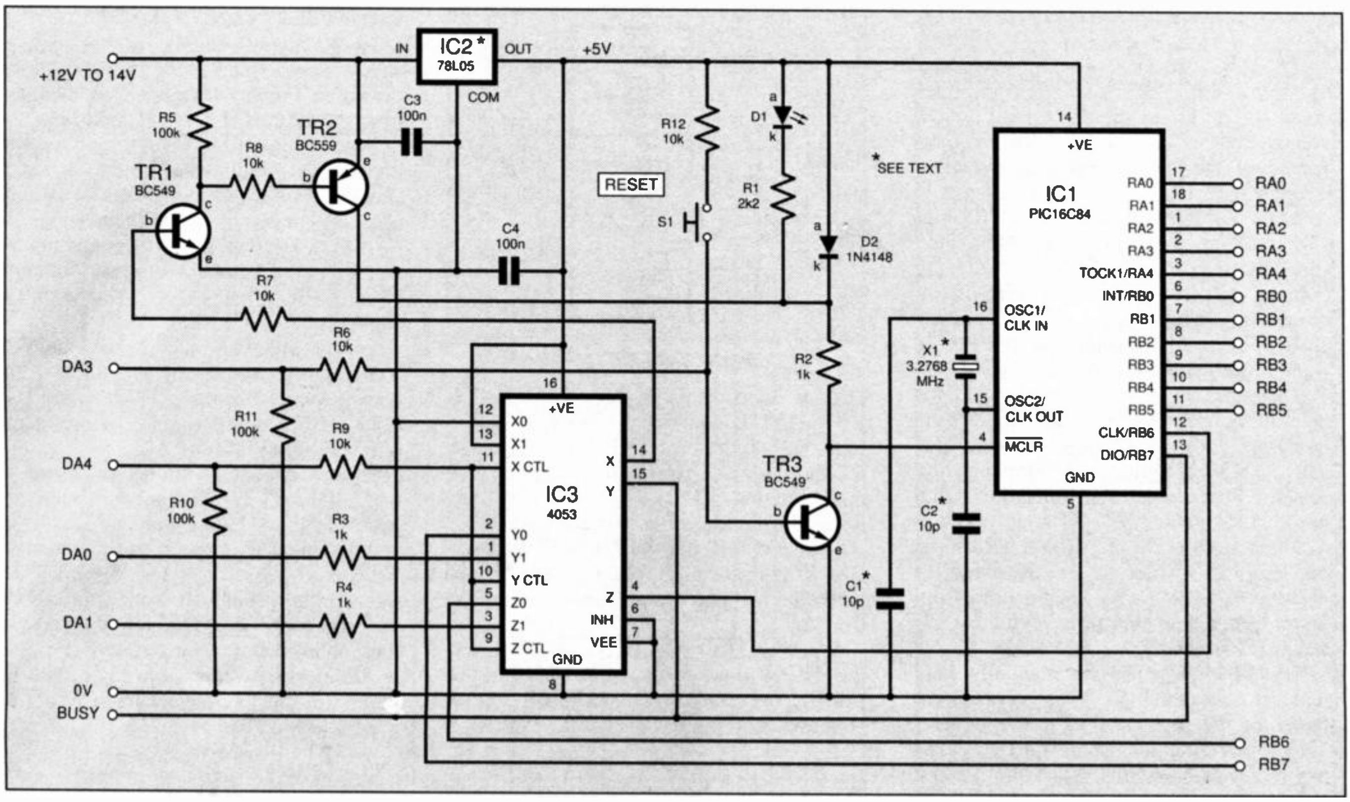


Fig.1. Complete circuit diagram for the PIC16x84 Toolkit.

MPASM ASSEMBLER

MPASM is the proprietary product of Arizona Microchip, the manufacturers of the PIC microcontrollers. In its full form, including MPLAB software and hardware, MPASM not only assembles source code, but also allows users to test, simulate and send code direct to the PIC. It handles the full range of PIC microcontrollers.

Whereas TASM generates a binary file (.OBJ), MPASM generates a hex code file (.HEX) which includes error checking and addressing values. The SEND program cannot use this file.

Whilst the facilities offered by MPASM and MPLAB far outreach those available with TASM, the author has found that, even with a 120MHz Pentium computer, getting in and out of MPASM takes considerably longer than getting in and out of TASM/SEND.

In this context, remember that when developing a PIC program, even if you use a simulator, sooner or later you probably have to keep swapping between a text editor for modifying the source code listing, and an assembler/sender for loading revised and re-assembled code into a PIC.

As a result, since integrating the Toolkit into his system, the author continues to use TASM as the assembling language in preference to MPASM. With the use of a suitable .BAT command file (discussed later), it is so easy to nip in and out between DOS EDIT, TASM and TOOLKIT.

WIDER APPEAL

On a wider front, though, we know that both MPASM and TASM have a loyal following. A great number of readers have TASM, having acquired it with our general software disk, or with our PIC-Tutor Disk.

It is interesting, though, that many of the PIC projects which we are offered for publication are written using one of the several versions of MPASM. Of the PIC projects we've published, the split is about 50:50 between TASM and MPASM.

Consequently, we have recognised the need to publish our own software which allows easy translation between TASM and MPASM, in both directions. The Toolkit, therefore, includes this option as well.

The translation routines have been written to correct for the TASM/MPASM source code "grammar" differences associated with the PIC16C84 command codes as published in the *PIC16/17 Microcontroller Data Book* (from here on referred to as the *PIC Data Book*).

However, whilst TASM and MPASM can be used just as assembly programs, they are also languages in their own right and have programming structures which allow a variety of operations to be expressed in a type of shorthand. With a few exceptions, Toolkit cannot translate these structures and the user must correct any source code translation if they occur, referring to the TASM or MPASM documentation. A summary of MPASM's special structure commands is tabled later.

Interestingly, though, very few of the special commands have been used in any of the PIC-based projects published in *EPE*.

Details of how to obtain the software for Toolkit and the documentation for MPASM and TASM are given at the end.

TOOLKIT CIRCUIT

The complete circuit diagram of the PIC16x84 Toolkit is shown in Fig.1.

In essence, the circuit is very similar to the heart of the circuits used for the *Simple PIC16C84 Programmer* and *EPE PIC Tutorial*. The difference is that, whereas the latter two programs require manually switched setting of Program/Run switches, Toolkit's switching is automatically controlled by the computer via a simple routing selection circuit, based around multiplexer IC3.

In Fig.1, IC1 represents the PIC microcontroller. As with the previous two circuits, the computer's parallel printer port supplies the required clock and data signals to the PIC. Printer port line DA0 supplies program data for IC1 pin RB7, and line DA1 supplies the clock signal for IC1 pin RB6.

The PIC's other I/O (input/output) lines, RA0 to RA4 and RB0 to RB5 are not used in the Toolkit circuit, but may be made use of if the circuit is connected as part of a test-bed in a development situation for other PIC-controlled circuits.

The circuit diagram shows the PIC under crystal control (X1) in association with capacitors C1 and C2. These three components are only required when the circuit is used as a test-bed – they may be omitted if the Toolkit is used purely as a programmer/disassembler. The value of 3.2768MHz for crystal X1 is a suggested value only, other values may be used to suit test bed requirements.

PIC16C84 devices require a programming supply of between 12V and 14V (henceforth referred to as 12V), and an operational supply of between 3V and 7V. For the latter supply, 5V is used here.

The 12V supply is brought in to IC2, a 5V 100mA voltage regulator. The resulting 5V output supplies power to the PIC and to the signal routing chip IC3.

The network around transistors TR1, TR2 and TR3 is responsible for switching the PIC's program control input, $\overline{MCLR}$, between Program, Run and Reset modes.

Computer line DA4 (via IC3) is responsible for controlling transistor pair TR1 and TR2. When the base (b) of TR1 is set high (5V) by DA4, TR1 and TR2 are turned on, allowing the 12V supply to pass through TR2 and resistor R2 to the $\overline{MCLR}$

pin (ignoring TR3 for the moment). This puts the PIC into Program mode.

Simultaneously, the same supply flows through resistor R1 and light emitting diode (l.e.d.) D1 to the 5V supply line (a voltage drop of 7V). The l.e.d. is turned on whenever the 12V supply is switched through TR2.

When line DA4 is low, both TR1 and TR2 are turned off. Pin $\overline{MCLR}$ is then supplied from the 5V line via diode D2 (which, as an unimportant side-effect, drops the voltage reaching this pin by about 0·6V). In this condition, the PIC is set into Run mode.

Computer line DA3 is responsible for controlling the PIC's Reset mode via transistor TR3. When DA3 is held low (0V), TR3 is turned off, allowing the selected Program or Run voltage to reach pin $\overline{MCLR}$.

When DA3 is set high (5V), TR3 turns on, shorting $\overline{MCLR}$ to 0V. Resistor R2 prevents the 12V or 5V supply lines from being affected at this time. With $\overline{MCLR}$ low, the PIC is held in Reset mode.

The PIC may also be manually held reset by pushswitch S1. When pressed, S1 feeds the 5V line via R12 to the base of TR3, overriding the status of DA3. The use of S1 is beneficial when the Toolkit board is being used as a test bed, allowing programs to be reset at will. Resistor R6 prevents DA3 from being affected when S1 is pressed.

Note that l.e.d. D1 is unaffected when the PIC is in Reset mode, it will continue to glow whenever TR2 conducts the 12V supply, irrespective of the status of TR3.

There is also a connection between the PIC's RB7 pin and the printer port's BUSY line. This is the path along which the PIC's stored program data can be read and disassembled by the controlling software.

SELECTOR IC3

The purpose of IC3 is basically to separate the PIC's RB6 and RB7 pins from computer lines DA0 and DA1 when the PIC is in Run mode.

Regardless of whether the PIC is simply being programmed prior to insertion into another circuit, or is being used as part of a test-bed, as soon as it is put into Run mode, any program-controlled activity on RB6 and RB7 could, unless prevented, adversely affect lines DA0 and DA1, as well as themselves.

As you may have seen in other circuits, the problem can be limited by inserting a resistor in each of the two lines. However, although the computer's lines are protected in this instance, any other circuit connected to RB0 and RB1 could still be affected by the current flowing back to the computer via the resistors. The insertion of semiconductor gate IC3 prevents this.

Referring to Fig.2, IC3 is shown as a 3-pole changeover switch under control by computer line DA4. When DA4 is low (Run mode), RB7 is routed through path Y/Y0 from where it can be connected to any other circuit. Likewise, RB6 is routed through path Z/Z0, for the same reason. Simultaneously, the base of TR1 is held low via R7 and the X/X0 path to the 0V line. In this situation, DA0 and DA1 are isolated from RB6 and RB7.

When DA4 is high (Program mode),

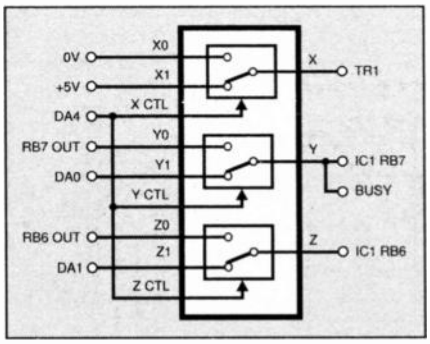


Fig.2. Equivalent circuit for IC3.

DA0 is connected via path Y1/Y to IC1 RB7, DA1 is connected via Z1/Z to IC1 RB6, and the base of TR1 is held high via R7 and the X/X1 path to the +5V line. In this situation IC1's RB6 and RB7 are isolated from any other external circuit.

Resistors R10 and R11 hold the respective DA connection points biassed low when the computer is not connected to the Toolkit.

Whereas DA0 and DA1 are I/O lines, the BUSY line is an input-only to the printer port (control register bit 6), and its isolation from pin RB7 is not necessary.

CONSTRUCTION

Track layout details of the printed circuit board (p.c.b.) for the Toolkit are shown in Fig.3a. This board is available from the *EPE PCB Service*, code 196.

Two component layout and wiring illustrations are shown. The one in Fig.3b should be followed if the Toolkit is to be used on its own (i.e. *independent* of the *EPE PIC Tutorial* p.c.b. Components S1, X1, C1 and C2 may be omitted if there is no intention of using the Toolkit as part of a test-bed.

Sockets should be used for IC1 and IC3. It is strongly recommended that a ZIF (zero insertion force) socket should be used for IC1, allowing easy insertion and removal of the PIC.

If the Toolkit is to be connected to the *EPE PIC Tutorial* p.c.b., follow the details in Fig.4. Note that IC1, IC2, C1, C2 and X1 are not required in this situation. To save expense, it is recommended that the existing computer connector on the Tutorial board is desoldered and used for the Toolkit board (also see later).

Additionally shown in Fig.4 are the points on the Tutorial board to which the Toolkit should be connected.

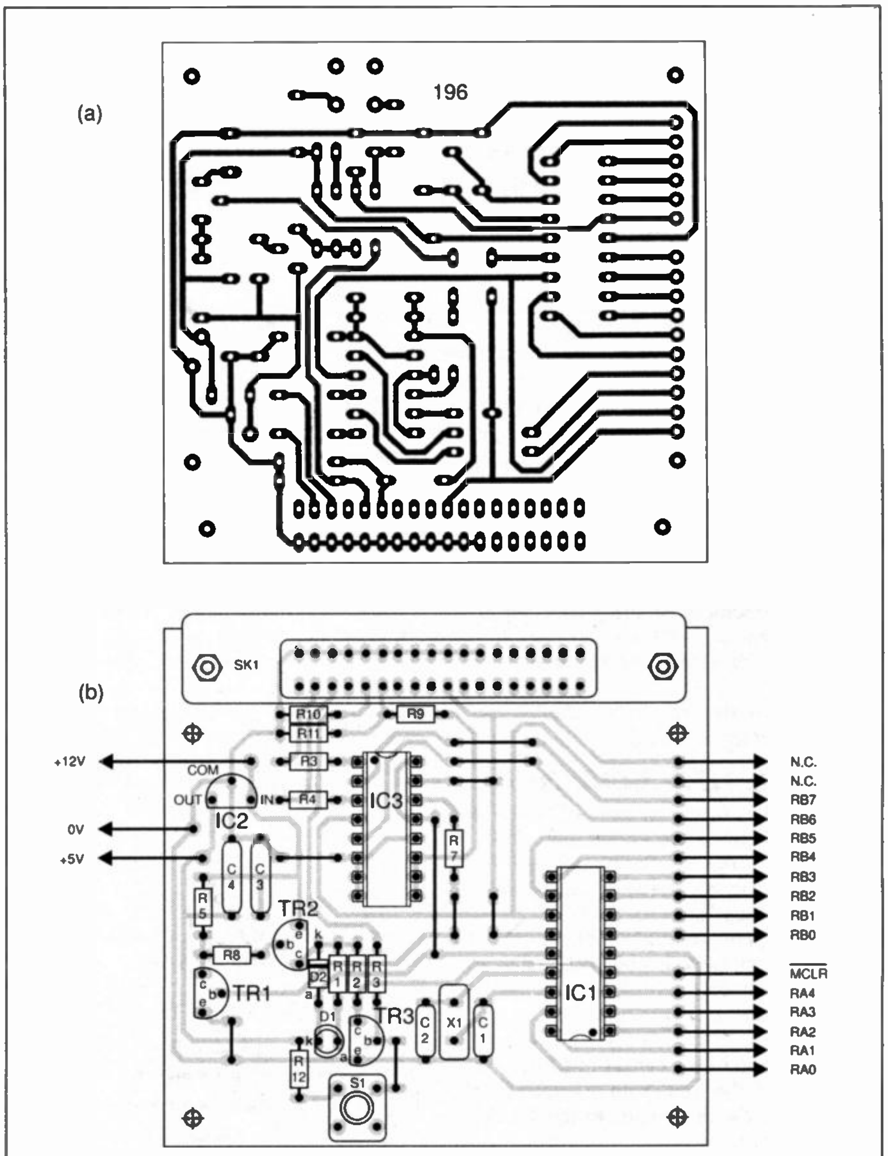


Fig.3. (a) Full size copper foil track master. (b) Complete component layout and termination points when using the Toolkit as an independent unit.

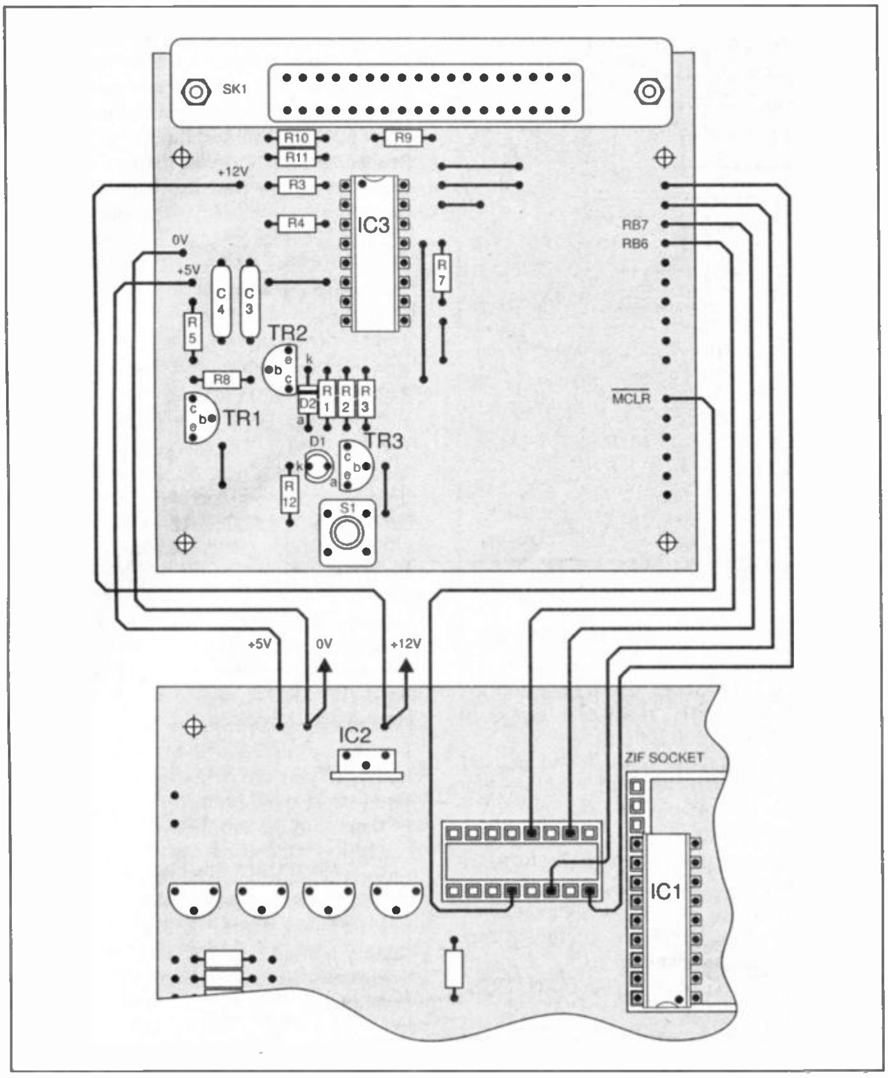


Fig.4. Component layout and interconnections when Toolkit is used with the PIC Tutorial p.c.b.

