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EVERYDAY

DECEMBER 1998

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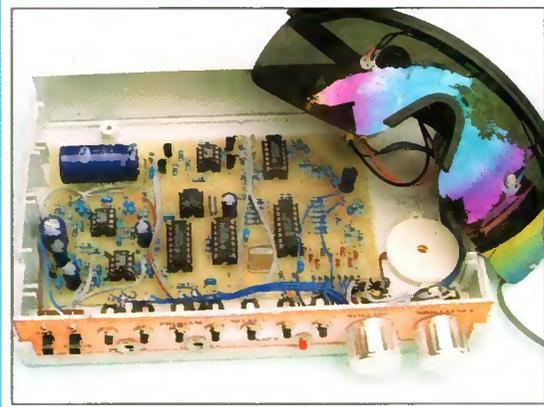
# ELECTRONICS

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£2.65

## MIND PICKLER

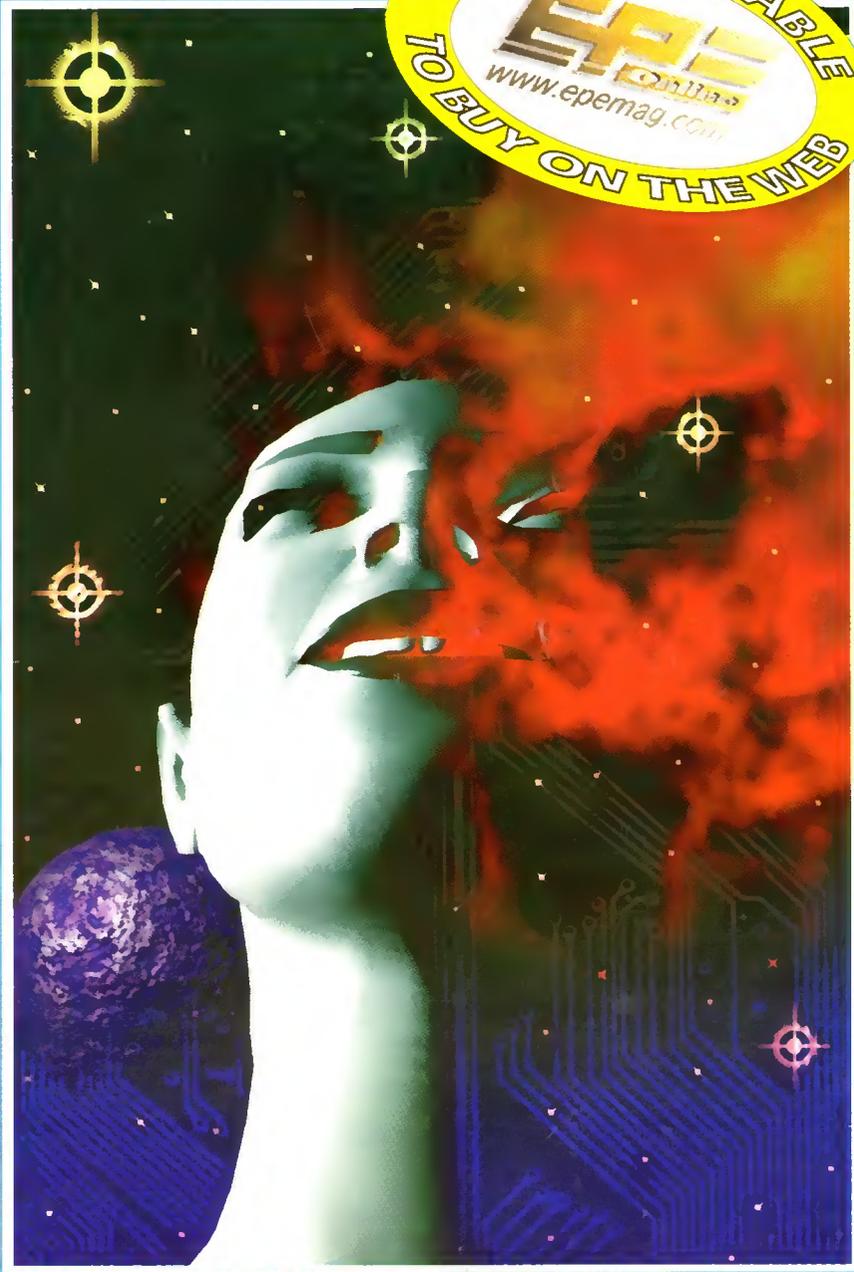
Easy to use mind  
entrainment/relaxation unit



**HANDHELD FUNCTION GENERATOR** Sine, square & triangle waveforms from 50Hz to 20kHz

**PIC CHRISTMAS LIGHTS** Programmable lighting for your tree

**PhizzyB -2**  
Understanding Computers



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## WIND GENERATORS 380 WATT

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

**HYDROPONICS DO YOU GROW YOUR OWN?** We have a full colour hydroponics catalogue available containing nutrients, pumps, fittings, environmental control, light fittings, plants, test 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 psychic 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/IEH2.

**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.

**VOICE SCRAMBLER PLANS** Miniature 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

**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.

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

**ANTI DOG FORCE FIELD PLANS** Highly effective circuit produces time variable pulses of acoustical 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

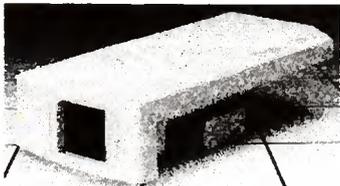
**PHASOR BLAST WAVE PISTOL SERIES PLANS** Handheld, has large transducer and battery capacity with external controls. £6/set Ref F/PSP4

**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

**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

**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 From £99

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 XF150, 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 SMXK

**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 swave. 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 inc £24 ref 1028

**PIR CAMERA** Built in CCTV camera (composite output) IR strobe light, PIR detector and battery backup. Designed to 'squirrel' pictures down the 'phone line but works well as a standalone unit. Bargain price £49.95 ref SS81, 3 or more £44.95 ref SS80

**4AH D SIZE NICADS pack of 4 £10 ref 4AHPK**

**ELECTRIC FENCE KIT** Everything you need to build a 12vdc electric fence. Complete with 200m of electric fence wire. £49 ref AR2

**SENDER KIT** Contains all components to build a A/V transmitter complete with case £35 ref VSXX2

**UV LIGHTS 4' fluorescent 340nm £38.99 ref UV23**

**33 KILO LIFT MAGNET** Neodymium 32mm £15 ref MAG33

**10 WATT SOLAR PANEL** Amorphous silicon panel fitted in a anodized aluminium frame. Panel measures 3' by 1' with screw terminals for easy connection. 3' x 1' solar panel £55 ref MAG45