COMPONENTS

Resistors

R1	2k2	
R2 to R4	1k (3 off)	
R5, R10, R11	100k (3 off)	
R6 to R9, R12	10k (5 off)	

See SHOP TALK Page

Capacitors

C1, C2	10p polystyrene (2 off) (see text)
C3, C4	100n polyester (2 off)

Semiconductors

D1	red l.e.d.
D2	1N4148 signal diode
TR1, TR3	BC549 *npn* transistor (2 off)
TR2	BC559 *pnp* transistor
IC1	PIC16C84 or PIC16F84 microcontroller (see text)
IC2	78L05 5V 100mA regulator (see text)
IC3	4053 triple 2-channel analogue multiplexer

Miscellaneous

S1	s.p. pushswitch, p.c.b. mounting
X1	3.2768MHz crystal (see text)

Printed circuit board, available from the *EPE PCB Service*, code 196; 16-pin d.i.l. socket; 18-pin d.i.l. ZIF socket (see text); p.c.b. supports (4 off); 36-way Centronics female parallel printer connector, p.c.b. mounting (see text); connecting wire; solder, etc.

Approx Cost Guidance Only £16

The five wires shown connected to the switch (S1 to S4) position should be soldered to the trackside of the board, taking care to connect them to the correct points! If the switches are left in position, they should switched off (up).

Assemble the Toolkit p.c.b. in any order you wish, but do not insert IC1 or IC3 until the correctness of the power supply has been confirmed (PIC16C84s can die if greater than 7V is present on their +VE pin 14).

Ensure that the transistors, diodes and IC2 are correctly orientated.

COMPUTER SOCKET

The Toolkit p.c.b. has been designed to accept a 36-pin p.c.b. mounting socket into which a standard (Centronics) parallel printer lead can be plugged. Most people probably already have such a lead. Those who do not, though, might prefer to avoid the expense of buying one and make up their own connector.

In this case, a 25-pin Centronics connector (male) is required for the computer end. Solder about two metres of 6-way ribbon cable to the connector as shown in Fig.5. Solder the other ends to the Toolkit p.c.b. as shown.

This technique is potentially more prone to noise interference than with a proper printer lead, but the author has used it on many occasions without problems.

POWER SUPPLY

Power for the Toolkit may be supplied by any 12V to 14V d.c. source. Even a 12V car battery could be used. Alternatively, the power could be taken straight from the controlling computer.

Within a PC are one or more expansion sockets which are normally used for customised interface boards. Both 12V and 5V supplies are available via these sockets, as shown in Fig.6 (check your computer manual for the orientation of the socket).

A piece of 0.1 inch grid stripboard (e.g. Veroboard) could be cut to suit the socket, and 0V/12V power leads connected accordingly. A 5V lead could be connected as well, in which case regulator IC2 can be omitted.

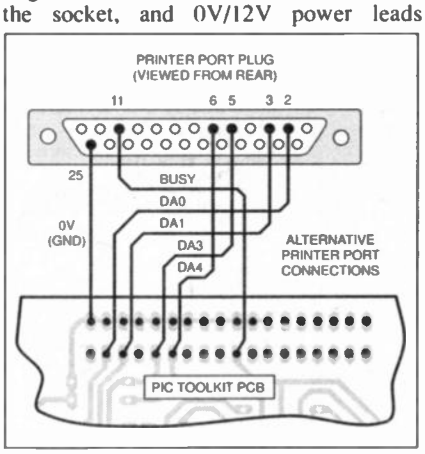


Fig.5. Alternative computer interconnection method.

The drawback of using the computer as the power source is that PICs cannot be inserted or removed from the Toolkit while the computer is switched on, unless an additional switch is included in the Toolkit power lines.

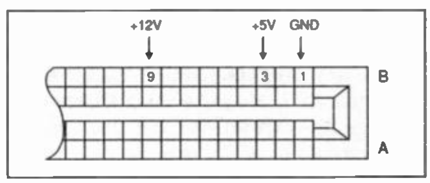


Fig.6. Computer expansion connector showing d.c. power slots.

PRINTER PORT

Generally, PCs have their parallel printer port configured as LPT1, using register &H378 for data output and register &H379 for such control functions as handshakes, paper-out etc.

Full use of the Toolkit requires access to both registers, the control register being the one through which the PIC's data can be read back for verifying or disassembling, using the BUSY line.

It is possible, though, that individual computers may be configured to use one of two other pairs of registers instead of &H378 and &H379. The most likely pair is &H278 and &H279, although &H3BC and &H3BD might be used.

The Toolkit program has been written so that any of the three pairs can be selected for use. Towards the head of the Basic listing (TOOLKIT.BAS) are three statements equating the printer port register number, two preceded by an apostrophe:

portout% = &H378
'portout% = &H278
'portout% = &H3BC

The statement without the apostrophe is the one whose value will be used for printer port output by the rest of the program. As shown, &H378 is the chosen value. To select one of the others, delete its apostrophe and insert an apostrophe in front of the first line. Having done so, resave the program under the same file name.

The printer port's control register value is one greater than the output register. The program automatically allocates the correct number according to the selected output value. You need take no action in this respect.

The author has used the Toolkit in all its input/output modes on several computers. The validity of the three codes was confirmed by configuring a Dell Pentium to regard each of them as being LPT1 when instructed.

COMPAQ SNAG

However, a snag arose when trying to use it with a Compaq 386 machine. First, it was found that this was the only machine which did not use &H378 as the LPT1 output register, being configured for &H3BC.

This machine was purchased second-hand and without documentation. No amount of investigation revealed how it could be reconfigured to one of the other values. Furthermore, it was found that the control register's BUSY line (via &H3BD) could not be read. No solution was found.

It is suspected that this Compaq uses an interface card for printer control and that the card somehow prevents handshake data etc. from being read by the rest of the system. This, though, is pure conjecture.

The result is that, although this Compaq can be used to program PICs, it cannot be used to verify or disassemble them.

In the belief that other readers might have similarly uncooperative machines, a facility to prevent the Toolkit program from trying to verify and disassemble has been included.

A few lines further down from the program's register value selection is the statement that **verify% = 1**.

When **verify%** is set for 1, the Toolkit performs all functions. If your machine does not allow BUSY line reading, set **verify% = 0**. This inhibits the verify routine. It also prevents menu options 6 and 7 (disassembly) from being shown or selected. TOOLKIT.BAS should be resaved if you amend **verify%**.

If any reader can throw light on the Compaq problem, we would be pleased to hear from them.

PORT CHECKING

You may be able to check that the correct value has been set for the printer port output by either calling MSD through DOS, or through the printer port properties display in Windows. Alternatively, key in and run the Basic program in Listing 1.

LISTING 1
Port output register check routine

```
portout% = &H378
'portout% = &H278
'portout% = &H3BC

checkit:
OUT portout%,0
PRINT portout%, "All low"
GOSUB hold
OUT portout%,1
PRINT portout%, "DA0 high"
GOSUB hold
OUT portout%,2
PRINT portout%, "DA1 high"
GOSUB hold
OUT portout%,8
PRINT portout%, "DA3 high"
GOSUB hold
OUT portout%,16
PRINT portout%, "DA4 high"
GOSUB hold
GOTO checkit

hold:
IF INKEY$ = "" THEN GOTO hold
RETURN
```

Provided that the correct output register value has been selected, this program first sets all printer port output lines low (0V). Each time you then press any key, individual output pins go high in turn, as shown. It then loops back to repeat the procedure.

At each step, the status of the printer port lines can be checked using a multimeter. You need only check DA0, DA1, DA3 and DA4.

If the meter shows no change at any step, select the next **portout%** value. Pressing CTRL/BREAK together stops the program to allow the value change.

There is no check for the BUSY line being readable until you try to verify or disassemble a programmed PIC.

If you do the above output check with the Toolkit p.c.b. connected and powered-up (with IC1 omitted), you can also check that the power supply is working. When the correct register value has been chosen, l.e.d. D1 should be on when DA4 is high, but off for any other output value.

Pin 4 of socket IC1 should be at about 4·4V when all outputs are low, and when DA0 or DA1 are high. It should be at 0V when DA3 is high, and at 12V when DA4 is high. This pin should always be at 0V when switch S1 is pressed.

Pin 14 of socket IC1 should always be at 5V.

You will have noticed that line DA2 is not used, even though it seems available. The prototype Toolkit was developed on a Dell Pentium and it was found that (for reasons unknown) the default level for DA2 when the computer is first powered up was high, but with all other DA pins low.

Consequently, it was decided to not use DA2 as a control line. Ironically, other computers have been found to set various other DA pins high as their default value. So much for PC compatibility!

The result is that in a test-bed situation, a circuit can be running correctly under test with the computer off and the printer port lead connected. But it might then be disrupted (possibly held reset or in Program mode) when the computer is powered-up.

This can be avoided by removing the connecting lead until the computer has been powered up and the Toolkit program run as far as its menu display, by which time the printer port has been set with all outputs low.

INSTALLING SOFTWARE

Software for the Toolkit is on the *EPE* PIC-Disk 1. There are four files, TOOLKIT.BAS, TOOLKIT.COM, TOOLKIT.J and PK.BAT.

TOOLKIT.BAS is the Basic program for Toolkit. TOOLKIT.COM is the machine code program which is automatically loaded and accessed through TOOLKIT.BAS. Its source code (TOOLKIT.J) was written for the shareware assembler A86/D86. Program PK.BAT is a quick-loader "BATCH" command program that allows you to rapidly switch between DOS EDIT, TASM and TOOLKIT (PK stands for PicKit!).

Place the disk into the relevant drive. It is now assumed that your disk is in drive A and that you are working in DOS. Windows users must act according to the needs of their own system.

From DOS, copy the three TOOLKIT programs into the same directory in which your QBasic or QuickBASIC software is held. For example, if they are in a directory named QBASIC, use the following commands (pressing <enter> after each command):

c:
cd\qbasic
copy a:toolkit.*

Then copy PK.BAT into the root directory of drive C:

cd
copy a:pk.bat

Program PK.BAT consists of the following commands:

cd\qbasic
qb /run toolkit/l
cd\pic

If the directory names given in the above (those following the **cd** statement) differ, amend them to suit. To change the commands in PK.BAT, type the following command (while still in the root directory of drive C):

edit pk.bat

This loads the DOS EDIT program which then automatically loads and displays the text of PK.BAT.

Amend the statement in the first line to suit the directory in which your Basic is held.

If you are using QBasic, delete the /l statement in line 2 (becoming **qb/run toolkit**).

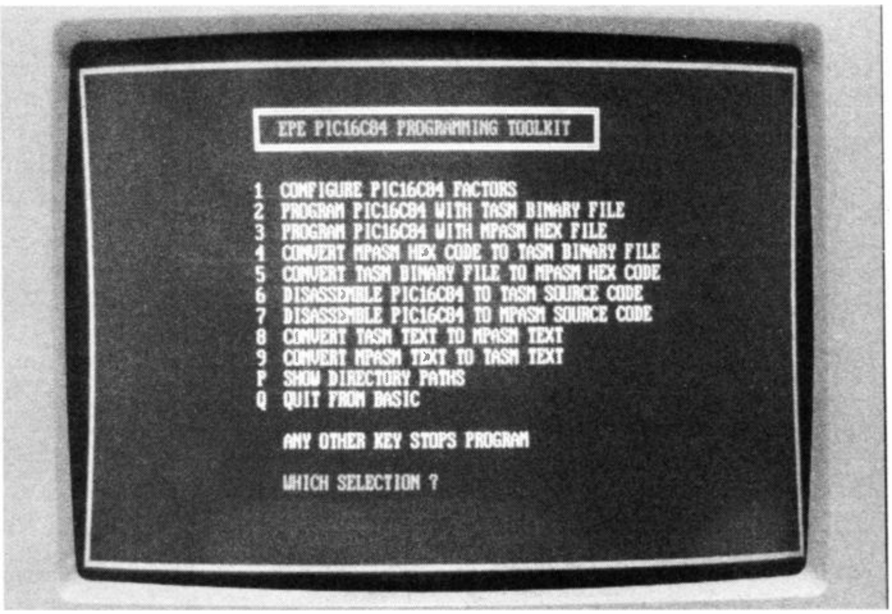
In the third line, substitute the directory name in which your PIC files (including TASM if you use it) are held.

Now resave PK.BAT to the root directory, and also save it to the directory in which your PIC files are held. This allows you to access PK.BAT from either the root or PIC directories.

When you type the command **pk** (do not type **.bat** as well) the actions called for in PK.BAT will be actioned in order. First of all your Basic software is loaded, which then loads TOOLKIT.BAS and runs it. On exit from Basic, the directory is changed back to PIC (or whatever you have chosen to name it).

From the latter directory, you have immediate use of TASM and DOS EDIT. This allows you to modify a PIC source code in EDIT, assemble it via TASM, and then re-enter TOOLKIT using the **pk** command.

A similar structure could be devised if you want to use MPASM (which can be made accessible from DOS or Windows).



The main menu for the Toolkit.

FILES AND DIRECTORIES

The directories and extension codes used for file inputting and outputting are allocated within the body of the TOOLKIT.BAS program. They cannot be specified when you are asked for file names in the various program modes. Should you inadvertently enter an extension code (for example .ASM or .OBJ) the extension is stripped off and the allocated extension added instead.

All directories and extensions can be changed by stopping the program and amending the allocations to whatever you want (the choice of whether or not to re-save TOOLKIT.BAS is yours).

The allocated names supplied with TOOLKIT.BAS are shown in Table 1.

To change a directory or extension name, find the routing section near the beginning of the program (about line 34). Select the routine relating to the mode whose parameters you wish to change, and amend accordingly. For example, the relevant routine for Mode 4 is shown in Listing 2.

Here the source directory is stated as "C:\EPEPIC\" (held in dir$(4)) and its extension is ".HEX" (held in dot$(4)). The destination directory is "C:\PIC\" (held in destdir$(4)) and its extension is ".OBJ" (held in destdot$(4)).

You may change any of the above four statements between quotes to whatever you wish.

The "xxx" statements play no active role and should not be changed, they simply indicate that the file name chosen when running will be inserted between the directory and extension names.

If a directory does not exist, you must create it from DOS. For example, to create the directory called EPEPIC on drive C, you would type:

c:
cd
md epepic

These three statements ensure that you are (1) in the C drive, (2) set for the root directory, (3) have a new directory called EPEPIC.

The ability to search directories for file names and to automatically load them has not been included as it would have complicated the program (a lot of code went into doing it for the *EPE Virtual Scope* of Jan '98!).

If you need to search a directory, stop the program by pressing any non-menu key while the main menu is on display. Then press function key F6 and search via the Files command. To restart the program, press F5.

KEYBOARD EASE

So far as is reasonable, the program has been written for ease of keyboard use, in particular allowing the use of the <enter> key to indicate that you wish to accept an offered action (it's tedious to have to search for character keys when your finger is already above the <enter> key!). In most cases, all you need to do is press <enter> in answer to any of the yes/no questions.

Note, though, that when you first enter a mode, pressing <enter> returns you to the main menu.

Table 1. Default directory paths

Mode	Source	Destination
2	C:\PIC\xxx.OBJ	PIC16C84
3	C:\EPEPIC\xxx.HEX	PIC16C84
4	C:\EPEPIC\xxx.HEX	C:\PIC\xxx.OBJ
5	C:\PIC\xxx.OBJ	C:\MPASMCNVxxx.HEX
6	PIC16C84	C:\PIC\DECODE.ASM
7	PIC16C84	C:\MPASMCNV\DECODE.ASM
8	C:\PIC\xxx.ASM	C:\MPASMCNV\xxx.ASM
9	C:\PIC\xxx.ASM	C:\PIC\xxx.TSM

where xxx is the file name you supply when requested in the selected mode.

LISTING 2
Mode 4 file parameter statements

```
LOCATE 10, 20: PRINT "4 CONVERT MPASM HEX
   CODE TO TASM BINARY FILE"
dir$(4) = "C:\EPEPIC\": dot$(4) = ".HEX"
destdir$(4) = "C:\PIC\": destdot$(4) = ".OBJ"
smid$(4) = "xxx": dmid$(4) = "xxx"
```

PROGRAM MODE 1

CONFIGURE PIC16C84 FACTORS

Program Mode 1 provides the standard facilities for configuring the PIC. From the main menu, press numeral key 1 to select it, whereupon the following menu will appear:

1 LP LOW POWER CRYSTAL 32kHz – 200kHz
2 XT MEDIUM SPEED CRYSTAL 100kHz – 4MHz
3 HS HIGH SPEED CRYSTAL 4MHz – 10MHz
4 RC RESISTOR-CAPACITOR OSCILLATOR

WHICH OSCILLATOR TYPE ?

Select the required timing mode by its number. Confirmation of the choice will then be displayed, e.g.:

XT SELECTED

Three questions are then asked in turn:

ENABLE WATCHDOG TIMER Y/N (DEFAULT NO)
ENABLE POWER-UP TIMER Y/N (DEFAULT YES)
LOAD CONFIGURATION Y/N (DEFAULT YES)

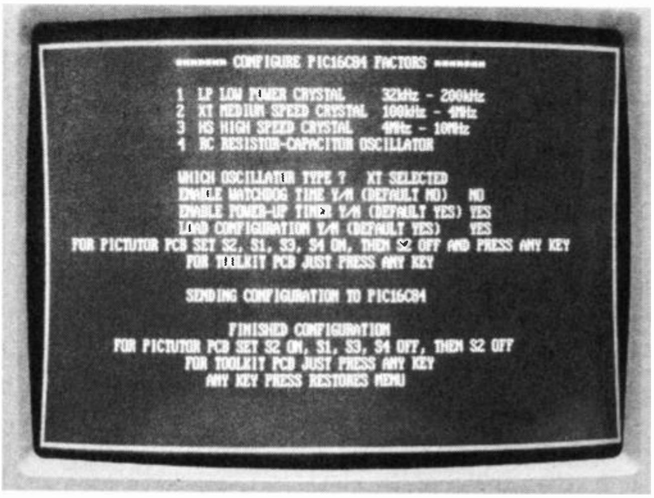
To each as it appears press the relevant Y or N key, or press <enter> to accept the default. Confirmation of the selection is displayed.

With the LOAD question, if N is selected, the configuration routine is abandoned and the display returns to the main menu. If LOAD is accepted, the following instructions appear:

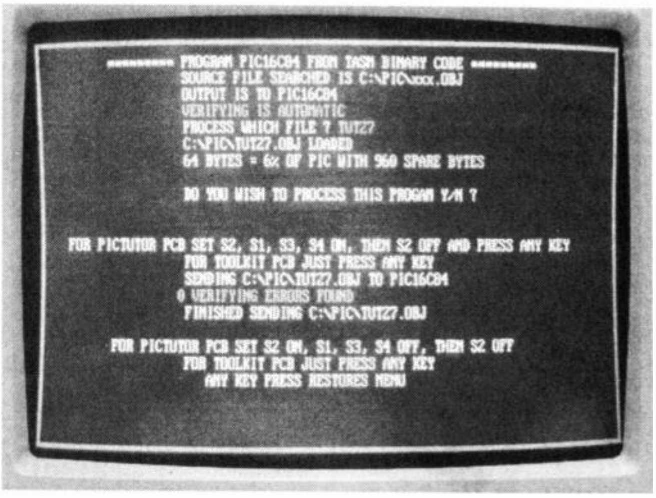
FOR PICTUTOR PCB SET S2, S1, S3, S4 ON, THEN S2 OFF AND PRESS ANY KEY
FOR TOOLKIT PCB JUST PRESS ANY KEY

If the software is being used with the PIC Tutorial board and without the Toolkit board, follow the switching instructions.

If the Toolkit board is in use (with or without the Tutorial board) pressing any key will start the down-loading procedure and this confirmation line will appear:



Typical screen display for Mode 1.



Typical screen display for Mode 2.

SENDING CONFIGURATION TO PIC16C84

to be followed on completion of the code being sent (about 12 seconds maximum for 1024 bytes) by:

FINISHED CONFIGURATION

FOR PICTUTOR PCB SET S2 ON, S1, S3, S4 OFF, THEN S2 OFF
FOR TOOLKIT PCB JUST PRESS ANY KEY
ANY KEY PRESS RESTORES MENU

Follow the appropriate instructions to return to the main menu.

As part of the configuration procedure, the Code Protection option (see *PIC Data Book*) is disabled, allowing code to be disassembled whenever required.

The act of configuring a PIC, however, automatically erases all previous data, replacing it with code that disassembles back as ADDLW 17.

PROGRAM MODE 2

PROGRAM PIC16C84 WITH TASM BINARY FILE

From the main menu, pressing numeral key 2 allows the PIC to be programmed by a TASM-created .OBJ file. On selection, the display confirms the menu choice and advises which directory path is being used (this advice is given in each mode from two to nine).

If the verifying mode is active (**verify% = 1**) the statement that **VERIFYING IS AUTOMATIC** is shown. This statement is omitted if **verify% = 0**.

You are then asked which file you want to process (send to the PIC). Having entered the file name, the program attempts to load it. If you have given a file name that does not exist, you are told so (on screen and by a "beep") and offered the choice to enter another name.

Should you choose not to send a file after all (you might have gone into Mode 2 by mistake) just press <enter> to return to the main menu.

When the chosen file has been loaded into the computer's memory, you are advised of the number of bytes to be sent to the PIC, the percentage of PIC space used and the number of bytes that will still be free. You are also offered the choice of whether or not to send the code. From here, the procedure is the same as with Mode 1 at the same point, with the same sending and closing instructions being displayed.

There is a slight difference in the conclusion statements though. If Verify is active, a verification check is automatically made by the program after the code has been sent to the PIC. The results of this check are then displayed.

In reality, the author has never experienced an incorrectly programmed PIC, nonetheless, the inclusion of a verification process seemed preferable.

It is likely that the only time when you are told that verification errors have been found is if you have forgotten to connect the printer port lead. In this case the number of errors reported will be close to the maximum number of bytes sent. The same will apply if you are trying to program a dead PIC (yes, they can die – but probably only if you power them at a voltage greater that 7V. The author has done it once!).

Note, though, that in the above instances, the reported error number is likely to be smaller than the total byte count since an unconnected BUSY line, or one that is connected to a dead PIC, could be read as zero, matching any zero which occurs in the file code stored in the computer's memory.

There is a minor bug in the machine code that assesses the verification (and the author can't find it!): sometimes an error count of one is reported – ignore it.

If an error count of greater than one is found, the computer "beeps" at you.

PROGRAM MODE 3

PROGRAM PIC16C84 WITH MPASM HEX FILE

From the main menu, pressing numeral key 3 allows the PIC to be programmed by an MPASM-created .HEX file. On selection, the display messages are the same as with Mode 2.

During processing of the MPASM code, the software automatically decodes the hex file and converts it into binary, which is then sent to the PIC in the same way as a TASM binary file is sent.

PROGRAM MODE 4

CONVERT MPASM HEX CODE TO TASM BINARY FILE

In Mode 4, an MPASM hex code file is translated and output to disk as a TASM binary file. This file may then be sent to a PIC via Mode 2, or via the original *EPE* SEND program.

The translation takes into account any .ORG address jumps which have occurred in the MPASM code, adding NOP padding to the binary file where necessary.

The following is an example line taken from a typical MPASM .HEX file:

:0800200079201128 8E0B1C2829

it takes the coded format:

:nnaaaarrxxyyxxyyxxyyxxyycctt

where:

:	=	record start character
nn	=	data byte quantity in line as hex value
aaaa	=	address of first byte in hex
rr	=	record type in hex (00 except for last record which is 01)
xxyy	=	data bytes in hex
cc	=	checksum in hex
tt	=	line terminator (carriage return, line feed)

The checksum is defined by first of taking the sum as:

SUM = byte count + address high + address low + record type + (sum of all data bytes)

then the checksum (cc) = (– SUM) AND 255.

With colon and line terminator discarded, imagine the example line split as:

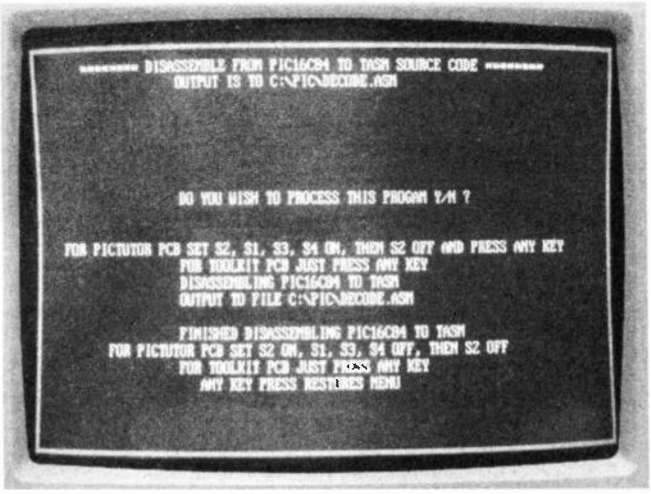
08	**0020**	**00**	**79**	**20**	**11**	**28**
nn	**aaaa**	**rr**	**xx**	**yy**	**xx**	**yy**
8e	**0b**	**1c**	**28**	**29**		
xx	**yy**	**xx**	**yy**	**cc**		

where:

nn	=	hex 08 (decimal 8) data bytes to be translated from hex into binary
aaaa	=	hex 0020 (decimal 32) is the address within the PIC at which the first of these bytes is to be placed
rr	=	00 indicating that this is not the last line to be processed
cc	=	hex 29 (decimal 41), being the checksum for this line

The eight **xx/yy** bytes (quantity as indicated by **nn**) are the only values which are to be put into the binary code file. Their decimal values are:

121, 32, 17, 40, 142, 11, 28, 40



Typical screen display for Mode 6.

Listing 3
Example of disassembled PIC16C84 code.

```
        .ORG 4
        GOTO    JMP367
        .ORG 5
JMP5:   CLRF    PORTA
        CLRF    PORTB
        BSF     STATUS,5
        MOVLW   15          ; %00001111 $0F ""
        MOVLW   5           ; %00000101 $05
        CLRF    PORTB
        MOVLW   5           ; %00000101 $05
        MOVWF   TMR0
        BCF     STATUS,5
        GOTO    JMP37
JMP15:  ADDWF   PCL,F
        RETLW 77            ; %01001101 $4D "M"
        RETLW 50            ; %00110010 $32 "2"
        RETLW 44            ; %00101100 $2C ","
        RETLW 6             ; %00000110 $06
```

The Toolkit software does not make a checksum calculation, but had it done so the addition total for the SUM would be calculated as:

nn + aa + aa + rr + (sum of all xx + yy values) = 40 + 431 = 471

Checksum therefore = (− 471) AND 255 = 41, which equals the value of cc. In other words, there has been no corruption of the data on the disk and the checksums match for this line.

We now come to a difference between MPASM and TASM. With MPASM/MPLAB, the xx/yy bytes are held in hex code files in the opposite order to those in the TASM binary files (and TASM hex files).

Consequently, when translating from MPASM hex to TASM binary (and vice versa), the MPASM byte pairs have to be swapped, as is done by the machine code software.

On entry into Mode 4, you are asked for the name of the MPASM file (.HEX) to be translated into TASM (.OBJ). The same file name is used for the translation, but with a .OBJ extension instead of .HEX. As with other modes so far, if the named file does not exist, you are told so.

PROGRAM MODE 5

CONVERT TASM BINARY CODE TO MPASM HEX FILE

The routine of Mode 5 performs the opposite action of Mode 4. A named TASM binary file (.OBJ) is translated into an MPASM hex file (.HEX). The software calculates the **nn**, **aaaa**, **rr**, **xxyy** and **cc** values, formatting them correctly. The chosen default **xxyy** byte count (**nn**) for a complete line is 16 decimal (10 hex).

On entry into Mode 5, you are asked for the name of the TASM file to be translated into MPASM. The same file name is used for the translation, but with a .HEX extension instead of .OBJ. If the named file does not exist, you are told so.

PROGRAM MODE 6

DISASSEMBLE PIC16C84 TO TASM SOURCE CODE

On entry into Mode 6, you are given the option to exit this mode or proceed with reading the contents of the PIC, and creating a source code file formatted for TASM. There is no choice of file name, it is automatically allocated as DECODE.ASM. Any existing file of the same name is overwritten.

The entire 1024 bytes of the PIC are read during disassembly. Consequently, if the PIC has been programmed before, it may not be immediately obvious where the end of the most recent program occurs – intelligent inspection may be needed!

Be aware that any PIC which has its Code Protection enabled cannot have its code disassembled. It is not possible to turn off Code Protection without erasing the PIC's contents.

The data is output from the PIC as serial data via the BUSY line. It is formatted in software to become 8-bit bytes. A look-up table is used to establish what source code details should be allocated to it.

In the unlikely event that a code is not recognised, the code is noted as such in the created source code file (and a screen announcement is also made at the end of disassembly).

Any addresses indicated in CALL and GOTO commands are noted and destination addresses are prefixed with their numerical value as a Label. Details of how the data is evaluated are too complex for discussion here. For more information, study the program's data statements, the *Simple PIC16C84 Programmer* article, and the PIC16C84 programming specifications section of the *PIC Data Book*.

The disassembled source code file is headed by an identity statement, e.g.:

; DISASSEMBLY FROM PIC16C84 TO TASM ON 02-15-1998 AT 01:16:14

It is then prefixed by various equational statements such as:

```
         .AVSYM
INDF:    .EQU $00
TMR0:    .EQU $01
PCL:     .EQU $02
STATUS:  .EQU $03
FSR:     .EQU $04
PORTA:   .EQU $05
PORTB:   .EQU $06
```

As shown in the example in Listing 3, the disassembled source code commences from PIC address 4, the Interrupt vector address, which in this case holds the command to jump to address 367 (GOTO JMP367). The program itself starts at address 5 (JMP5), the reset vector address.

These two vector addresses are integral to the PIC16C84's operational requirements. When an Interrupt occurs, the PIC automatically jumps to address 4 and follows any instruction (if any) at that address, such as a GOTO command.

The Reset vector at address 5 is that to which the PIC jumps when first powered-up or reset. The command to jump to address 5 is actually held in address 0 and is automatically placed there when a PIC is being programmed. The contents of addresses 0 to 3 are not disassembled to the source code listing (note that addresses 1 to 3 are not available for data programming use – see *PIC Data Book*).

In the main source code statements, any numerical values are given in decimal. Values which do not represent register bit numbers (e.g. BCF STATUS,5) are also interpreted as binary (% prefix), hex ($ prefix), and ASCII values where appropriate (enclosed in double-quotes). They are shown as comments following a semicolon.

Having disassembled the PIC to source code, it is up to the user to examine and further notate the code (the purpose of each routine cannot be assessed through the software, of course). The numerical "comments" may help in this.

PROGRAM MODE 7

DISASSEMBLE PIC16C84 TO MPASM SOURCE CODE

In Mode 7, PIC disassembly operates in the same way as with Mode 6, except that certain formats are changed to suit MPASM (more about TASM/MPASM source code differences later).

As with Mode 6, the destination file is also named DECODE.ASM (but may be in a different directory).

PROGRAM MODE 8

CONVERT TASM TEXT TO MPASM TEXT

Mode 8 translates a TASM source code file to one which can be recognised by MPASM. This file can then be used to create an MPASM.HEX file. The purpose of this mode is to allow users to modify an original TASM source code and tailor it to their own MPASM needs.

The MPASM file retains the same name as the TASM file, complete with .ASM extension (the two files can be held in different directories, so there need be no conflict here).

PROGRAM MODE 9

CONVERT MPASM TEXT TO TASM TEXT

Mode 9 fulfils the same purpose as Mode 8, but in the opposite direction: translation of MPASM source code to TASM source code.

The two files retain the same name, but a different extension can be given to the TASM file. TASM can be told to accept any extension instead of .ASM in its assembly command line – the following is legitimate, for example:

tasm –1684 –b decode.tsm

Note that the only .ORG statements allowed by TASM (and hence in any conversion from MPASM to TASM), are those at addresses 4 and 5. Any others in an MPASM text must be removed by the user prior to conversion. In this case, of course, the MPASM text must be rewritten to no longer need any additional ORG statements.

PROGRAM MODE P

SHOW DIRECTORY PATHS

Mode P shows the file names, plus source and destination paths set for Modes 2 to 9. Amendment of these names and paths was discussed earlier.

Also shown is the printer port output register number in use.

PROGRAM MODE Q

QUIT FROM PROGRAM

The intended use of Mode Q is to exit from the program back to the directory stated in program PK.BAT (or the directory from which TOOLKIT.BAS was called if PK.BAT is not used).

For it to work correctly, the program must first have been called and run through the allocated PK.BAT call (see later). Secondly, no modifications or re-saving of the program must have occurred.

If any of these conditions are not met, the program remains in Basic with the screen displaying the message "Press any key to continue". Pressing any key then drops the program into Basic's edit mode.

This is a limitation imposed by both QBasic and QuickBASIC and has nothing to do with the Toolkit program itself.

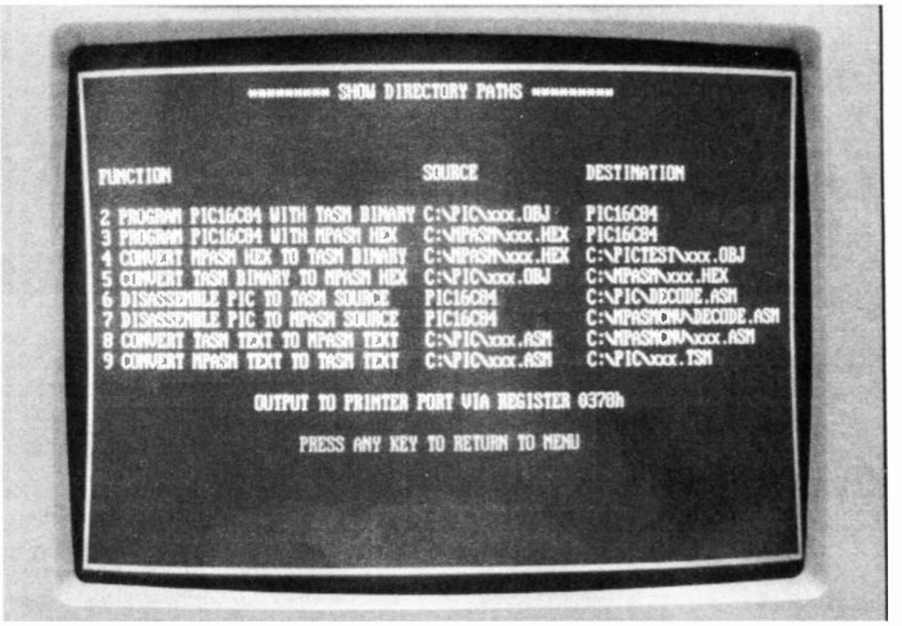
TASM AND MPASM DIFFERENCES

The information given in this section is an expansion on that given in the *EPE PIC Tutorial*, Part 3.