**Unframed 4 pack (3'x1') £58.99 ref SOLX**

**12V SOLAR POWERED WATER PUMP** Perfect for many 12v DC uses, ranging from solar fountains to hydroponics! Small and compact yet powerful. Will work direct from our 10 watt solar panel in bright sunlight. Max head 17 ft Max flow = 8 Lpm, 1.5A Ref AC8 £18.99

**SOLAR ENERGY BANK KIT 50x 6" 8"x12" 6v solar panels(amorphous)+50 diodes £99 ref EF112**

**PINHOLE CAMERA MODULE WITH AUDIO!** Superb board camera with on board sound! extra small just 28mm square (including microphone) ideal for covert surveillance. Can be hidden inside anything, even a matchbox! Complete with 15 metre cable, psu and tv/cv connectors. £73.95 ref CC6

**SOLAR MOTORS** Tiny motors which run quite happily on voltages from 3-12vdc. Works on our 6v amorphous 6" panels and you can run them in the sun! 32mm dia 20mm thick. £1.50 each

**WALKIE TALKIES 1 MILE RANGE £37/PAIR REF MAG30**

**DRILL OPERATED PUMP** Fits to any drill in seconds, uses standard garden hose, pumps up to 40 gph! £8.99 ref DRL3

**GIANT SCREEN VIEWER** Turn your TV picture into a supersize screen! This high precision Fresnel lens converts even the smallest screen up to a massive 26", at a fraction of the cost of a big TV. Easily fitted in minutes. Also ideal for PC monitors etc £26.95 ref SVGA2

**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, tone or pulse (switchable), recall, redial and pause, high/low and off ringer switch and quality construction, finished in a smart off white colour and is supplied with a standard international lead (same as US or modems) 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

**LIQUID CRYSTAL DISPLAYS Bargain prices,**

**20 character 2 line, 83x19mm £3.99 ref SMC2024A**

**16 character 4 line, 62x25mm £5.99 ref SMC1640A**

**40 character 1 line 154x16mm £6.00 ref SMC4011A**

**LM255X HITACHI LAPTOP SCREENS 240x100mm, 640x200 dots. New with data £15 ref LM2**

**SEALED LEAD ACID BATTERIES**

**12V 6.5AH, NEW £12 REF BATT12**

**12V 6.5AH, S/HAND PACK OF 5 £20 REF EF99**

**12V 15AH AS NEW, £18 REF LOT8**

**THE ULTIMATE ENCLOSURE** for your projects must be one of these! Well made ABS screw together beige case measuring 120 x 150 x 50mm. Fitted with rubber feet and front mounted LED. Inside is a pcb fitted with other bits and pieces you may find useful. Sold as a pack of five for £10 ref MD1, pack of 20 for £19.95 ref MD2

**YOUR HOME COULD BE SELF SUFFICIENT IN ELECTRICITY** Comprehensive plans with loads of info on designing systems, panels, control electronics etc £7 ref PV1

**LOW COST CORDESS MIC** 500' range, 90 - 105mhz, 115g, 193 x 26 x 39mm, 9v PP3 battery required. £17 ref MAG15P1

**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** 2x 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

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

**200 WATT INVERTERS** plugs straight into your car cigarette lighter socket and is fitted with a 13A socket so you can run your mains operated devices from your car battery £49.95 ref SS66

**THE TRUTH MACHINE** Tells if someone is lying by micro tremors in their voice, battery operated, works in general conversation and on the 'phone and TV as well! £42.49 ref TD3

**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

**ENERGY SAVER PLUGS** Saves up to 15% electricity when used with fridges, motors up to 2A, light bulbs, soldering irons etc. £9 ea ref LOT71, 10 pack £69 ref LOT72

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

**DRILL OPERATED PUMP** Fits to any drill in seconds, uses standard garden hose, pumps up to 40 gph! £8.99 ref DRL3

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

**CCTV CAMERA MODULES** 46X70X29mm, 30 grams, 12v 100mA, auto electronic shutter, 3.6mm F2 lens, CCR, 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. £49 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! covers 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, night sights 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 & rear waveguides, 1.1"x2.7"x4.6" fits on visor or dash £149

**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 alignment. 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, 6000hz pulse frequency. The units also contain an electronic receiver to detect reflected signals from targets. £199 Ref LOT4

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

**EXTERNAL CAMERA** Introducing the Bulldog model 4 vandal resistant camera in heavy steel case for interior or exterior use. Top quality case housing a 420 line camera module. Each camera is supplied with a 15m cable terminating in Scart and phono plugs. Multi angle bracket for easy installation in any situation. A 12vdc psu is also included. Easily installed in a few minutes, plugs straight into VCR or TV (phono or scart). Bargain price £89.95 ref CC1

**3HP MAINS MOTORS** Single phase 240v, brand new, 2 pole, 340x180mm, 2850 rpm, builtin automatic reset overload protector, keyed shaft (40x16mm) Made by Leeson. £99 each ref LEE1

**LOPTX** Made by Samsung for colour TV £3 each ref SS52

**LAPTOP LCD SCREENS** 240x175mm, £12 ref SS51

**PIR WITH BUILT IN CCTV CAMERA** Module also includes an infra red strobe light, battery backup etc. 320x240 pixels, 90x65 field of view. £49.95 ea ref SS81, 3 or more £44.95 ref SS82

**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. £22 ref MOT4

**ELECTRONIC SPEED CONTROLLER KIT** For the above motor is £19 ref MAG17. Save £5 if you buy them both together, 1 motor plus speed controller rrp is £41, offer price £36 ref MOT5A