The mnemonic codes as published in the *PIC Data Book* for the PIC16C84 are common to both TASM and MPASM. Differences exist, though, in the way in which numerical values are expressed. Additionally, MPASM has a few idiosyncrasies whose equivalents do not exist with TASM.

First, note that different versions of MPASM exist, having been introduced over several years. The comments here relate to the latest version, V01.40. Some may (unintentionally) also relate to earlier versions, but we cannot be specific about this.

To find out more about MPASM, refer to Microchip's current *MPASM User's Guide*.



Typical display for Mode P, showing the user-selected directory paths for Modes 2 to 9.

NUMERICAL FORMATS

TASM requires the numerical formats as shown in the following examples:

Decimal:	**153**
Hexadecimal:	**$2B**
Binary:	**%10010110**
ASCII:	**'C'**

Decimal requires no prefix, hex and binary need $ and % prefixes respectively, ASCII requires enclosing in "right-handed" single quotes (').

MPASM, though, uses styles that (usually) require both prefix letters and enclosing "right-handed" quotes:

Decimal:	**D'153'**
Hexadecimal:	**H'2B'**
Binary:	**B'10010110'**
ASCII:	**'C' or A'C'**
Octal:	**0'777'**

Note the choice of two equivalent styles for ASCII, and that TASM has no equivalent for the Octal expression.

A significant difference for MPASM is that the user may choose to express decimal, hex or binary values without the use of a prefix and enclosing quotes, defining this requirement in an initialisation line which is prefixed with the statement "**list**".

The term *radix* is used in this respect, and the radix is then equated to be in decimal, hex or binary, according to the user's needs. This same line also states the processor for which the code is to be assembled. For example, the following line tells MPASM that the code is to be assembled for the PIC16C84 (p = 16c84) and that the radix is decimal (r = dec):

list p = 16c84, r = dec

Having specified the radix, any unprefixed value encountered by MPASM during assembly will be taken to be in that notation. Thus if the radix is decimal (r = dec), 10 will be taken as decimal ten. If the chosen radix is hex (r = hex), then 10 will be taken as $10 (decimal 16). For a binary radix (r = bin), 10 will be interpreted as %00000010 (decimal 2).

If no radix statement is made, the default radix is hexadecimal. Toolkit is programmed to look for the radix.

OTHER LIST OPTIONS

Several other equational statements may occur following the "list" statement. These control the format process when MPASM is assembling the source code. They have no relevance to TASM and can be ignored in any translation. The options you might encounter are shown in Table 2 (taken from the *MPASM User's Guide*, Chapter 3, Table 3.2).

In MPASM listings, all options are evaluated as decimal numbers.

LABELS AND DOTS

Whereas TASM's labels need to be followed by colon (:), MPASM's do not (although MPASM seems to accept them).

A decimal point prefix is required by TASM, but not MPASM, in the following instances:

TASM	**MPASM**
.EQU	EQU
.ORG	ORG
.END	END

Additionally, note that MPASM allows ORG statements to set code to start at a variety of addresses and that these addresses may not be in numerical order. TASM does not allow this option; all source codes must follow in strict numerical address sequence from address 5 onwards.

The use of #DEFINE is common to both TASM and MPASM, e.g.:

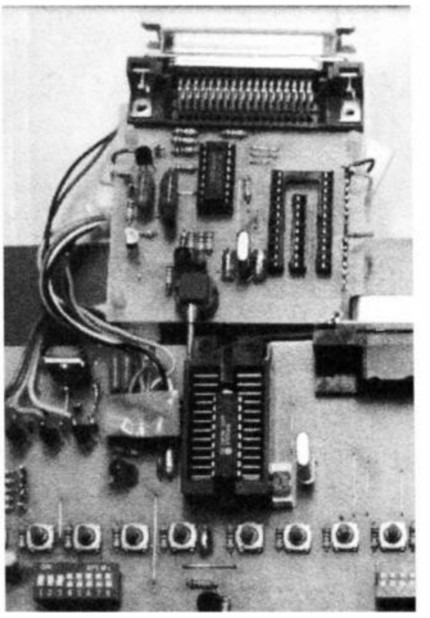
#DEFINE PAGE0 BCF 3,5 (TASM) and
#DEFINE PAGE0 BCF H'03',5 (MPASM)

MPASM SHORTHAND

MPASM permits routines to be defined as "macros", allowing them to be stored as library routines which can be called by name and processed during assembly run-time. Calls to these macros are made through the MPASM source code using the "#include" prefix.

Table 2. MPASM List Directive Options

Option	Default	Description
b=nnn	8	Set tab spaces
c=nnn	132	Set column width
f=<format>	INHX8M	Set the hex file output
free	FIXED	Use free-format parser – backward compatibility only
fixed	FIXED	Use fixed-format parser
mm=ON/OFF	ON	Print memory map in file list
n=nnn	60	Set lines per page
p=<type>	None	Set processor type; for example, PIC16C54
r=<radix>	Hex	Set default radix: hex, dec, oct
st=ON/OFF	ON	Print symbol table in hex file
t=ON/OFF	OFF	Truncate lines of listing (otherwise wrap)
w=0/1/2	0	Set message level (see MPASM User's Guide)
x=ON/OFF	ON	Turn macro expansion on or off



Right: prototypes of the Toolkit and PIC Tutorial p.c.b.s interconnected.

Table 3. MPASM Special Instruction Mnemonics recognised by Toolkit

Mnemonic	Description	Equivalent
ADDCF f,d	Add Carry to File	BTFSC 3,0 INCF f,d
ADDDCF f,d	Add Digit Carry to File	BTFSC 3,1 INCF f,d
B k	Branch	GOTO k
BC k	Branch on Carry	BTFSC 3,0 GOTO k
BDC k	Branch on Digit Carry	BTFSC 3,0 GOTO k
BNC k	Branch on No Carry	BTFSS 3,0 GOTO k
BNDC k	Branch on No Digit Carry	BTFSS 3,1 GOTO k
BZ k	Branch on Zero	BTFSC 3,2 GOTO k
CLRC	Clear Carry	BCF 3,0
CLRDC	Clear Digit Carry	BCF 3,1
CLRZ	Clear Zero	BCF 3,2
MOVFW f	Move File to W	MOVF f,0
NEGF f,d	Negate File	COMF f,1 INCF f,d
SETC	Set Carry	BSF 3,0
SETDC	Set Digit Carry	BSF 3,1
SETZ	Set Zero	BSF 3,2
SKPC	Skip on Carry	BTFSS 3,0
SKPDC	Skip on Digit Carry	BTFSS 3,1
SKPZ	Skip on Zero	BTFSS 3,2
SUBCF f,d	Subtract Carry from File	BTFSC 3,0 DECF f,d
SUBDCF f,d	Subtract Digit Carry from File	BTFSC 3,1 DECF f,d
TSTF f	Test File	MOVF f,1

Where:
d = destination (0 or 1 – W or F)
f = file
k = literal value

Table 4. MPASM Directive Summary

BADRAM	EQU *	NOEXPAND
CBLOCK *	ERROR	NOLIST
CONFIG	ERRORLEVEL	ORG *
CONSTANT	EXITM	PAGE
DATA	EXPAND	PROCESSOR
DB	FILL	RADIX
DE	IDLOCS	RES
#DEFINE *	IF	SET
DT	IFDEF	SPACE
DW	IFNDEF	SUBTITLE
ELSE	#INCLUDE	TITLE
END *	LIST *	#UNDEFINE
ENDC *	LOCAL	VARIABLE
ENDIF	MACRO	WHILE
ENDM	MAXRAM	
ENDW	MESSG	

* = terms recognised by Toolkit

TASM also allows macro use, as described in the text file supplied with it – TASM.DOC.

Note, though, that Toolkit cannot translate any macros. Consequently, before converting MPASM or TASM source codes, macros should be amended by the user to fully expanded lines of source code.

You may also encounter mnemonics in MPASM source codes that are not included in the standard PIC command set but which are recognised by MPASM as legitimate commands during code assembly. They are a form of "definition" allowing one statement to be translated as one or more other statements. In other words, they are a form of shorthand, as shown in Table 3 (taken from the *MPASM User's Guide*, Appendix D, Table 11).

Toolkit recognises all the terms in Table 3.

In addition to the terms shown in Table 3, MPASM recognises another group of terms which are referred to as the "Directive Language". With the exception of the terms CBLOCK, #DEFINE, END, ENDC, EQU, LIST and ORG, Toolkit does not recognise them. The full list supported by MPASM is shown in Table 4. It is expanded in the *MPASM User's Guide*, Chapter 3, Table 3.1.

Any terms not recognised by Toolkit will be copied into the conversion file as found. Their presence will be reported when the code is assembled.

RESOURCES

Software for the Toolkit is available from the Editorial office on a 3.5 inch disk which also contains the TASM documentation. See the *EPE PCB Service* page for details of how to order the disk, plus the postage charges.

The software is also available free via our Web site:

ftp://ftp.epemag.wimborne.co.uk/pub/PICS/PICtoolkit for the Toolkit and

ftp://ftp.epemag.wimborne.co.uk/pub/PICS/TASM for TASM.

The *PIC16/17 Microcontroller Data Book*, *MPASM User's Guide* and *Embedded Control Handbook* (which gives PIC applications notes and example program listings) are available from various leading component suppliers, or from Arizona Microchip Technology Ltd., Microchip House, 505 Eskdale Road, Winnersh Triangle, Woking, Berks RG41 5TU. Tel: 0118 921 5800. Fax: 0118 921 4820.

The contents of the books, plus the software for MPASM and MPLAB are also on the *Microchip Technical Library* CD-ROM, available from Microchip and their agents. If you have a CD-ROM drive, we strongly recommend you obtain a copy of this CD-ROM – you will find it invaluable.

The contents of the CD-ROM are also available for down-load through Microchip's Web site: **http://www.microchip.com.**

Other Microchip internet sites are at:

http://www.microchip2.com/wwwsites.htm (Microchip links to related Web sites).

http://www.microchip2.com/enth.htm (Microchip links to enthusiasts pages).

http://www.arizona.co.uk/arizona (Microchip UK sales rep).

techdesk@arizona.co.uk (E-mail, Arizona UK Tech Desk).

The Public Domain Shareware Library (PDSL) can be contact at: PDSL, Dept EPE, Winscombe House, Beacon Road, Crowborough, E.Sussex TN6 1Ul. Tel: 01892 663298. Fax: 01892 667473.

If you have any queries about the PIC16x84 Toolkit, you can contact John Becker at the Editorial office, by phone, mail or E-mail:
editorial@epemag.wimborne.co.uk

PEAK DCA50 COMPONENT ANALYSER

ANDY FLIND

A unit for automatic analysis of discrete semiconductors

THE Peak DCA50 Component Analyser is designed to provide rapid testing and identification of many types of discrete semiconductor, including diodes, l.e.d.s, bipolar transistors and MOSFETs. First impressions are of a very neat and professional-looking instrument. It is housed in a matt black plasic case, enhanced by attractive purple and gold metallic lettering. Three colour-coded leads terminated with gold-plated crocodile clips are provided for connection to the component on test, and the only control is a single blue pushbutton which initiates the testing process.

Information about the component appears on an alphanumeric l.c.d. display with two lines of sixteen characters. The instrument is very compact and can be easily slipped into a pocket where portable use is intended.

CONSTRUCTION

The front of the DCA50's case simply unclips for easy replacement of the single PP3 battery. The printed circuit board can then be seen, with the pushbutton plus an intelligent l.c.d. display module attached to it by four pillars and screws. This simply plugs into the main board, suggesting easy replacement would be possible should this ever become necessary.

For those with an inquisitive turn of mind the removal of four self-tapping screws releases the whole assembly. The board is a top-quality double-sided fibreglass product, on the underside of which are some surface-mount components. At centre-stage a 44-pin PIC16C64 is obviously the prime mover of the circuit. The p.c.b. is shown in the photograph on the next page.

In general it would be hard to fault the design and construction of the instrument. About the only criticism the author has to make is that the croc. clips provided are difficult to attach to small transistors. Miniature test probes would be better. However it is appreciated that the makers need to supply the unit with robust connectors and most users will have no difficulty in making a set of suitable adapter leads if necessary.

OPERATION

Operation could not be more simple. The three leads (or any two in the case of single diodes) are clipped onto the component in any order and the button is pressed. The legend "Peak Electronic Design Limited" appears briefly, rapidly followed by a couple of seconds of "DCA50 Component Analyser" whilst the instrument carries out a series of tests. Component details are then shown for a period before automatic switch-off takes place.

The upper display line indicates the type of component, such as "NPN Transistor", whilst the lower line shows which colour lead is connected to which component terminal. For bipolar transistors a figure is given for the current gain. The information continues to be displayed for over a minute and a useful feature is that it continues for this period even when the component is disconnected.

In the event of the component being faulty or the DCA50 being unable to identify it the message "No valid part found" is displayed for a slightly shorter period and interestingly, should the user still be watching, this is followed by a brief display of the designer's name plus the date and version of the firmware.

Pairs of diodes with a common connection can be tested in any configuration, the display then flashes between the two anode-cathode connections. This allows three-terminal packages containing two diodes to be tested, and with a little ingenuity it is also possible to test and identify the connections of bridge rectifiers.

The anodes and cathodes of most Zeners can be identified, although of course there is no indication of voltage rating. The unit is especially useful for testing l.e.d.s, since in addition to indicating anode and cathode it flashes the l.e.d. on test during the timeout period.

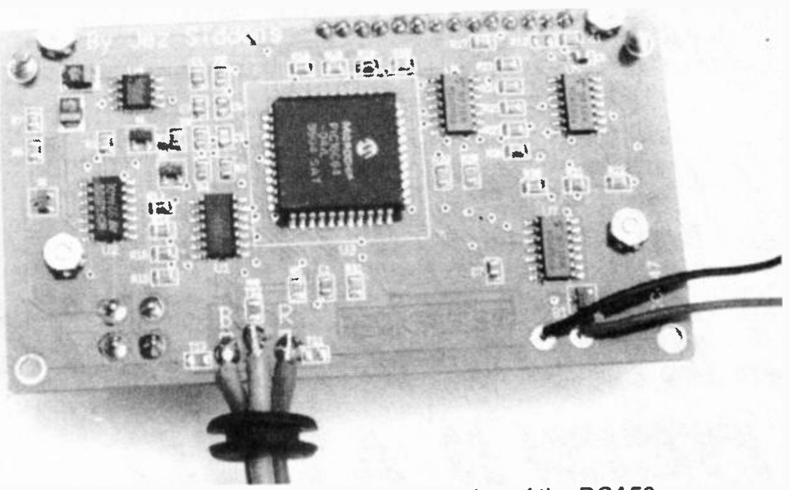
OTHER COMPONENTS

The author could not resist trying the unit with various components it is not intended to test! In most cases, with triacs for ex-

The DCA50 together with its simple operating instructions.

ample, the result is "No valid component detected" but a 2N3819 junction f.e.t. was identified as being two diodes, which of course it is when tested in this way!

An extensive selection of assorted transistors was tried, ranging from ancient OC45 and OC71 germanium types to an MPSA14 silicon Darlington device and valid results were obtained for all of them. With Darlingtons the gain is likely to exceed 1000. Where this happens the DCA50 will give its maximum gain reading of 995 together with a "greater than" (>) sign, so the user will be aware that the actual gain is higher. A couple of TO3-cased power transistors with unfamiliar numbers turned out to be *pnp* types with gains of several hundred, suggesting they may also be Darlington types. Further examination of these will be taking place shortly!



The high quality surface-mount construction of the DCA50.

INDISPENSABLE

So, is it worth purchasing one? The answer depends on how many transistors and diodes the buyer intends to test. For checking just the occasional one or two it is probably not worthwhile. However, for those people who buy large bags of cheap surplus devices this instrument will rapidly become indispensable. Experimenters and circuit designers will probably also find it invaluable.

The author uses transistors and l.e.d.s of many types and frequently cannot remember which lead is which. Tedious reference must then be made to data sheets, or in the case of l.e.d.s it is necessary to locate a suitable series resistor and fiddle about with the bench power supply to determine the anode and cathode through trial and error.

The DCA50 eliminates all this, providing the information in seconds, together with the bonus of a full functional check and a guide to the gain of bipolars so it is well worth keeping on hand. Another area where it will probably find many devotees is in the service industry, where portability is often essential. At around £60 the instrument represents very good value for money and probably won't make a significant dent in the budget, even for hobbyists.

The author would like to end with a couple of suggestions for Peak. The concept of really simple operation with just a test button and an l.c.d. display is excellent and could be extended to all kinds of similar test equipment.

Might the ability of future models of the DCA50 be extended to include junction f.e.t.s, with an indication of mutual conductance for these and MOSFETs? Best of all, how about a passive component analyser, displaying the values of L, C and R of anything connected to it? If such an instrument could be produced at the right price it would undoubtedly find a huge market. So how about it, Peak?

The DCA50 is available for £59 including VAT and p&p from Peak Electronic Design Ltd., 70 Nunsfield Road, Buxton, Derbyshire, SK17 7BW. Tel. 01298 70012, Fax 01298 70046. E-mail sales@peakelec.co.uk.

SHOP TALK
with David Barrington

PIC16x84 Toolkit

It is strongly recommended that a ZIF (zero insertion force) socket is used for accommodating the PIC on the *PIC16x84 Toolkit* printed circuit board. The price of these sockets is not cheap in comparison with standard i.c. sockets, but is well worth the investment.

The rest of the components for the Toolkit, including 16C84/16F84 PICs and Centronics connector, should be readily available. We understand that **Magenta Electronics** (☎ ***01283 565435,*** E-mail: **Magenta_Electronics@compuserve.com**) are putting together a kit of parts, excluding a ZIF socket, for the sum of £13.99 (£21.99 built and tested), add £3 for p&p.

The printed circuit board for the Toolkit is available from the *EPE PCB Service*, code 196 (see page 548). The software is also available from the Editorial Offices on a 3·5 inch PC-compatible disk, which also contains the TASM documentation, order as PIC-Disk 1. See *EPE PCB Service* page for postage charges. Alternatively, if you are an Internet user, it is available free from our FTP site: **ftp://ftp.epemag.wimborne/co.uk/pub/PIC/PICtoolkit**

Greenhouse Computer

With most of the components for the *Greenhouse Computer* mounted on one of two printed circuit boards, it is inevitable that parts will have to be selected with care if they are to fit on the boards. In the light of this, we shall be guided by the author's sourcing experiences.

Starting with the mains transformer. This was purchased from **Rapid Electronics** (☎ ***01206 751166*** or E-mail: **sales@rapidelec.co.uk**), code 88-0160. They also supplied the specified 12V 270 ohm coil relay, with 10A contacts (code 60-0165), and the disc NTC thermistor, code 61-0310. It is quite possible that most disc thermistors with a rating of 5k at 25°C will function here.

We have been unable to trace *waterproof* boxes to the exact dimensions given for the prototype models, so we suggest readers select one from the range stocked by **Maplin**. For the power supply you could use the small version (code YM90X) and for the controller the medium size (code YM91Y).

If you are contemplating the addition of the *Radio Link*, the Transmitter (code TXM-418-F) module is available from **Radio-Tech** (☎ ***01992 576107***). The merits of the Receiver modules will be discussed when the Radio Link option is published.

The two printed circuit boards are available from the *EPE PCB Service*, codes 197 (Controller) and 198 (Power Supply) respectively.

Software for the Greenhouse Computer is available from the *EPE* Editorial Office on a 3·5 inch disk, order as PIC-Disk 1. See *EPE PCB Service* page for postage charges.

The software is also available free from our Web site: **ftp://ftp.epemag.wimborne.co.uk/pub/8051/Greenhouse**

Controller IC1 is available as a pre-programmed device direct from the author: **Colin Meikle, 9 Coldstream Drive, Strathaven, Lanarkshire, ML10 6UD.** Make cheques payable to him. The price, inclusive of UK postage is £12 (add £1 for overseas post).

You can also contact the author via E-mail at **colin.meikle@virgin.net.**

Noise Cancelling Unit

The main concern regarding the intriguing *Noise Cancelling Unit* project will be the choice of the microphones and headphones. The mics. used in this system are quite expensive, but unless you are prepared to pay for good quality types the project is unlikely to give satisfactory results.

Good quality electret microphones seem to be the minimum requirement for acceptable results. The ones used with the model came from **Maplin** and are from their lapel or tie-clip range, code YW71N. An alternative, less expensive, tie-clip electret mic from the same company is coded LB69A. These are the only two microphones that have been tested with the model.

The specified headphones are rated at 22 ohms to 32 ohms and also came from Maplin, they are their lightweight type, code RJ96E. They also stock the low-profile Vero 2000 series case, code LL05F or alternatively a slightly higher version, code LL06G.

It is best to stick with the TLE2037CP low-noise op.amp as the use of cheaper alternatives will result in a marked degradation of the signal-to-noise ratio. This op.amp was purchased from the above, code CP87U.

Low Battery Indicator

All components called up for the *Low Battery Indicator* project should be readily available items from nearly all our component advertisers. However, when purchasing the transistors be sure to specify the suffix **L** for the BC184L type.

This one has its collector (c) lead in the centre of the pinout line-up. Other types have a different pinout arrangement and you would need to bend their leads to suit the stripboard layout.

USING THE L200CV VOLTAGE REGULATOR

ANDY FLIND

Over-voltage, over-current and thermal shutdown protection serve to make the L200 voltage regulator an easy-to-use chip for the experimenter.

THE L200CV voltage regulator is a 3V to 36V, 2A adjustable regulator. In addition to simple voltage setting it features an easy-to-use and highly accurate current limiting circuit which makes it ideal for the construction of simple power supplies.

Over-voltage, over-current and thermal shutdown protection serve to make it practically bomb-proof, enhancing its usefulness for experimenters. The basic technical details for the regulator chip are shown in the specification panel.

REGULAR CIRCUIT

Pin connections and a standard application circuit for the L200CV are shown in Fig.1, with values to give a 12V output limited to 1A. The 220n capacitor C1 and

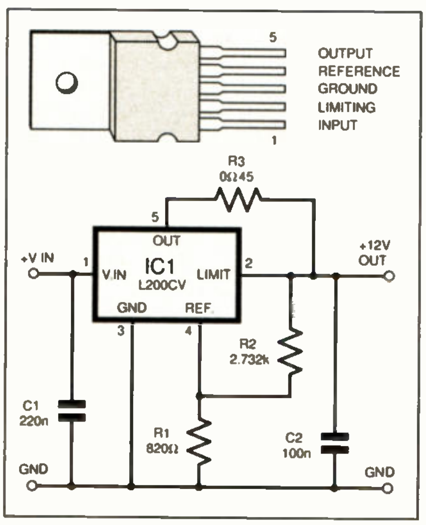


Fig.1: Standard application circuit diagram and pinout details for the L200 Voltage Regulator.

Specification

L200CV

Input Voltage range:	*5V to 40V*
Quiescent Current:	*4·2mA*
Output Voltage Range:	*2·85V to 36V*
Output Current:	*2A max*
Short Circuit Current:	*2·5A*
Line Regulation:	*0·03% typical*
Load Regulation:	*0·1% typical*
Ripple Rejection:	*70dB typical*
Output Resistance:	*1·5mΩ*
Output Noise Voltage:	*80μV*

100n C2 are specified by the manufacturers and should be placed as close to the pins as possible to ensure stability, though it has to be said that this is not a "difficult" chip to use in this respect, the author never having experienced any stability problems even in untidy breadboard layouts.

Most circuits will also have *electrolytic* capacitors in parallel with these two. The one on the input side should be large enough to keep power supply ripple within reasonable limits, but the one on the output can be small as the L200CV will compensate for variations here.

The output voltage is calculated from:

$$V_{out} = 2{\cdot}77\left(1 + \frac{R2}{R1}\right)\text{ Volts} \qquad (1)$$

A value of 820 ohms is often shown for resistor R1 in application notes. This probably provides the right impedance for the reference feedback input at pin 4, so the best method of setting voltage is to calculate the appropriate value of R2 to go with the value shown for R1, using the formula:

$$R2 = \left(\frac{V_{out}}{2{\cdot}77} - 1\right) \times 820\text{ Ohms} \qquad (2)$$

In practice a preset potentiometer, wired as a variable resistor, is often used in series with a fixed resistor in this position to provide some output voltage adjustment. The action of this adjustment is linear, which can prove useful in some applications.

CURRENT AFFAIRS

Readers used to the vague limiting action of the old "723" type of regulator will find the limiting action of this i.c. something of a revelation as it is clean, sharp and accurate.

The maximum output current is set by the value of resistance used for R3. The value required is calculated from formula:

$$R3 = \frac{0{\cdot}45}{I_{MAX}\text{ (Amps)}} \qquad (3)$$

for amps (A); or

$$R3 = \frac{450}{I_{MAX}\text{ (mA)}} \qquad (4)$$

for milliamps (mA).

Note that the full output current flows through R3 so where this is likely to be fairly high a resistor capable of carrying it should be chosen. Resistor R3 will also dissipate some heat, about 0·5W at 1A and 1W at 2A. However, high currents require very low resistance values for R3, which will then usually be either a wirewound type or consist of several resistors in parallel which will share the current and heat dissipation.

If current limiting is not required, it is possible to ignore pin 2 and take the output directly from pin 5 as shown in Fig.2 for an even simpler circuit. Another option is to use the device purely as a current source, with a single resistor to set the current.

The circuit for this is shown in Fig.3, where both pins 3 and 4 are connected to "ground" (0V) supply. As demonstrated earlier, the output current is set by selecting the value of resistor R3 using either formula (3) for amps (A), or (4) for milliamps (mA).

It must be borne in mind that a supply of at least 6V is required to operate the i.c. in this mode, but it still requires only 2V of differential between input and output. So, with a 6V supply, loads developing up to 4V at full current can be driven.

It should be possible to design very simple and versatile NiCad chargers with this circuit, which has none of the high-frequency instability problems sometimes associated with transistor current-generating circuits.

DUE CONSIDERATION

Mounting requirements are fairly simple, especially as two versions of the i.c. are available. So far, this article has referred to the device having a CV suffix which has pins arranged for vertical mounting. There is also a CH version which – you've guessed it! – has angled pins for horizontal mounting.

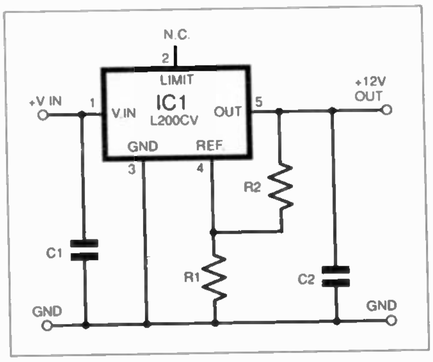


Fig.2. Where no current limiting is needed this simple circuit can be employed.

Consideration must be given to the maximum amount of heat the device may be called upon to dissipate. Basically this is calculated by subtracting the minimum expected output voltage from the maximum input voltage and multiplying this difference by the maximum current. A suitable heatsink can then be selected to cope with this dissipation wattage.

The mounting tab on the device is internally connected to pin 3, the negative (0V) supply connection. In many circuits this corresponds to the potential on a metal chassis or case, so it might prove possible to dissipate the heat by bolting it directly to one of these.

The simplicity of the L200CV, coupled with its versatility and robust nature, makes it an ideal choice for many projects and experiments, so hopefully this explanation of its use will enable readers to employ it in future designs of their own.

A good example of using the L200 regulator chip is to be found in the circuit for the *Float Charger* appearing in next month's issue.

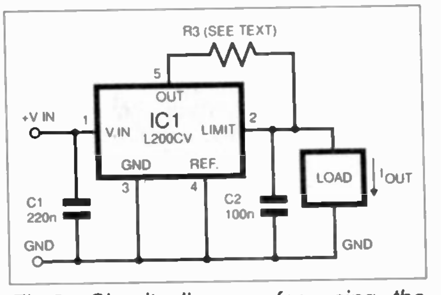
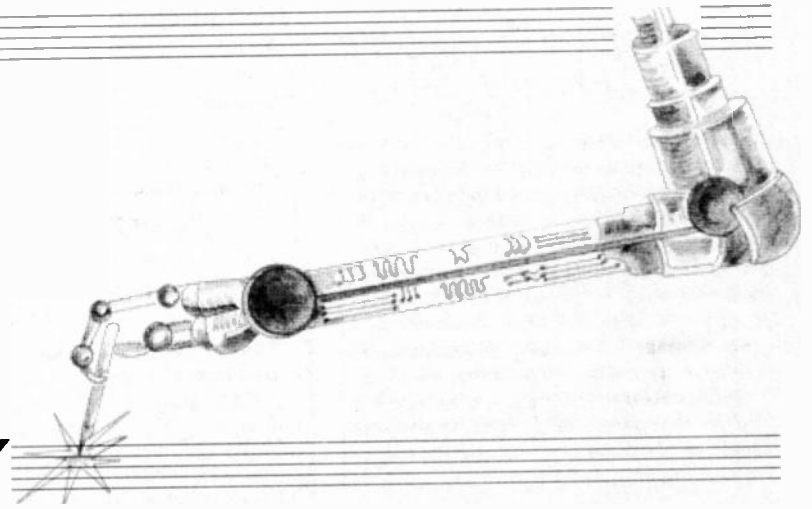


Fig.3. Circuit diagram for using the L200-regulator purely as a constant current source.

Regular Clinic

CIRCUIT SURGERY

ALAN WINSTANLEY



Advice on digital resets and "hot on the trail" of a mains power unit to help test HGV trailer lights.

With the help of the Dept. of Electronic Engineering at the University of Hull, we start this month's round-up of readers' queries and questions with a couple of problems related to digital reset signals.

I tried to design a lamp which increases in brightness in five-minute intervals to make awakening in dark winter mornings less severe. My circuit uses a 4017 counter which controls a mains power controller/dimmer i.c. in several stages; this then drives a mains lamp directly. The problem is that my sequence sometimes starts in random order, rarely in the correct order, so the bulb is driven erratically. Could you shed some light on this – pardon the pun!

Alister Bottomley, Strathblane, Nr. Glasgow.

You are using a 555 to generate a clock pulse, which you are passing to a 4017 divide-by-ten counter. This counts up and drives four transistor buffers, each transistor powering a relay which applies a resistor to a dimmer chip. The problem is that after powering up, the 4017 is not starting from the same count each time, so the sequence does not progress in the right order.

You need a power-on reset (POR) which sets the 4017 to a known state when the circuit is first triggered. A simple *RC* network using an inverter connected to pin 15 (reset) will hopefully do the trick. Note that when a 4017 chip is reset (pin 15 high), the output "0" is actually high because this is a 1-of-10 counter. The following question will also be of interest, Alister!

Resets Cause Upsets!

The next query was sent by a reader following our *Teach-In '98* series – *An Introduction to Digital Electronics*.

I would appreciate some help with an item I saw in Teach- In 98, *in the April 98 issue (Fig. 6.19). This relates to using an inverter gate as a Power-On Reset circuit, with an RC network connected to the input. Is there a formula to calculate the time delay of this network, as the "suck it and see" approach is a bit hit and miss?*

Also, could I drive a piezo sounder instead of an l.e.d. without damage? Finally, will the 74LS14 work from a 9V battery, as I do not yet have a variable power supply. Hope you can help me with my experiments.

Clive Conroy via CompuServe.

The circuit you referred to is a demo from *Lab Work*, Part 6 (see Fig. 1). The big problem is this: the time taken for the Schmitt inverter to switch over is strictly related to the "threshold" voltage of a particular gate. This parameter varies from one example to another. My Texas Instruments data book quotes the "positive-going threshold voltage" for the 74LS14 as

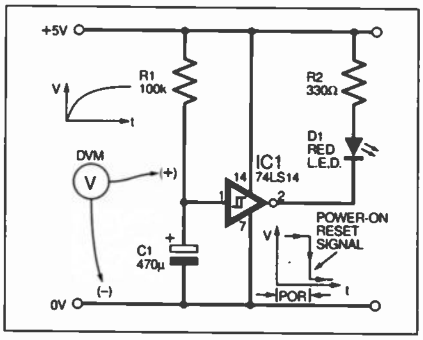


Fig.1. The Power-On Reset (POR) circuit from Teach-In 98 – Lab Work 6, *Fig.6.19.*

anything from 1·4V to 1·9V, so there is quite a tolerance to begin with.

Ian Bell of the University of Hull explains the problem: the real answer requires the use of the classic exponential capacitor charging equation, rearranged to produce a value of *RC* from a given period, says Ian. Assuming the capacitor is discharged on power-up, the *RC* value required to generate a power-on reset pulse of duration *t* with a supply rail voltage of V_{DD} and a logic threshold voltage of V_{LT} is given by the following equation:

$$RC = \frac{-t}{\ln\left[1 - \frac{V_{LT}}{V_{DD}}\right]} \quad \text{ln = natural log)}$$

By "logic threshold" we mean the voltage on the capacitor when the Schmitt trigger switches, in order to end the POR pulse. As an example, if the gate switches at 1·3V on a 5V supply and we require a 10ms pulse, the value of *RC* is 0·033. So values of R = 100k and C = 0·33µF would do.

If we assume the logic threshold is a fixed fraction of the supply voltage then we can simplify the equation quite a lot. If, for example, we assume that the threshold is one third of the supply, then the formula becomes:

$$RC = \frac{t}{0{\cdot}41} \text{ or } RC = 2{\cdot}47t$$

As the exact length of the pulse is probably not important, then $RC = 2.5t$ would do. For a 10ms pulse we get R = 100k and C = 0·25µF, which is not much different from before. Note that if V_{LT}/V_{DD} is 0.63 (63%) then we get $RC = t$, the "standard" period associated with an RC delay. In an application like this, it's perfectly acceptable to use a rule of thumb, because that's all that is needed to calculate an approximate time delay.

It is also worth remembering the fact that the timing components (especially electrolytic capacitors) can have huge tolerances, as well as an awful leakage current which contributes to the inaccuracy, and you are in any case restricted by what values are available off the shelf, so choose the capacitor first then calculate the resistor. Incidentally, we dealt with RC-related equations back in *Circuit Surgery*, August 1996 issue, where we explained why a capacitor can never reach the supply voltage rail when charging through a series resistor. If you wanted a more precise delay, choose the good old 555 or another timer chip.

To answer your other queries, the maximum output sink current of a 74LS14 is 8mA which isn't a lot for driving external loads (more than adequate for high-efficiency l.e.d.s though). Remember that TTL is better at *sinking* current rather than sourcing it.

If you can obtain a low-power piezo sounder which consumes only a few milliamps, the 74LS14 would drive it without problem. Remember too that you need a self-contained sounder (with built-in driver oscillator), not a piezo disc or "element".

Finally, you couldn't run a 74LS14 chip from a 9V battery (not twice, anyway). The absolute maximum rating is 5·5V. We described a cheap way of adding a 5V regulator onto a very cheap mains adaptor, back in the foundation parts of *Teach-In 98*.