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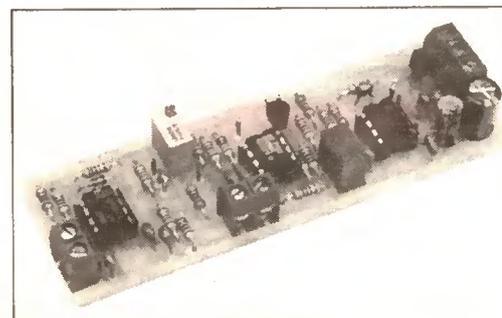
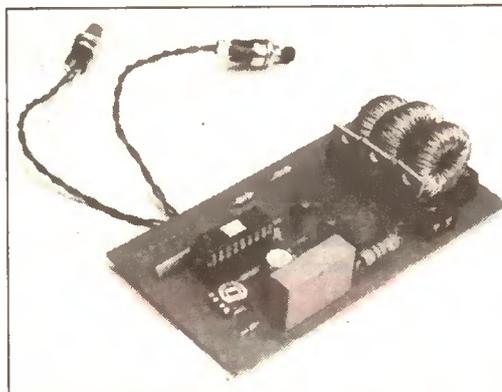
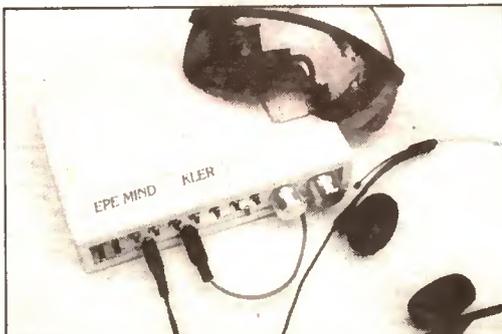
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 Sine, triangle and square wave signals always at hand, with almost full audio range coverage – and output adjustability
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 Got rising (or falling) damp? This controller should provide a solution

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**FREE**

PASSIVE COMPONENTS BOOKLET

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Our January '99 issue will be published on Friday, 4 December 1998. See page 843 for details.

Everyday Practical Electronics, December 1998

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# THE ORIGINAL SURPLUS WONDERLAND!

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## THE AMAZING TELEBOX

Converts your colour monitor into a QUALITY COLOUR TV!!



TV SOUND & VIDEO TUNER  
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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 £89.95  
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 Teleboxes, code (B)

**NEW** State of the art PAL (UK spec) UHF TV tuner module with composite 1V pp video & NICAM hi fi stereo sound outputs. Micro electronics all on one small PCB only 73 x 160 x 52 mm enable full software control via a simple 2 wire link to any IBM type computer. Supplied complete with simple working program and documentation. Requires +12V & +5V DC to operate.  
BRAND NEW - Order as MY00. Only £49.95 code (B)

## FLOPPY DISK DRIVES 2 1/2" - 14"

Massive purchases of standard 5 1/4" and 3 1/2" drives enables us to present prime product at industry beating low prices! All units (unless stated) are BRAND NEW or removed from often brand new equipment and are fully tested, aligned and shipped to you with a full 90 day guarantee. Call for over 2000 unlisted drives for spares or repair.

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- 3 1/2" Mitsubishi MF355C-L 1.4 Meg. Laptops only £25.95(B)
- 3 1/2" Mitsubishi MF355C-D 1.4 Meg. Non laptop £18.95(B)
- 5 1/4" Teac FD-55GFR 1.2 Meg (for IBM pc's) RFE £18.95(B)
- 5 1/4" Teac FD-55F-03-U 720K 40/80 (for BBC's etc) RFE £29.95(B)
- 5 1/4" BRAND NEW Mitsubishi MF501B 360K £22.95(B)
- Table top case with integral PSU for 5H 5 1/4" Floppy or HD £29.95(B)
- 8" Shugart 800/801 8" SS refurbished & tested £210.00(E)
- 8" Shugart 810 8" SS HH Brand New £195.00(E)
- 8" Shugart 851 8" double sided refurbished & tested £260.00(E)
- 8" Mitsubishi M2894-83 double sided NEW £285.00(E)
- 8" Mitsubishi M2896-83-02U DS slimline NEW £285.00(E)
- Dual 8" cased drives with integral power supply 2 Mb £499.00(E)

## HARD DISK DRIVES

- 2 1/2" TOSHIBA (19 mm H) MK2101MAN 2.18 Gb. New £199.00
  - 2 1/2" TOSH. (12.5 mm H) MK1002MAV 1.1 Gb laptop. New £115.00
  - 2 1/2" to 3 1/2" conversion kit for PC's, complete with connectors £12.95
  - 3 1/2" FUJI K-309-26 20mb MFM I/F RFE £59.95
  - 3 1/2" CONNER CP3024 20 mb IDE I/F (or equiv.) RFE £59.95
  - 3 1/2" CONNER CP3044 40mb IDE I/F (or equiv.) RFE £69.00
  - 3 1/2" RODIME R03057S 45mb SCSI I/F (Mac & Acorn) £69.00
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  - 5 1/4" SEAGATE ST-238R 30 mb RLL I/F Refurb £69.95
  - 5 1/4" CDC 94205-51 40mb HH MFM I/F RFE tested £69.95
  - 5 1/4" HP 9754B 850 Mb SCSI RFE tested £99.00
  - 5 1/4" HP C3010 2 Gbyte SCSI differential RFE tested £195.00
  - 8" NEC D2246 85 Mb SMD interface. New £199.00
  - 8" FUJITSU M2322K 160Mb SMD I/F RFE tested £195.00
  - 8" FUJITSU M2392K 2 Gb SMD I/F RFE tested £345.00
- Many other drives in stock - Shipping on all drives is code (D)

## TEST EQUIPMENT & SPECIAL INTEREST ITEMS

- MITS. FA3445ETKL 14" Industrial spec SVGA monitors 1KW to 400 KW - 400 Hz 3 phase power sources - ex stock £245
- IBM 8230 Type 1, Token ring base unit driver EPOA £760
- Wayne Karr RA200 Audio frequency response analyser £250.00
- IBM 53F5501 Token Ring IC5 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
- ALLGON 8360.11805-1880 MHz hybrid power combiners £250
- Trend DSA 274 Data Analyser with G703(2M) 64 Vo EPOA
- Marconi 6310 Programmable 2 to 22 GHz sweep generator £6500
- Marconi 2022C 10KHz-1GHz RF signal generator £1550
- Marconi 2030 opt 03 10KHz-1.3 GHz signal generator, New £5150
- HP1650B Logic Analyser £3750
- HP3781A Pattern generator & HP3782A Error Detector EPOA
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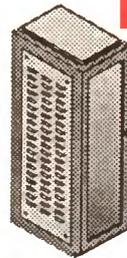
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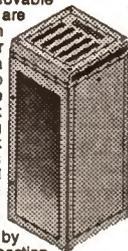
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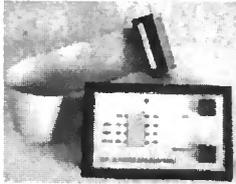
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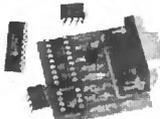