• Would you like to meet everyone at the Teach-In Team? Subject to confirmation of numbers, we plan to hold a Teach-In "Meet" in the Department of Electronic Engineering at the University of Hull during September, when you can bring along any demos which you struggled with (if any). Entry is by invitation only, so register in advance! In order that we can gauge the likely turnout, please let us know as soon as possible if you are interested – check the announcement on page 513. We hope to see you there! *A.R.W.*

Trailing the Light Fantastic

Here's a query related to truck trailer lighting – or at least, how to test them when you don't have half a ton of truck batteries handy.

My friend repairs the lighting circuits on articulated trucks and small trailers. I've been asked to make him a control box to test the trailer lights, using the mains supply. I need a 24V d.c. 6A output and a 12V 6A output too. Nothing too elaborate!

J. Waby, Lincoln.

Our solution to this intriguing problem, a simple power supply with a difference, see Fig.2. Because of the high currents required, this calls for some serious smoothing of a rectified d.c. supply. Truck repair shops have lorry batteries galore (trucks use 24V d.c.), so instead of using enormous and expensive capacitors, how about the twin 12V output supply of Fig. 2? It uses two lead-acid batteries on each output, to serve as "reservoirs".

Each supply provides about 12V and needs a 72VA transformer winding (144VA in total for transformer T1). To obtain 24V, place a **heavy duty link** as shown to wire the batteries in series. All terminals and components **must** be suitably rated, and two thermal cut-outs or fuses as near to the battery positive terminals as possible, are recommended. Wires should be as short as possible and rated for 10A or more.

Lead-acid batteries have enormous capacity to provide several hundred amperes peak (a car starter motor draws some 200A-300A) and must be treated with respect. It will be perfectly safe provided you observe the usual safety rules concerning these types of battery.

If you don't like the idea of using 12V batteries, then find some ex-computer power supply capacitors, e.g 10,000µF 25V and use those instead, correctly polarised: they will make as big a mess as any car battery, if mistreated, so handle everything with due respect.

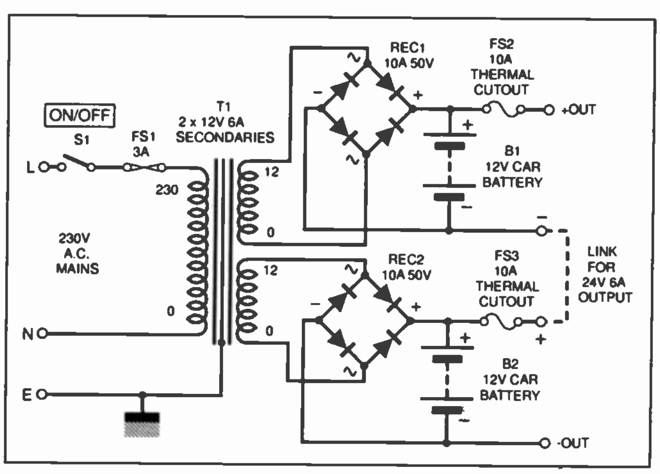
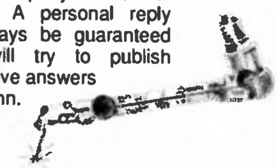


Fig.2. Circuit for a 12V/24V Trailer Light Tester for workshop use.

CIRCUIT THERAPY

Circuit Surgery is your column. If you have any queries or comments, please write to: Alan Winstanley, *Circuit Surgery*, Wimborne Publishing Ltd., Allen House, East Borough, Wimborne, Dorset, BH21 1PF, United Kingdom. E-mail **alan@epemag.demon.co.uk**. Please indicate if your query is not for publication. A personal reply cannot always be guaranteed but we will try to publish representative answers in this column.



Ingenious Neon Torch

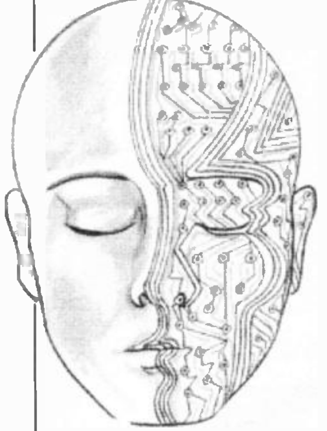
*I do a lot of mountain walking and often find myself returning after dark. The "Neon Torch" by the Rev. Thomas Scarborough (*Ingenuity Unlimited, *February 1998) looks a great idea to save myself a few spare batteries, but I can't find any of those "green fluorescent glow lamps" the Rev. used in his design. Can you help?*

Frederick Armour-Brown, Clwyd, Wales.

I too am stuck on this one. An ordinary neon bulb uses two electrodes and "strikes" when a voltage of roughly 60V to 70V or so is applied, to produce the characteristic orange glow. They are suitable as mains-powered indicators if a voltage-dropper resistor is used, though the preferred way nowadays is to use an l.e.d. on the low-voltage side.

The only such "green" neon-type lamp I have ever come across was used in my desktop "Ion Prism" ioniser, as a power indicator: the green glow matched the green printing of the artwork! I think the tube used a phosphorescent coating (like that of a fluorescent tube) to provide a coloured glow, but I am unsure what gas is used. They must be available somewhere!

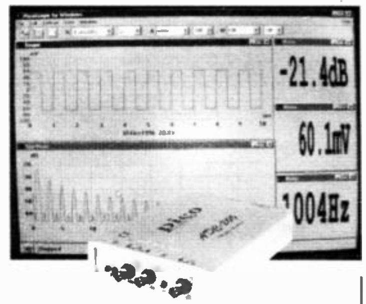
I've sent your details on to Thomas who has promised to mail you one, all the way from South Africa. Meantime, can any readers "shed some light" on this glow-lamp?



INGENUITY UNLIMITED

Our regular round-up of readers' own circuits. We pay between £10 and £50 for all material published, depending on length and technical merit. We're looking for novel applications and circuit tips, not simply mechanical or electrical ideas. Ideas *must be the reader's own work* and **not have been submitted for publication elsewhere.** The circuits shown have NOT been proven by us. *Ingenuity Unlimited* is open to ALL abilities, but items for consideration in this column should preferably be typed or word-processed, with a brief circuit description (between 100 and 500 words maximum) and full circuit diagram showing all relevant component values. **Please draw all circuit schematics as clearly as possible.**

Send your circuit ideas to: Alan Winstanley, *Ingenuity Unlimited*, Wimborne Publishing Ltd., Allen House, East Borough, Wimborne, Dorset BH21 1PF. They could earn you some real cash **and a prize!**



WIN A PICO PC BASED OSCILLOSCOPE

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- Signal Generator

If you have a novel circuit idea which would be of use to other readers then a Pico Technology PC based oscilloscope could be yours.

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Electronic Dice – A Logical Choice

THE CIRCUIT presented in Fig.1 is an Electronic Dice in which seven l.e.d.s are arranged to represent the face of a dice. Circuits performing a similar job have been designed before, several kits are available and even a dedicated i.c. However, I wanted to design a version that does not rely on hardwired OR gates, usually associated with circuits of this kind, and my design illustrates the versatility of the JK flip-flop.

The l.e.d.s run through the six possible combinations at high speed, leaving one combination displayed when a pushswitch, S2, is released. Only three chips are used, a quad 2-input NOR gate (IC1, 4001B) and two dual-input JK flip-flops (IC2 and IC3, 4027B). These inexpensive devices are widely available and they enable the circuit to be powered by a 9V battery.

A common clock signal is provided by an oscillator comprising two NOR gates IC1a and IC1b, with resistor R3 and capacitor C1 providing a frequency of approximately 20Hz when the pushbutton switch S2 is pressed. All four clock inputs of the flip-flops are connected together, and the condition of the J and K inputs will determine the state of the flip-flop after the clock pulse.

The first flip-flop IC2a, which controls the central l.e.d. "A" (D1), has the J and K inputs held high; this is toggle mode, which means that the output state will change with every clock pulse and provide the necessary odd/even effect. *(See* Teach-In '98 *Part 7 and* Lab Work 7 *in the May 98 edition, for more background information on JK flip-flops. A.R.W.)* The three remaining flip-flops of IC2 and IC3 each control pairs of l.e.d.s which must be "set" in turn when the central l.e.d. extinguishes. For example, after the number "1" has been displayed the clock pulse will cause the central l.e.d. to extinguish and l.e.d. pair "B" (D2 and D3) to light up.

A JK flip-flop will set, following a clock pulse, whenever the J input is high and the K input is low. The J input to IC2b is derived from the output controlling the central l.e.d., so a "set" condition will follow a clock pulse when the central l.e.d. is on.

The flip-flop IC3a controlling l.e.d. pair "C" (D4 and D5) will be set following a clock pulse, with both the central l.e.d. and l.e.d. pair "B" switched on. In this case the display would be showing number "3". This is achieved by the J input being the result of an AND operation of the two l.e.d. outputs concerned. IC3b controls the l.e.d. pair "D" (D6 and D7), this time the J input depends upon the state of l.e.d. pair "C" and the central l.e.d.; another AND operation occurs in much the same way as for IC3a.

When number "6" is displayed the K input to the last three flip-flops will be made high, the effect being that on the next clock pulse, all three flip-flops will reset and extinguish the corresponding l.e.d.s. The central l.e.d. will re-light and display number "1".

When power is first applied, the state of the flip-flops is unpredictable, and may cause an illegal display, this is rectified within a few clock pulses. The whole circuit operates from a 9V PP3-type battery. ***Steve Teal, Witney, Oxon.***

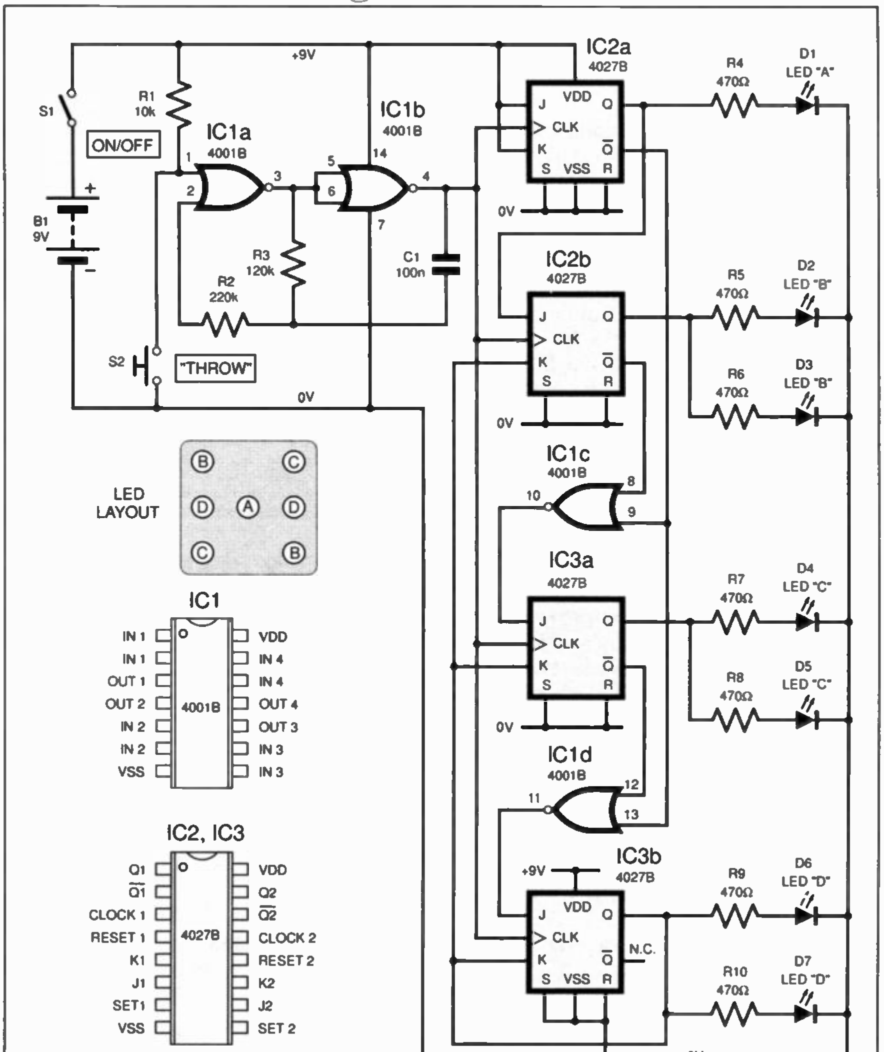


Fig. 1. Flip-flop based Electronic Dice.

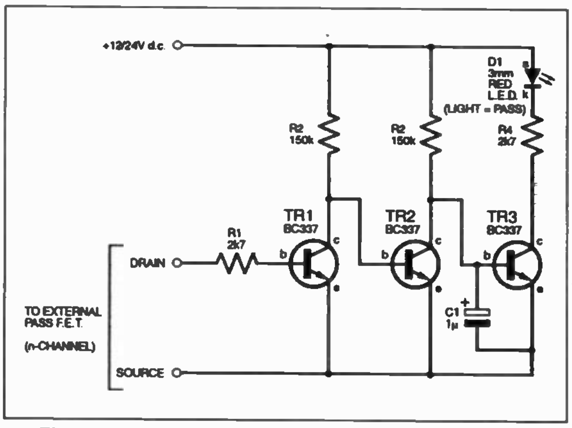


Fig.2. Linear Regulator Performance Monitor.

Linear Regulator Performance Monitor – Check the Regs.

A NOVEL circuit which will help to determine the performance of a linear regulator which uses an external MOSFET pass transistor is shown in Fig.2. It functions by checking if the pass element "bottoms out" even on a ripple trough, hence the inclusion of capacitor C1. If the regulator is bottoming out, the output voltage must start to fall and the l.e.d. will extinguish. If the pass element is shorted due to failure, or driven hard due to an open feedback loop, then an over-voltage condition will exist and the l.e.d. will also extinguish.

The circuit, with values shown, is suitable for negative *n*-channel FET linear regulators and has been built and tested on my *Versatile Linear Regulator* published in *Ingenuity Unlimited*, July 1997.

Gerard La Rooy,
Christchurch, New Zealand.

Generating Short Pulses With Ripple Counters – Repetitive

THE 4060 ripple counter represents a cheap method of providing system clocking for many digital circuits because of its built-in clock generator and multiple outputs. However, if low duty cycle pulses are needed, the combinational logic needed on the outputs can be difficult to design, and propagation delay glitch problems can set in (*for further background reading, see* Teach-In '98 *Part 6, page 288 – A.R.W.*).

The circuit of Fig. 3 generates an output waveform with pulse width set by the clock and a repetition frequency set by the divisor. IC1 is a 4060 ripple counter with internal clock, the frequency of operation of which is determined by an external *RC* network (R1, R2 and C1). The output at pin 9 sets the clock output pulse width, whilst the divisor sets the repetition rate (e.g. pin 1 is divide by twelve). IC2 is a 4013 dual flip-flop of which one half is used as a latch. The output is taken from the Q output, pin 1 and sample waveforms are also given.

Gerard La Rooy,
Christchurch, New Zealand.

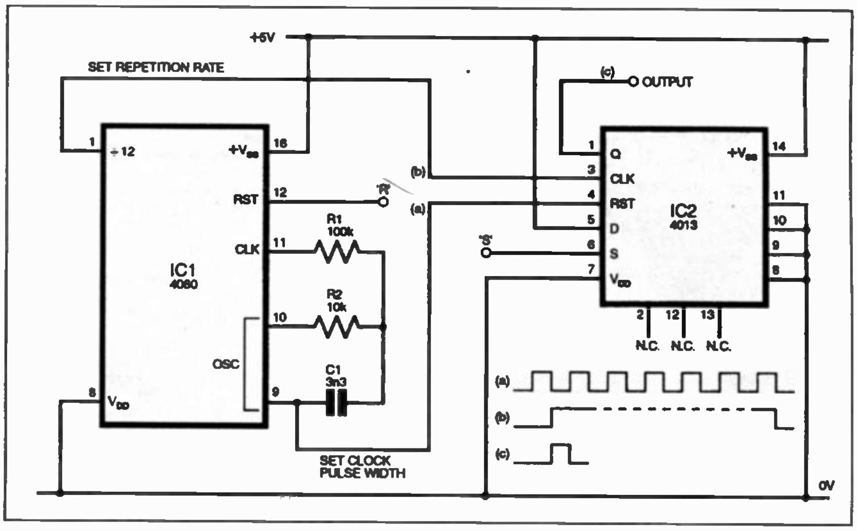


Fig.3. Generating short pulses with ripple counters.

Novice Enthusiast's Radio – For First-Time Hams

THE CIRCUIT shown in Fig.4 is my attempt at constructing a simple radio receiver with just a handful of components. It is hoped that this will appeal to novices who have never experienced the thrill of listening to a home-brew radio receiver for the first time.

The radio signal received induces a weak radio frequency signal across L1b, which is wound on a *ferrite rod* and forms a "tank circuit" in conjunction with the tuning control, VC1. *PNP* transistors TR1 and TR2 are in Darlington configuration and their associated components form an amplitude modulation (a.m.) detector and amplifier.

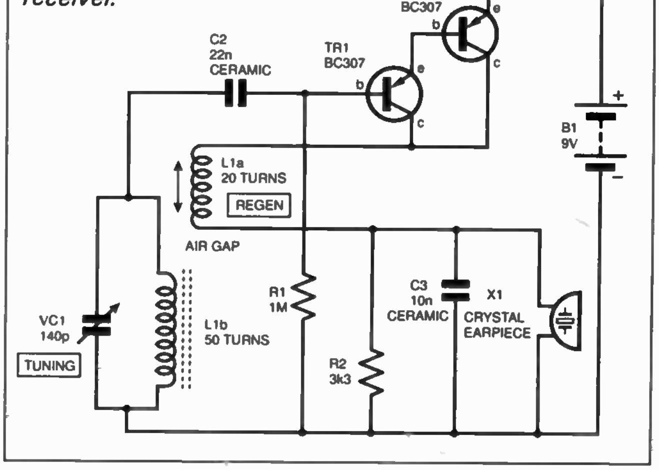
The amplified signal is fed across coil L1a to provide some "regeneration". The audio frequency developed across resistor R2 is decoupled by capacitor C3 and can be heard over a crystal earpiece, X1. Note that L1a is *not* on the aerial rod is magnetically coupled over an air gap.

Place the two coils close together initially , then attempt to tune in any "whistles" using tuning capacitor VC1. Slowly separate L1a away from L1b and the whistles will hopefully suddenly become clear audio. Reverse the wires to L1a if you cannot hear the oscillation. The entire circuit runs from a 9V PP3- style battery.

Michael Robertson,
Chasetown.

(I do indeed know the thrill of listening to one's first home-made radio, Michael: my first crystal set used a motley mixture of standard r.f. parts duly cobbled together. An aerial made from 20 feet of zip wire was dangled out of my upstairs bedroom window, the radio was earthed to a copper stake in Dad's flowerbed and I fed the output into my brother's Grundig tape recorder when he wasn't looking. I immediately tuned in to a live transmission from Nashville, Tennessee! I still have the tape in my attic. A.R.W.)

Fig.4. Simple regenerative receiver.



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SOLAR MOTORS Another new line for us are these tiny motors which run quite happily on voltages from3-12vdc. We have tried one on our 6v amorphous 6" panels and you can run them from the sun! 32mm dia 20mm thick. £1.50 each

TELEPHONES Just in this week is a huge delivery of telephones, *all brand new and boxed. Two piece construction with the following* features- Illuminated keypad, nice clear easy to use keypad, tone or pulse (switchable), reacall, redial and pause, high/low and off ringer switch and quality construction. Each telephone is finished in a smart off white colour and is supplied with a standard international lead (same as US or modem card sockets) if you wish to have a BT lead supplied to convert the phones these are also available at £1.55 each ref BTLX **Phones £4.99 each ref PH2**

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GIANT INSULATORS Just in this week are some giant ceramic insulators, each one measures 130mm high and about 170mm diameter. Finished in a high gloss brown and black glaze. In the base of each insulator is a threaded hole approx 1" diameter, rather like a mop/broom head thread. If you are into shortwave radio, crystal sets or high voltage experiments then these are for you. (We've got one as a door stop) Not too sure what their original purpose was, all we know is they were made for export about 25 years ago, never exported and been in store since then. **Price is £8 each ref INSX**

NATO RADIATION MONITORS Interesting new line! These are small modules that strap on your wrist (strap supplied) and monitor radiation. We have stripped one apart and they contain a small piece of "crystal" this could be something like Naphthalene or any other rare radiation sensitive crystal. When radiation strikes the crystal, it scintillates and a small amount of light is produced in the crystal in reaction to the radiation exposure. That light is then picked up by a micro pv cell measuring about 2mm square! Also in the unit is a sheet of foil, a circular metal plate (insulation between the two) and a small pair of additional parallel metal plates. NATO part no is 6665-99-225-2314 any information gratefully received!! Alternatively if you wish to buy one they are **just £3 each** ref NATOX

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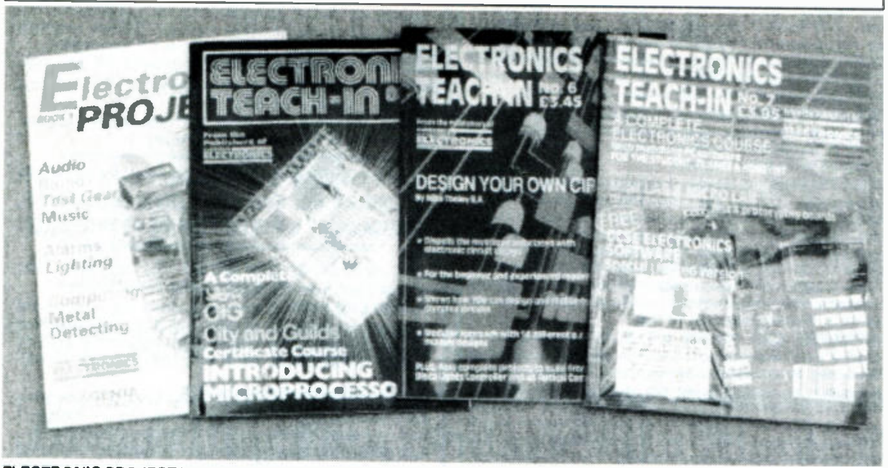
Everyday Practical Electronics Books



DIRECT BOOK SERVICE

The books listed have been selected by Everyday Practical Electronics *editorial staff as being of special interest to everyone involved in electronics and computing. Books are supplied by mail order direct to your door. Full ordering details are given on the last book page.*

For another selection of books see the next two issues of EPE.

ELECTRONIC PROJECTS – BOOK 1
Published by *Everyday Practical Electronics* in association with Magenta Electronics.
Contains twenty of the best projects from previous issues of EE each backed with a kit of components. The projects are: Seashell Sea Synthesiser, EE Treasure Hunter, Mini Strobe, Digital Capacitance Meter, Three Channel Sound to Light, BBC 16K Sideways Ram, Simple Short Wave Radio, Insulation Tester, Stepper Motor Interface, Eprom Eraser, 200MHz Digital Frequency Meter, Infra Red Alarm, EE Equaliser Ioniser, Bat Detector, Acoustic Probe, Mains Tester and Fuse Finder, Light Rider – (Lapel Badge, Disco Lights, Chaser Light), Musical Doorbell, Function Generator, Tilt Alarm, 10W Audio Amplifier, EE Buccaneer Induction Balance Metal Detector, BBC Midi Interface, Variable Bench Power Supply, Pet Scarer, Audio Signal Generator.
128 pages (A4 size) **Order code EP1** **£2.45**

ELECTRONICS TEACH-IN 88/89 – INTRODUCING MICROPROCESSORS
Mike Tooley BA (published by *Everyday Practical Electronics*)
A complete course that can lead successful readers to the award of a City and Guilds Certificate in Introductory Microprocessors (726/303). The book contains everything you need to know including full details on registering for assessment, etc. Starting with basic terminology, integrated circuits, logic families and numbering systems the text builds in stages, with revision and assessments built in, up to programming, languages, flow charts, etc. The course is ideal for the newcomer to the subject.
80 pages (A4 size) **Order code TI-88/89** **£2.45**

TEACH-IN No. 7 plus FREE Software
ANALOGUE AND DIGITAL ELECTRONIC COURSE
(Published by *Everyday Practical Electronics*)
Alan Winstanley and Keith Dye B.Eng(Tech)AMIEE
The highly acclaimed *Teach-In* series, which included the construction and use of the *Mini Lab* and *Micro Lab* test and development units, has been put together in book form. Additionally EPT Educational Software have developed a GCSE Electronics software program to compliment the course and a FREE DISC covering the first two parts of the course is included with the book.

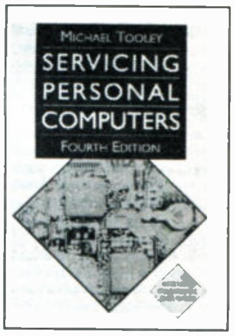
An interesting and thorough tutorial series aimed specifically at the novice or complete beginner in electronics. The series is designed to support those undertaking either GCSE Electronics or GCE Advanced Levels, and starts with fundamental principles.

If you are taking electronics or technology at school or college, this book is for you. If you just want to learn the basics of electronics then this is for you. If you are teaching electronics or technology you must make sure you see it. *Teach-In No. 7* will be invaluable if you are considering a career in electronics or even if you are already training in one. The Mini Lab and software enable the construction and testing of both demonstration and development circuits. These learning aids bring electronics to life in an enjoyable and interesting way: you will both see and hear the electron in action! The Micro Lab microprocessor add-on system will appeal to higher level students and those developing microprocessor projects.
152 pages (A4 size) **Order code TI7** **£3.95**

Testing and Test Gear

HOW TO USE OSCILLOSCOPES AND OTHER TEST EQUIPMENT
R. A. Penfold
This book explains the basic function of an oscilloscope, gives a detailed explanation of all the standard controls, and provides advice on buying. A separate chapter deals with using an oscilloscope for fault finding on linear and logic circuits, plenty of example waveforms help to illustrate the control functions and the effects of various fault conditions. The function and use of various other pieces of test equipment are also covered, including signal generators, logic probes, logic pulsers, and crystal calibrators.
104 pages **Order code BP267** **£3.50**

SERVICING PERSONAL COMPUTERS – 4th EDITION
Mike Tooley BA



The revised and enlarged forth edition has been completely re-written to cover the latest technology, such as 32-bit microprocessors and serial communications servicing. It includes a diagnostic disk offer. Essential for anyone concerned with the maintenance of personal computer equipment or peripherals, whether professional service technician, student or enthusiast.
387 pages Hardback **Order code NE15** **£30**

Computers and Computing

MULTIMEDIA ON THE PC
Ian R. Sinclair
In this book, you'll find out what a CD ROM is, how it works, and why it is such a perfect add-on for a PC, allowing you to buy programmes, text, graphics and sound on a CD. It also describes the installation of a CD ROM drive and a sound card, pointing out the common problems that arise, and then shows how to use them to create a complete multimedia presentation that contains text, photos, a soundtrack with your own voice recorded as a commentary, even animation and edited video footage.
184 pages **Order code PC112** **£11.95**

A CONCISE INTRODUCTION TO MS-DOS
N. Kantaris
(Revised Edition Covers Version 6.2)
This guide is written with the non-expert, busy person in mind and, as such, it has an underlying structure based on "what you need to know first, appears first". Nevertheless, the guide is also designed to be circular, which means that you don't have to start at the beginning and go to the end. The more experienced user can start from any section.
176 pages **Order code BP232** **£4.99**

UNDERSTANDING PC SPECIFICATIONS
R. A. Penfold (Revised Edition)
If you require a microcomputer for business applications, or a high quality home computer, an IBM PC or compatible is often the obvious choice. They are competitively priced, and are backed up by an enormous range of applications programs, hardware add-ons, etc. The main difficulty for the uninitiated is deciding on the specification that will best suit his or her needs. PCs range from simple systems of limited capabilities up to complex systems that can happily run applications that would have been considered beyond the abilities of a microcomputer not so long ago. It would be very easy to choose a PC system that is inadequate to run your applications efficiently, or one which goes beyond your needs and consequently represents poor value for money.

This book explains PC specifications in detail, and the subjects covered include the following: Differences between types of PC (XT, AT, 80386, etc); Maths co-processors; Input devices (keyboards, mice, and digitisers); Memory, including both expanded (EMS) and extended RAM; RAM disks and disk caches; Floppy disk drive formats and compatibility; Hard disk drives (including interleave factors and access times); Display adaptors, including all standard PC types (CGA, Hercules, Super VGA, etc); Contains everything you need to know if you can't tell your EMS from your EGA!
128 pages **Order code BP282** **£4.95**

Radio, TV, Satellite

PROJECTS FOR RADIO AMATEURS AND S.W.L.S.
R. A. Penfold
This book describes a number of electronic circuits, most of which are quite simple, which can be used to enhance the performance of most short wave radio systems.

The circuits covered include: An aerial tuning unit; A simple active aerial; An add-on b.f.o. for portable sets; A wavetrap to combat signals on spurious responses; An audio notch filter; A parametric equaliser; C.W. and S.S.B. audio filters; Simple noise limiters; A speech processor; A volume expander.

Other useful circuits include a crystal oscillator, and RTTY/C.W. tone decoder, and a RTTY serial to parallel converter. A full range of interesting and useful circuits for short wave enthusiasts.
92 pages **Order code BP304** **£3.95**

AN INTRODUCTION TO AMATEUR RADIO
I. D. Poole
Amateur radio is a unique and fascinating hobby which has attracted thousands of people since it began at the turn of the century.

This book gives the newcomer a comprehensive and easy to understand guide through the subject so that the reader can gain the most from the hobby. It then remains an essential reference volume to be used time and again. Topics covered include the basic aspects of the hobby, such as operating procedures, jargon and setting up a station. Technical topics covered include propagation, receivers, transmitters and aerials etc.
150 pages **Order code BP257** **£4.99**

SIMPLE SHORT WAVE RECEIVER CONSTRUCTION
R. A. Penfold
Short wave radio is a fascinating hobby, but one that seems to be regarded by many as an expensive pastime these days. In fact it is possible to pursue this hobby for a minimal monetary outlay if you are prepared to undertake a bit of d.i.y., and the receivers described in this book can all be built at low cost. All the sets are easy to costruct, full wiring diagrams etc. are provided, and they are suitable for complete beginners. The receivers only require simple aerials, and do not need any complex alignment or other difficult setting up procedures.

The topics covered in this book include: The broadcast bands and their characteristics; The amateur bands and their characteristics; The propagation of radio signals; Simple aerials; Making an earth connection; Short wave crystal set; Simple t.r.f. receivers; Single sideband reception; Direct conversion receiver.

Contains everything you need to know in order to get started in this absorbing hobby.
88 pages **Order code BP275** **£3.95**

Our postage is the same no matter how many books you buy – just £1.50 in the UK.

Theory and Reference

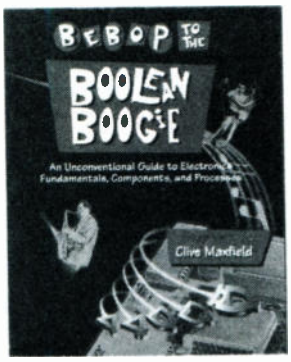
Bebop To The Boolean Boogie

By Clive (call me Max) Maxfield
ORDER CODE BEB1
£24.95

470 pages. Large format

Specially imported by EPE – Excellent value

An Unconventional Guide to Electronics Fundamentals, Components and Processes



This book gives the "big picture" of digital electronics. This indepth, highly readable, up-to-the-minute guide shows you how electronic devices work and how they're made. You'll discover how transistors operate, how printed circuit boards are fabricated, and what the innards of memory ICs look like. You'll also gain a working knowledge of Boolean algebra and Karnaugh maps, and understand what Reed-Muller logic is and how it's used. And there's much, MUCH more (including a recipe for a truly great seafood gumbo!). Hundreds of carefully drawn illustrations clearly show the important points of each topic. The author's tongue-in-cheek British humor makes it a delight to read, but this is a REAL technical book, extremely detailed and accurate. A great reference for your own shelf, and also an ideal gift for a friend or family member who wants to understand what it is you do all day....

DIGITAL ELECTRONICS – A PRACTICAL APPROACH
With FREE Software: Number One Systems – EASY-PC Professional XM and Pulsar (Limited Functionality)
Richard Monk
Covers binary arithmetic, Boolean algebra and logic gates, combination logic, sequential logic including the design and construction of asynchronous and synchronous circuits and register circuits. Together with a considerable practical content plus the additional attraction of its close association with computer aided design including the FREE software.

There is a 'blow-by-blow' guide to the use of EASY-PC Professional XM (a schematic drawing and printed circuit board design computer package). The guide also conducts the reader through logic circuit simulation using Pulsar software. Chapters on p.c.b. physics and p.c.b. production techniques make the book unique, and with its host of project ideas make it an ideal companion for the integrative assignment and common skills components required by BTEC and the key skills demanded by GNVQ. The principal aim of the book is to provide a straightforward approach to the understanding of digital electronics.

Those who prefer the 'Teach-In' approach or would rather experiment with some simple circuits should find the book's final chapters on printed circuit board production and project ideas especially useful.
250 pages **Order code NE28** **£16.99**

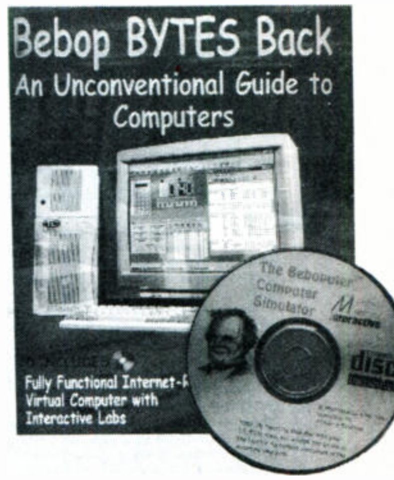
Bebop Bytes Back

By Clive "Max" Maxfield and Alvin Brown
ORDER CODE BEB2
£29.95

Over 500 pages. Large format

Specially imported by EPE – Excellent value

An Unconventional Guide To Computers



Plus **FREE CD-ROM** which includes:
Fully Functional Internet-Ready Virtual Computer with Interactive Labs

This follow-on to Bebop to the Boolean Boogie is a multimedia extravaganza of information about how computers work. It picks up where "Bebop I" left off, guiding you through the fascinating world of computer design . . . and you'll have a few chuckles, if not belly laughs, along the way. In addition to over 200 megabytes of mega-cool multimedia, the accompanying CD-ROM (for Windows 95 machines only) contains a virtual microcomputer, simulating the motherboard and standard computer peripherals in an extremely realistic manner. In addition to a wealth of technical information, myriad nuggets of trivia, and hundreds of carefully drawn illustrations, the book contains a set of lab experiments for the virtual microcomputer that let you recreate the experiences of early computer pioneers. If you're the slightest bit interested in the inner workings of computers, then don't dare to miss this one!

DIGITAL GATES AND FLIP-FLOPS
Ian R. Sinclair
This book, intended for enthusiasts, students and technicians, seeks to establish a firm foundation in digital electronics by treating the topics of gates and flip-flops thoroughly and from the beginning.

Topics such as Boolean algebra and Karnaugh mapping are explained, demonstrated and used extensively, and more attention is paid to the subject of synchronous counters than to the simple but less important ripple counters.