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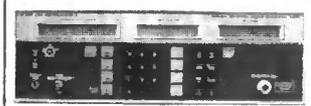


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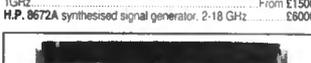
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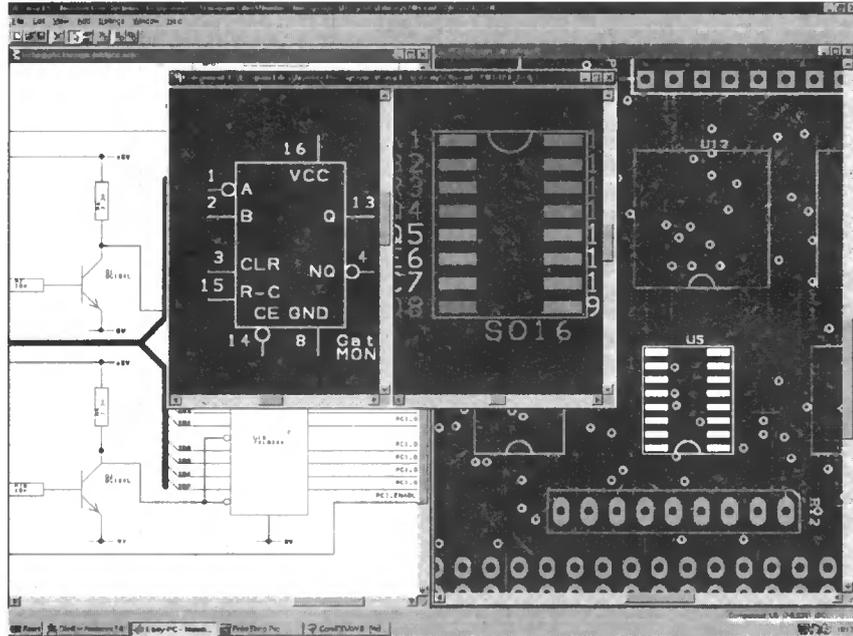
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# EVERYDAY PRACTICAL ELECTRONICS

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## WAY OUT IN FRONT

It's good to know that all our efforts to provide an exciting, technically informative, value for money publication each month are being rewarded by an increase in our UK newsstand market share. *EPE* now has over fifty-five per cent of the total UK "electronics hobbyist market", with three other publications making up the remaining forty-five per cent between them. In fact, we sell over twice as many copies on the UK newsstands than any other magazine in this market, so, hopefully, we are doing something right.

Far from seeing a decline in interest in project building, as has been reported elsewhere in the hobbyist press, we are actually finding a greater demand for some p.c.b.s and project software, etc. than has been the case in the last few years. We have also had to extend our web download quota recently because we have been exceeding the limit by more than fifty per cent for the last few weeks.

You just need to look at the *Chat Zone* on our web site to realise how active *EPE* readers are. By the way, if you want to contact us with queries etc. please E-mail us, don't just post a query to *Chat Zone* as, whilst we keep an eye on what is going on and chip in occasionally with pointers, etc., this space is intended for readers to contact each other and to help each other. It is very rewarding to see this happening and once again we have our Webmaster Alan to thank for getting it all off the ground, monitoring that everyone is playing by the rules and, of course, helping it along, particularly in the early days, with help and directions etc. But it is *your* space for you to enjoy and to help each other, there are already some "EPE regulars" in full flow, so don't be afraid to join them with your queries or comments etc. It has proved to be a lively forum.

## WORLD LEADER?

We expect another boost to all this web interest now that we have *EPE Online*. Incidentally, as far as we can tell, we are the first magazine anywhere to be selling a web version of the printed magazine.

We feel that it is quite an achievement for a relatively small UK hobbyist publication to have beaten *every other magazine in the world* and achieved what has been talked about for some time. We have Maxfield and Montrose in the USA to thank for the World beating software that has allowed us to do this.



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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.

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

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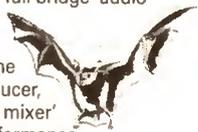
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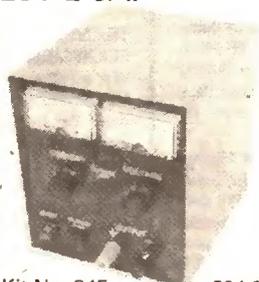
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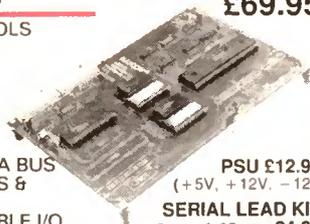
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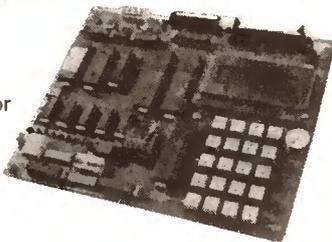


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# EPE MIND PICKLER

## ANDY FLIND Part One



Seven mind-bending, built-in programs to soothe your state of mind. Relax with the power of a PIC entrainment machine.

**R**EGULAR readers of *EPE* will probably be aware of the author's enthusiasm for the design of "Mind Machines", as several of these have been published in previous issues. Although effective, the designs presented in the past have been fairly complex to construct which may have discouraged some enthusiasts who would otherwise have liked to build one of these devices.

The main problem has been the method of providing a "program" of output frequencies over an adjustable period. The most recent version, in the March '96 to April '96 issues, was user-programmable by means of sixteen variable resistors and, whilst effective, it was by no means cheap or simple to construct.

With the arrival of the PIC microcontroller chip this situation has changed quite dramatically. PICs are ideally suited to such control tasks and can result in much simpler circuits, since much of the work is carried out by the software.

### TAKE YOUR PIC

It seemed natural therefore, that following assimilation of the excellent *EPE PIC Tutorial* series (March, April and May '98 issues and now available on CD-ROM) the author's first PIC-based design should be a new Mind Machine, and this project is the result. At around half the size and weight of the 1996 design, it is the first capable of operating from a single PP3 battery. With push-button selection of seven built-in programs and operating times it is also extremely easy to use, the only other controls being two knobs for Volume and Brilliance and a Phase switch.

Although the programs are not user-changeable constructors wishing to try out their own programs can do so by re-programming the PIC, since the seven session programs are just strings of numbers contained in a table (details next month) in the main program. It is not even necessary to be completely conversant with PIC assembly language to do this. Although still

not especially cheap and simple to build this project represents a huge improvement over earlier designs and is much easier to get working, since most of the complex functions are handled by the PIC.

### CIRCUIT DETAILS

A broad outline of the *EPE Mind PICKler* project's operation is shown in the block diagram of Fig.1. Program and operating time selections are communicated to the PIC microcontroller through three inputs and acknowledged by beeps from a directly driven piezo transducer. Following this a 400Hz squarewave signal is produced and a variable control voltage is created with seven binary outputs applied to an R-2R network.

### WARNING NOTICE

Photic stimulation at Alpha frequencies can cause seizures in persons suffering from Epilepsy. For this reason such people **MUST NOT** try this project.

A user who is not a known epileptic, but when using the *EPE Mind PICKler* begins to experience an odd smell, sound or other unexplained effects, should **TURN IT OFF IMMEDIATELY** and seek professional medical advice.

Because of the above possibility, the *EPE Mind PICKler* should not be used while on your own.

**YOU MUST TREAT THIS UNIT WITH DUE RESPECT**

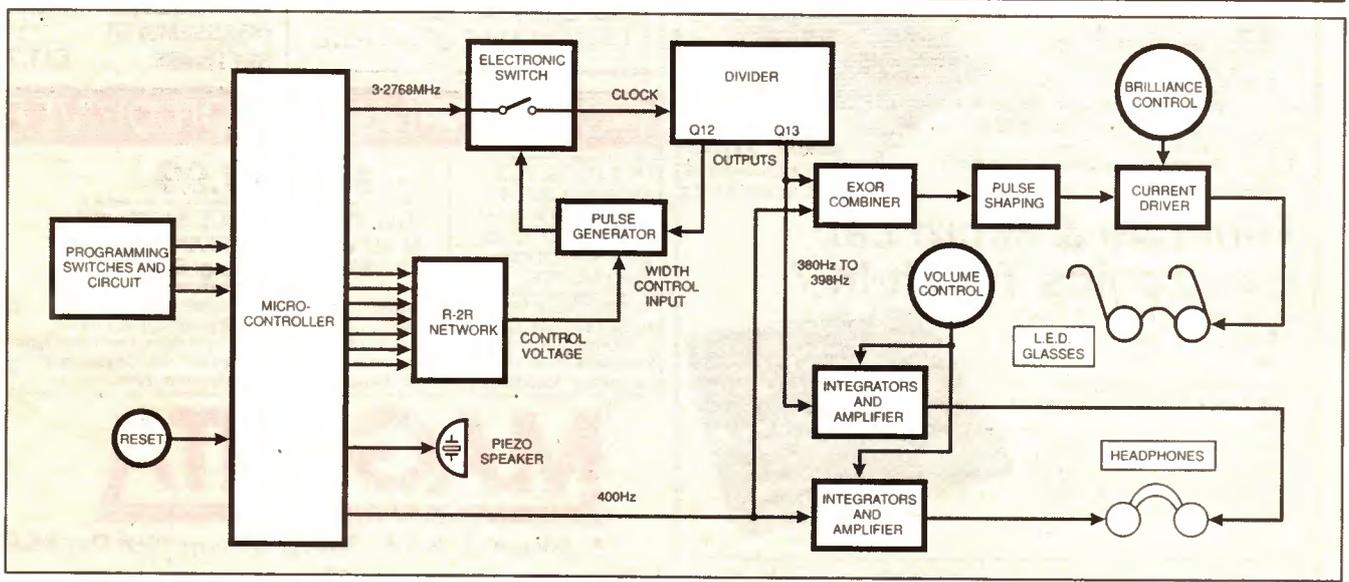


Fig.1. Simplified block schematic diagram for the *EPE Mind PICKler*.

The PIC's clock is tapped to drive a divider, which in turn triggers a pulse generator which blocks the clock to the divider through an electronic switch. The blocking period is voltage controlled by the R-2R network output so, effectively, the second frequency is controlled by the PIC.

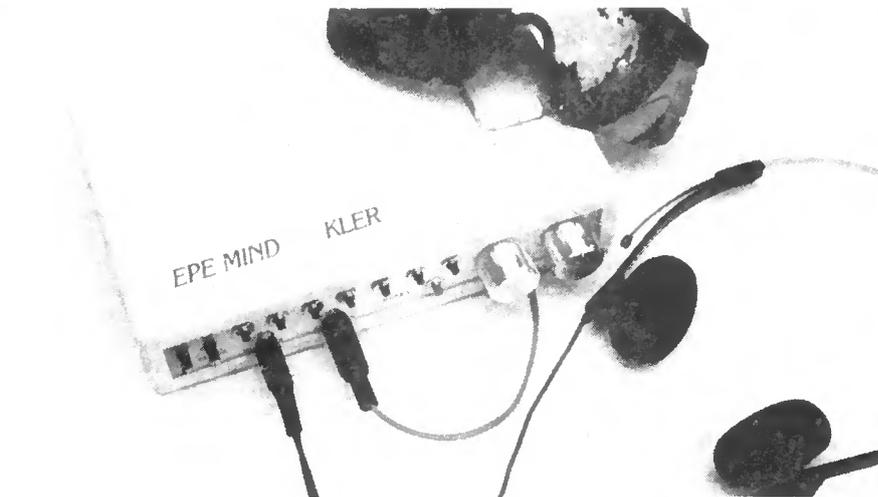
The two outputs are combined with an EXOR circuit to extract their difference frequency which is processed for driving I.e.d.s in the glasses. Each output also passes through two integrators which convert them into relatively pure audio sinewaves for driving the headphones.

The full circuit diagram for the EPE Mind PICKler is shown in Fig.2. The seven push-button switches S1 to S7 are used to select one of the seven programs, followed by one of seven session times.

So that these selections can be passed to the PIC, IC1, using only three connections some simple diode and resistor logic converts them to their binary equivalents, which are applied to port A bits 2, 3 and 4 (IC1 pins 1, 2 and 3). A third press of any button then sets the program running for the selected time.

At any point during operation pressing Reset switch S8 applies a brief reset pulse to take the program back to the start where it waits for fresh input. Power-up and all button presses are announced by brief "beeps" from the piezo transducer WD1, driven directly by port A bit 1.

The internal oscillator frequency of IC1 is set by crystal X1 to 3.2768MHz, which gives a convenient internal clock frequency for other timings required by the circuit. Two audio frequencies are needed, one fixed and the other differing from it by the programmed brainwave frequency.