No background other than a basic knowledge of electronics is assumed, and the more theoretical topics are explained from the beginning, as also are many working practices. The book concludes with an explanation of microprocessor techniques as applied to digital logic.
200 pages **Order code PC106** **£8.95**

Audio and Music

AN INTRODUCTION TO LOUDSPEAKERS AND ENCLOSURE DESIGN
V. Capel
This book explores the various features, good points and snags of speaker designs. It examines the whys and wherefores so that the reader can understand the principles involved and so make an informed choice of design, or even design loudspeaker enclosures for him – or herself. Crossover units are also explained, the various types, how they work, the distortions they produce and how to avoid them. Finally there is a step-by-step description of the construction of the *Kapellmeister* loudspeaker enclosure.
148 pages **Order code BP256** **£3.99**

ACOUSTIC FEEDBACK – HOW TO AVOID IT
V. Capel
Feedback is the bane of all public address systems. While feedback cannot be completely eliminated, many things can be done to reduce it to a level at which it is no longer a problem.

Much of the trouble is often the hall itself, not the equipment, but there is a simple and practical way of greatly improving acoustics. Some microphones are prone to feedback while others are not. Certain loudspeaker systems are much better than others, and the way the units are positioned can produce a reduced feedback. All these matters are fully explored as well as electronic aids such as equalizers, frequency-shifters and notch filters.

The special requirements of live group concerts are considered, and also the related problem of instability that is sometimes encountered with large set-ups. We even take a look at some unsuccessful attempts to cure feedback so as to save readers wasted time and effort duplicating them.

Also included is the circuit and layout of an inexpensive but highly successful twin-notch filter, and how to operate it.
92 pages **Order code BP310** **£4.99**

PREAMPLIFIER AND FILTER CIRCUITS
R. A. Penfold
This book provides circuits and background information for a range of preamplifiers, plus tone controls, filters, mixers, etc. The use of modern low noise operational amplifiers and a specialist high performance audio preamplifier i.c. results in circuits that have excellent performance, but which are still quite simple. All the circuits featured can be built at quite low cost (just a few pounds in most cases). The preamplifier circuits featured include: Microphone preamplifiers (low impedance, high impedance, and crystal). Magnetic cartridge pick-up preamplifiers with R.I.A.A. equalisation. Crystal/ceramic pick-up preamplifier. Guitar pick-up preamplifier. Tape head preamplifier (for use with compact cassette systems).

Other circuits include: Audio limiter to prevent overloading of power amplifiers. Passive tone controls. Active tone controls. PA filters (highpass and lowpass). Scratch and rumble filters. Loudness filter. Audio mixers. Volume and balance controls.
92 pages **Order code BP309** **£4.99**

COMPUTERS AND MUSIC – AN INTRODUCTION
R. A. Penfold
Computers are playing an increasingly important part in the world of music, and the days when computerised music was strictly for the fanatical few are long gone.

If you are more used to the black and white keys of a synth keyboard than the QWERTY keyboard of a computer, you may be understandably confused by the jargon and terminology bandied about by computer buffs. But fear not, setting up and using a computer-based music making system is not as difficult as you might think.

This book will help you learn the basics of computing, running applications programs, wiring up a MIDI system and using the system to good effect, in fact just about everything you need to know about hardware and the programs, with no previous knowledge of computing needed or assumed. This book will help you to choose the right components for a system to suit your personal needs, and equip you to exploit that system fully
174 pages **Order code PC107** **£8.95**

ELECTRONIC PROJECTS FOR GUITAR
R. A. Penfold
This book contains a collection of guitar effects and some general purpose effects units, many of which are suitable for beginners to project building. An introductory chapter gives guidance on construction.

Each project has an introduction, an explanation of how it works, a circuit diagram, complete instructions on stripboard layout and assembly, as well as notes on setting up and using the units. Contents include: Guitar tuner; Guitar preamplifier; Guitar headphone amplifier; Soft distortion unit; Compressor; Envelope waa waa; Phaser; Dual tracking effects unit; Noise gate/expander; Treble booster; Dynamic treble booster; Envelope modifier; Tremelo unit; DI box.
110 pages **Order code PC110** **£8.95**

HIGH POWER AUDIO AMPLIFIER CONSTRUCTION
R. A. Penfold
Practical construction details of how to build a number of audio power amplifiers ranging from about 50 to 300/400 watts r.m.s. includes MOSFET and bipolar transistor designs.
96 pages **Temporarily out of print**

Circuits, Data and Design

PRACTICAL ELECTRONIC FILTERS
Owen Bishop
This book deals with the subject in a non-mathematical way. It reviews the main types of filter, explaining in simple terms how each type works and how it is used.
The book also presents a dozen filter-based projects with applications in and around the home or in the constructor's workshop. These include a number of audio projects such as a rythm sequencer and a multi-voiced electronic organ.
Concluding the book is a practical step-by-step guide to designing simple filters for a wide range of purposes, with circuit diagrams and worked examples.
88 pages **Order code BP299** **£4.99**

ELECTRONIC HOBBYISTS DATA BOOK
R. A. Penfold
This book should tell you everything you are ever likely to want to know about hobby electronics, but did not know where to ask or refer. Comprehensive contents pages makes it easy to quickly locate the data you require.
The subjects covered include: Common circuits, and related data (including helpful graphs and tables of values); Colour codes for resistors, capacitors and inductors; Pinout details for a wide range of CMOS and TTL devices, plus basic data on the various logic families; Pinout details and basic data for a wide range of operational amplifiers; Data and leadout information for a wide range of transistors, FETs, power FETs, triacs, thyristors, diodes, etc; General data including MIDI message coding, radio data, ASCII/Baudot coding, decibel ratios, etc.
242 pages **Order code BP396** **£5.95**

50 SIMPLE LED CIRCUITS
R. N. Soar
Contains 50 interesting and useful circuits and applications, covering many different branches of electronics, using one of the most inexpensive and freely available components – the light-emitting diode (LED). Also includes circuits for the 707 common anode display.
64 pages **Order code BP42** **£2.99**

BOOK 2 50 more l.e.d. circuits.
50 pages **Order code BP87** **£2.99**

CIRCUIT SOURCE BOOK 1
A. Penfold
Written to help you create and experiment with your own electronic designs by combining and using the various standard "building block" circuits provided. Where applicable, advice on how to alter the circuit parameters is given.
The circuits covered in this book are mainly concerned with analogue signal processing and include: Audio amplifiers (op.amp and bipolar transistors); audio power amplifiers; d.c. amplifiers; highpass, lowpass, bandpass and notch filters; tone controls; voltage controlled amplifiers and filters; triggers and voltage comparators; gates and electronic switching; bargraphs; mixers; phase shifters, current mirrors, hold circuits, etc.
Over 150 circuits are provided, which it is hoped will be useful to all those involved in circuit design and application, be they professionals, students or hobbyists.
182 pages **Order code BP321** **£4.99**

A BEGINNER'S GUIDE TO TTL DIGITAL ICs
R. A. Penfold
This book first covers the basics of simple logic circuits in general, and then progresses to specific TTL logic integrated circuits. The devices covered include gates, oscillators, timers, flip/flops, dividers, and decoder circuits. Some practical circuits are used to illustrate the use of TTL devices in the "real world"
142 pages **Order code BP332** **£4.95**

HOW TO USE OP.AMPS
E. A. Parr
This book has been written as a designer's guide covering many operational amplifiers, serving both as a source book of circuits and a reference book for design calculations. The approach has been made as non-mathematical as possible.
160 pages **Order code BP88** **£3.99**

CIRCUIT SOURCE BOOK 2
R. A. Penfold
This book will help you to create and experiment with your own electronic designs by combining and using the various standard "building blocks" circuits provided. Where applicable, advice on how to alter the circuit parameters is provided.
The circuits covered are mainly concerned with signal generation, power supplies, and digital electronics.
The topics covered in this book include: 555 oscillators; sinewave oscillators; function generators; CMOS oscillators; voltage controlled oscillators; radio frequency oscillators; 555 monostables; CMOS monostables; TTL monostables; precision long timers; power supply and regulator circuits; negative supply generators and voltage boosters; digital dividers; decoders, etc; counters and display drivers; D/A and A/D converters; opto-isolators, flip/flops, noise generators, tone decoders, etc.
Over 170 circuits are provided, which it is hoped will be useful to all those involved in circuit design and application, be they professionals, students or hobbyists.
192 pages **Order code BP322** **£4.99**

Project Building

ANDROIDS, ROBOTS AND ANIMATRONS
John Lovine
Build your own working robot or android using both off-the-shelf and workshop constructed materials and devices. Computer control gives these robots and androids two types of artificial intelligence (an expert system and a neural network). A lifelike android hand can be built and programmed to function doing repetitive tasks. A fully animated robot or android can also be built and programmed to perform a wide variety of functions.
The contents include an Overview of State-of-the-Art Robots; Robotic Locomotion; Motors and Power Controllers; All Types of Sensors; Tilt; Bump; Road and Wall Detection; Light; Speech and Sound Recognition; Robotic Intelligence (Expert Type) Using a Single-Board Computer Programmed in BASIC; Robotic Intelligence (Neutral Type) Using Simple Neural Networks (Insect Intelligence); Making a Lifelike Android Hand; A Computer-Controlled Robotic Insect Programmed in BASIC; Telepresence Robots With Actual Arcade and Virtual Reality Applications; A Computer-Controlled Robotic Arm; Animated Robots and Androids; Real-World Robotic Applications.
224 pages **Order code MGH1** **£19.99**

ELECTRONIC PROJECTS FOR EXPERIMENTERS
R. A. Penfold
Many electronic hobbyists who have been pursuing their hobby for a number of years seem to suffer from the dreaded "seen it all before" syndrome. This book is fairly and squarely aimed at sufferers of this complaint, plus any other electronics enthusiasts who yearn to try something a bit different. No doubt many of the projects featured here have practical applications, but they are all worth a try for their interest value alone.
The subjects covered include:- Magnetic field detector, Basic Hall effect compass, Hall effect audio isolator, Voice scrambler/descrambler, Bat detector, Bat style echo location, Noise cancelling, LED stroboscope, Infra-red "torch", Electronic breeze detector, Class D power amplifier, Strain gauge amplifier, Super hearing aid.
138 pages **Order code BP371** **£4.95**

PRACTICAL FIBRE-OPTIC PROJECTS
R. A. Penfold
While fibre-optic cables may have potential advantages over ordinary electric cables, for the electronics enthusiast it is probably their novelty value that makes them worthy of exploration. Fibre-optic cables provide an innovative interesting alternative to electric cables, but in most cases they also represent a practical approach to the problem. This book provides a number of tried and tested circuits for projects that utilize fibre-optic cables.
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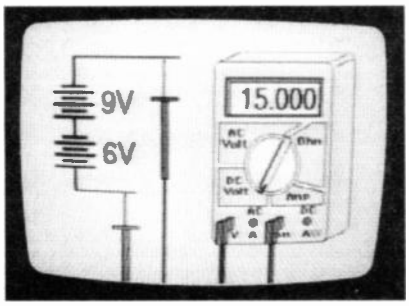

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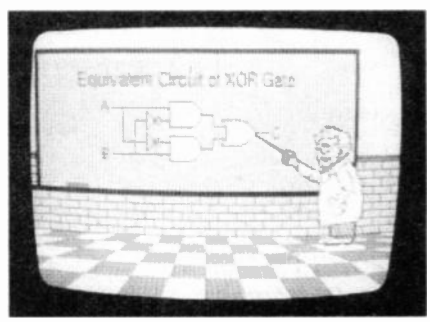

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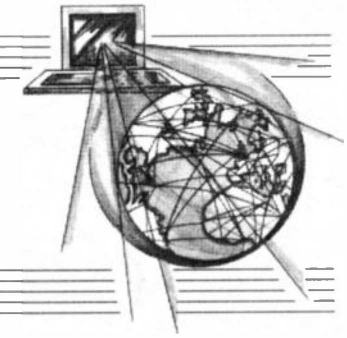

NET WORK is the page specially written for readers having access to the Internet, and for anything related to the *EPE* Internet presence, either on our popular web site **www.epemag.wimborne.co.uk** or our FTP file area at **ftp.epemag.wimborne.co.uk**. New on the web site is the "Teach-In Meet" page (at **Teach_In.htm**), where you can register your interest in our proposed September meeting at the University of Hull. New additions to the FTP site are this month's project files, available for free access by FTP at **pub/8051/Greenhouse** and **pub/PICS/PICtoolkit**.

More on FTP from DOS

Last month we saw how to initiate a command-line FTP session using the **open** command, then how to navigate to the required target on the FTP site in question. You usually start in the **/pub** directory of the remote FTP site. Now some more Unix commands:

asc sets ASCII file transfers (pure text files only)
bin sets binary transfers (images, programs, word processor documents etc.)
type displays the currently set file type (ASCII or binary)
cd PICS/Reaction.Timer takes you to the sub-directory containing the Reaction Timer files
cd#.. takes you back up to a higher level directory (the # is a space)
dir displays the contents and all the file data of the present working directory
ls lists the current files and folder names of the current directory
ls#-R gives a recursive listing of the files and directories (the # is a space) – avoid on a large FTP site!
pwd (print working directory) prompts you with your current directory name
cd (change directory) takes you back to the login root
get *filename* will fetch a file onto your system
mget *filenames* fetches multiple files

However, not all commands or variations work on every FTP site: it depends on the server software. Once at the target directory, use **get** to fetch the file, remembering to select either binary or ASCII by typing **bin** or **ascii** at the prompt: Windows 95 defaults to ASCII file type. The command **mget** is used to fetch multiple files in one batch, rather than individually. It can be used with wildcards (* or ?) to fetch several files in one batch.

In directories you will often see a string of letters adjacent to file names. Ever wondered what they mean? A typical example might be: **drwxr-xr-x 26 ftpuser ftpusers 512 Apr 1 22:16 PICS.**

The ten characters at the start tell you about the "ownership" of the file or directory. The first character will either be a "d" for directory (as in this example), or it will be a dash, indicating it is a file or program. The remaining nine characters are sub-divided into three groups of three, to indicate the permissions or rights available to the user. These denote the "owner" of the file or directory, then others from the same group, and finally other users anywhere else (e.g. anonymous FTP'ers). In this example the letters signify:

d directory (a "-" would signify a file)
rwx the owner has permission to read, write and execute the file
r-x others in the same group can read or execute, but not write to that file or directory
r-x everybody else can also read or execute the file/directory, but not write to it.

Let's navigate to the "PICoIo" project folder held in our PICS directory. A **dir** command reveals the following screen dump:

ftp> cd PICoIo
250 "/pub/PICS/PICoIo" is new cwd.
ftp> dir
200 PORT command successful.
150 Opening ASCII mode data connection for /bin/ls.
-rw-r--r-- 1 ftpuser ftpusers 496 Jul 4 1997 picolo.txt
-rw-r--r-- 1 ftpuser ftpusers 9856 Jul 4 1997 picolo56.asm
-rw-r--r-- 1 ftpuser ftpusers 472 Jul 4 1997 picolo56.obj

There are three files, as signified by the dash at the start of each permission. As an anonymous user, you can read them all, as denoted by the final three characters, **r--**.

The only other thing of interest is the file size in bytes, and of course the filename. Unix allows case sensitive names, and sometimes you may need to edit the name on the fly, in order to save it to your local system in a format recognised by your operating system. For large files (say 1MB or more) it is better to use software which allows you to re-commence (or "reget") an FTP session if the transfer fails halfway through, instead of having to repeat the transfer from scratch. A typical sign of bandwidth famine is where an FTP transfer slowly grinds to a halt, until you decide to abandon it. At times like that, having a "reget" function available is extremely valuable, and is one reason why an uninterruptible FTP client rather than web-style browser transfer is sometimes preferable.

As you will imagine, FTP at the command line is not to the liking of Joe Public, but the ability to recognise basic Unix commands is useful. With the widespread acceptance of graphical user interfaces, the process of FTP has been simplified to the point where it takes just a few mouse clicks to execute a file transfer. Macintosh and Windows users can utilise popular FTP programs including WS_FTP Pro (**www.ipswitch.com**) and Vicom's FTP Client for Mac (**www.vicomtech.com**). Both support the "reget" function.

Latest News

A roundup of the latest news: Demon Internet Services of London has been acquired by Scottish Telecom; rumours you now need a "Macintosh" to dial-in via Demon were soon "scotched"! Hopefully ST will knock some rough edges off this renegade pioneer of "all you can eat for a tenner-a-month". Whether the same price regime will continue, remains to be seen. Version 4 of Demon's Turnpike access software for Windows has been released in beta, which now at last includes multiple POP3 mailbox support. Presently for W95 users only, check **www.turnpike.com.**

At the time of writing, Microsoft continues to slug it out with the Department of Justice anti-trust moves over the incorporation of Internet Explorer into the forthcoming Windows 98. Bill Gates is indignant at this supposed "stifling of innovation" yet Microsoft spectacularly failed to anticipate the impact of the Internet from the start, while everybody else (e.g. Netscape) was busily innovating without them. Remember MSN? Attempting to include an MSN "handle" in its desktop OS (e.g. Windows 95 has several blatant plugs for signing up to the Microsoft Network) crystallises fears that Microsoft is attempting to use its OS to corner the market, but in the event the Internet turns out to be bigger than Microsoft. Judging by my Internet address book containing probably a thousand addresses or more, exactly six of them end in **msn-dot-com**.

Macintosh owners will (maybe) cheer to hear that Apple have finally recognised that if nothing else, IBM-compatible PC technology offers bucketloads of cheap upgrade paths including PCI local bus, AGP graphics and the USB serial bus, and Apple are finally set to buy these in.

Don't forget to check the *Net Work* page of the *EPE* web site for my latest suggested links for you to try. My E-mail address is **alan@epemag.demon.co.uk**.

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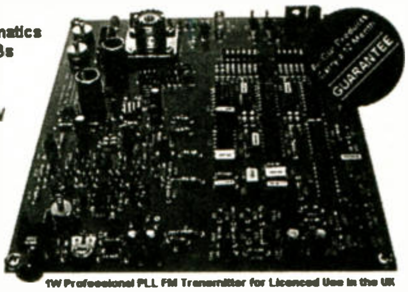

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