The first of these is generated directly by the PIC, using an interrupt routine to generate a 400Hz signal from port A bit 0 (IC1 pin 17) whilst the main program is running. The second is obtained from division of the PIC's oscillator signal, taken from "osc out" pin 15 and passed through the gates of IC2 to divider IC4 (at clock input), which reduces it to about 400Hz.

Port B bit 7, at IC1 pin 13, is used to block the input to IC4 until the main program starts. Whilst it is high, IC2a output (pin 6) is low, so the clock frequency does not appear at the output of IC2b. Frequency variation is achieved by blocking the clock signal briefly during each half-cycle of the output from Q13 of IC4, this time through IC2d.

### VOLTAGE CONTROL

The period for which the clock is blocked is voltage-controlled. To under-

stand the action of this part of the circuit, it should first be assumed that Q12 (IC4 pin 1) has been in the low state for some time (relatively speaking!). Q12 is the output preceding Q13 so it changes state twice for each change of Q13.

The low output from Q12 is applied to an input of IC2c, pin 13, so the output of this is high. Applied to an input of IC2d this allows the clock signal at the other input to pass to IC4.

Meanwhile, capacitor C6 will have discharged through resistor R21, so the output of comparator IC3 (pin 6) is high, and this is applied to the other input of IC2c, pin 12. When Q12 switches to the high state, IC2c initially has two high inputs so the output goes low, blocking the clock signal through IC2d.

However, capacitor C6 now commences charging through R21, increasing the voltage at pin 2 of IC3. When it exceeds the

## BRAINWAVES

THE EXISTENCE of electrical activity at various frequencies in the human brain was discovered many years ago, almost as soon as the first electronic system capable of amplifying it became available. The first regular waveform recorded, because of its high amplitude, was named **Alpha** with a frequency spectrum between of 8Hz and 14Hz. Subsequently other frequencies have been observed and are broadly classified into **Delta** (0.5Hz to 4Hz), **Theta** (4Hz to 8Hz) and **Beta** (14Hz to 20Hz and above).

During the sixties experiments were carried out with a master of Zen meditation, where it was discovered that during deep meditation very high levels of Alpha activity were generated. This led to further experiments in which feedback was used for training subjects to generate this kind of activity at will. The intention was to reach states similar to those of advanced meditation, which normally requires many years of dedicated training. Thus was born the technique known as **EEG** (electroencephalograph) biofeedback.

### All in the Mind

The science has advanced a long way since those early days and the states associated with the other frequencies are now well understood. The low frequencies of Delta are associated mainly with deep sleep (and young babies) and so have little practical application, except perhaps for insomniacs. Theta on the other hand has been linked with intense creativity and so is of interest to many people wishing to generate artistic inspiration and innovative solutions to problems. Beta is predominant in normal waking consciousness.

The original type of biofeedback device is not so common nowadays. They are difficult to build since they have to detect low frequency signals with an amplitude of a few microvolts, which generally have to be separated from several volts of induced "hum" caused by nearby household mains wiring.

They are also relatively difficult to use, since good, noise-free electrical contact must be made with the head. This usually involves silver electrodes and messy gels.

### Stimulation

Because of these disadvantages they have largely been replaced with devices intended to encourage production of the desired brain electrical activity. By far the most effective way of doing this is through "visual stimulation" by flashing lights before the user's eyes at the intended frequency.

The next most popular method is "binaural sound". At its simplest this consists of two audio tones having a frequency difference equal to the desired brain electrical activity. Played through loudspeakers these would produce the familiar "beat note" effect, but in this application they are played separately, one to each ear, through headphones. The user's brain "synthesises" the beat note internally and this is supposed to encourage the desired brain activity.

This is the method used by the EPE Mind PICKler in conjunction with flashing I.e.d.s and there is no doubt about the effectiveness of the two stimuli when combined in this way. The sound has a pleasant "bell-like" quality. It does have to consist of fairly pure sinewaves as any noise or distortion is subjectively far more intrusive than in most other audio applications.

Other methods of inducing brain activity at specific frequencies include magnetic fields (see the *EPE Mood Changer* - June '98 issue) and the passing of tiny electrical currents through the head. You're not going to see a design for this last method in *EPE*, though believe it or not, a couple of instruments using this method are actually on sale in the USA.

It is now generally accepted that the states experienced by users of this type of equipment are "different" from those attained in advanced meditation, though they may form a good starting point for those wishing to pursue deeper spiritual growth. However it is easy to reach states of deep relaxation, which in turn may help in the control of stress. For this, and simply for recreational use, the EPE Mind PICKler is a very useful tool.

voltage at pin 3 IC3's output goes low, causing the output of IC2c to return to the high state and allow the clock to pass through IC2d again.

When Q12 returns to the low state this is immediately applied to IC2c to maintain its high output and C6 commences discharging through R21, ready for the next operation. The period for which the clock cycles are blocked depends on the voltage applied to the non-inverting input of IC3, so a small voltage-controlled drop in the output frequency from IC4 is obtained.

Note that IC2 and IC4 are the 74HCxxx high-speed versions of the CMOS 4093 and 4060 devices. Standard types are close to their operating frequency limit at nearly 4MHz, and cannot be guaranteed to work in this circuit. In addition the 74HC132 pinout (see Fig.3) differs from that of the 4093.

The control voltage is taken from an R-2R resistor network, R6 to R19, connected to seven outputs from port B of the PIC which provides digital-to-analogue conversion of binary values on these pins. Each program is divided into 30 periods, each of which starts with a value corresponding to one voltage and ends with one corresponding to the next.

The PIC alternates rapidly between these two values, gradually dwelling less

on the first and more on the second as the end of the period approaches. The result is that the voltage appears to change smoothly through each step. The output is reduced to a maximum of just under half the supply voltage by resistor R20 and smoothed by capacitor C5.

Although this is the same procedure used in the last Mind Machine, there are almost twice as many values in each program and many more steps between them so the control action is much smoother. With precise voltage regulation and crystal frequency control the output is very accurate, and the shorter time constant needed for smoothing the output makes for a much improved settling time when the program commences.

The numerical values corresponding to control voltages and output frequencies, held within the PIC, take into account the exponential nature of the charging time of capacitor C6 and the output frequencies measured in the prototype were found to be within 0.1Hz of their intended values.

## INTEGRATED OUTPUTS

The two output signals initially have square waveforms. The audio outputs should be as close to pure sinewaves as

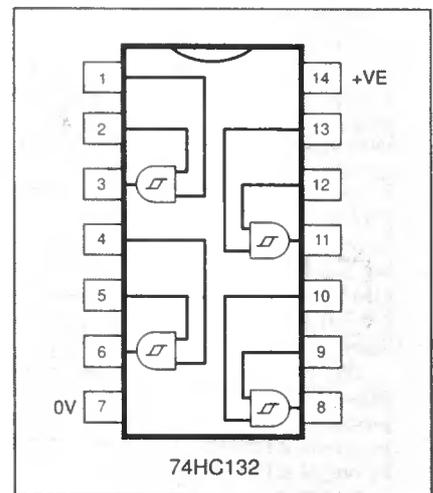


Fig.3. Internal and pinout details for the high-speed 74HC132 i.c.

possible so conversion is carried out by two integrators in each signal path.

Taking the upper signal path, which processes the fixed 400Hz tone, the first integrator is IC8a which converts the signal into a triangular waveform. The integration response is set by resistor R39 and capacitor C21. C20 and R42 are necessary for the stage to operate at the correct d.c. working point and, though they do introduce a little distortion, this is not audible in the output.

Following the Volume control, VR2a, a similar second integrator, IC9a, takes the triangle-wave from IC8a and converts it into a sinewave. It also provides sufficient power to operate Walkman type headphones.

The signal level should be kept reasonably high here for a good signal-to-noise ratio, so the output is reduced to an appropriate amplitude by series resistor R49 rather than by lowering the input. A small tendency to instability under some conditions was corrected by the addition of resistor R47 and capacitor C25.

The second signal path for processing the variable frequency output from IC4 is identical. The sound quality obtained from this circuit is greatly superior to that of the earlier Mind Machine designs.

## BRAINWAVES

As in the previous design the two squarewave signals are also combined through two XOR stages to extract the brainwave frequency (see separate panel) and provide phase switching, for flashing the I.e.d.s (mounted in the glasses) either in phase with the audio signals or in opposite phase to them.

The output from IC6b is an 800Hz train of pulses of varying width which, when averaged through a simple C-R filter, appear as a triangle wave. Resistor R24 applies d.c. biasing to this so that when passed through the Schmitt trigger stage built with IC6c the output pulses obtained are only about a quarter of the length of each cycle.

Finally, in case the user programs a very low frequency, C17 and R28 limit the maximum pulse width to prevent overload of the battery and output I.e.d.s.

The brilliance of the two I.e.d.s in the glasses is controlled by varying their current. A control voltage obtained from

### Derivation of Formula for Calculating PIC Program Values

The basic frequency of the two audio tones is 400Hz. One oscillator is fixed at this frequency, whilst the other is lowered by having its clock input stopped for a brief instant each half cycle. The actual length of this instant is the time it takes for C6 to charge to the same voltage as the control output from the R-2R network R6 to R20. The maximum output from this is 2.48V ( $127/128 \times 2.5V$ ). It varies in steps of  $2.5/128$  or about 19.5mV.

If the fixed audio tone is 400Hz, the variable one must be  $400 - f$  Hz, where f is the required frequency difference.

The period t for this is  $\frac{1}{400-f}$ . The period of the basic 400Hz tone is 1/400 or 0.0025 secs.

So, the clock must be blocked for  $\frac{1}{400-f} - 0.0025$  secs per cycle.

However, it is blocked twice per cycle, so the blocking period t is half this,

or  $\frac{0.5}{400-f} - 0.00125$  secs per cycle.

The control voltage V1 from the R-2R network is given by  $V = 2.5 \times \frac{N}{128}$ , where N is the decimal value of the binary state of the seven outputs from it.

The voltage V2 across C6 is given by  $V2 = 5 \times (1 - e^{-\frac{t}{\tau}})$ , where  $\tau$  is the time constant R21xC6

Hence the point where V1 and V2 coincide is reached when  $2.5 \times \frac{N}{128} = 5 \times (1 - e^{-\frac{t}{\tau}})$

which can be reduced to  $N = 256 \times (1 - e^{-\frac{t}{\tau}})$

$\tau$ , of course, is  $82k \times 1n5$ , which works out at 0.000123 secs.

So, we end up with  $N = 256 \times \left( 1 - e^{-\left( \frac{0.5}{400-f} - 0.00125 \right) / 0.000123} \right) - 1$

The "1" being subtracted to correct a small but constant error found in practical testing.

This formula can be reduced to  $N = 256 \times \left( 1 - e^{-\left( \frac{f}{39.36 - (0.0984 \times f)} \right)} \right) - 1$

which is slightly easier to use with calculators or spreadsheets.

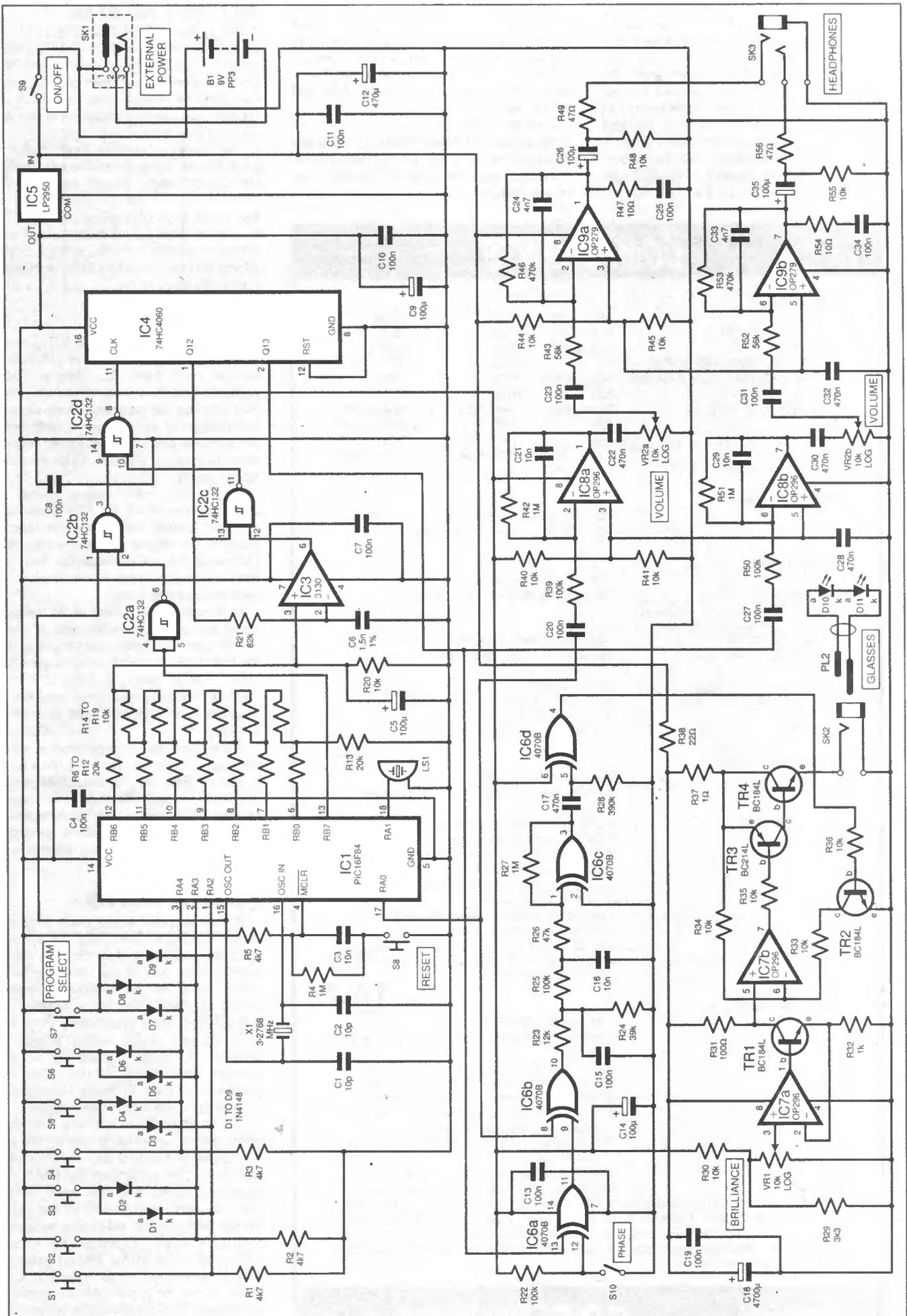


Fig.2. Complete circuit diagram for the EPE Mind Pickler.

potentiometer VR1 is used by op.amp IC7a and transistor TR1 to generate a small current which is converted back to a voltage, this time referenced to the positive supply, by resistor R31. Readers may be interested to learn that the eye, like the ear, has a logarithmic response to intensity, so potentiometer VR1 should be a *log law* type. The voltage across resistor R31 is used by IC7b, together with transistors TR3 and TR4, to generate a much larger current for driving the l.e.d.s.

This method results in a current which returns to negative supply, which is useful when the audio signals are also relative to the negative supply and sockets for both are fitted to the same metal panel. Insulated 3.5mm sockets are hard to find, and for this reason the earlier design had to use 6mm types with adapters.

Transistor TR2 turns off the l.e.d.s when switched on by IC6d, so the pulses from IC6d are negative-going to generate the output flashes.

## POWER NEEDS

Power for most of the circuit is 5V supplied by the regulator IC5. This is a micro-power equivalent of the well-known 78L05 device, featuring very low operating current and drop-out voltage which makes it ideal for use with battery supplies. It is also more accurate than the standard type.

The output stages for both audio and l.e.d. glasses are supplied directly from the 9V battery supply, though the l.e.d. stage receives this through resistor R38. It also has a very large decoupling capacitor, C18, to prevent a faint "popping" sound which otherwise results from the sudden drops in supply voltage caused by l.e.d. operation at high brilliance.

# COMPONENTS

## Resistors

R1 to R3, R5	4k7 (4 off)	R28	390k
R4, R27, R42, R51	1M (4 off)	R29	3k3
R6 to R13	20k (8 off)	R31	100Ω
R14 to R20, R30, R33 to R36,		R32	1k
R40, R41, R44, R45, R48, R55	10k (18 off)	R37	1Ω
R21	82k	R38	22Ω
R22, R25, R39, R50	100k (4 off)	R43, R52	56k (2 off)
R23	12k	R46, R53	470k (2 off)
R24	39k	R47, R54	10Ω (2 off)
R26	47k	R49, R56	47Ω (2 off)

All 0.6W 1% metal film type

## Potentiometers

VR1	10k min. rotary carbon, log.
VR2	10k dual min. rotary carbon, log.

## Capacitors

C1, C2	10p resin-coated ceramic (2 off)
C3, C16, C21, C29	10n resin-coated ceramic (4 off)
C4, C7, C8, C10, C11, C13,	
C15, C19, C20, C23, C25,	
C27, C31, C34	100n resin-coated ceramic (14 off)
C5, C9, C14, C26, C35	100μ radial elect. 16V (5 off)
C6	1n5 polystyrene, 1%
C12	470μ radial elect. 16V
C17, C22, C28, C30, C32	470n resin-coated ceramic (5 off)
C18	4700μ radial elect. 16V
C24, C33	4n7 resin-coated ceramic (2 off)

## Semiconductors

D1 to D9	1N4148 signal diode (9 off)
D10, D11	5mm hyper-bright red l.e.d. (for glasses) (2 off)
TR1, TR2, TR4	BC184L <i>nnp</i> silicon transistor (3 off)
TR3	BC214L <i>pnp</i> silicon transistor
IC1	PIC16C84 or PIC16F84, pre-programmed microcontroller, see text
IC2	74HC132 quad Schmitt NAND gate
IC3	3130 CMOS op.amp
IC4	74HC4060 14-stage ripple counter
IC5	LP2950 5V voltage regulator
IC6	4070B CMOS quad EXOR gate
IC7, IC8	OP296 dual op.amp (2 off)
IC9	OP279 dual op.amp

## Miscellaneous

X1	3.2768MHz crystal
S1 to S7	sub-min. pushswitch, push-to-make, black (7 off)
S8	sub-min. pushswitch, push-to-make, red
S9, S10	sub-min. double-pole slide switch (2 off)
SK1	2.1mm power socket, with break contact
SK2	3.5mm screened mono chassis socket, with matching jack plug for glasses
SK3	3.5mm screened stereo chassis socket for headphones
LS1	wire-ended piezoelectric sounder
B1	9V battery (PB3 type), with clip-in holder

Printed circuit board available from *EPE PCB Service*, code 214; plastic case, size 180mm x 120mm x 40mm; 8-pin d.i.l. socket (4 off); 14-pin d.i.l. socket (2 off); 16-pin d.i.l. socket; 18-pin d.i.l. socket; 20mm dia. max. plastic knob (2 off); headphones, Walkman type; glasses (see next month); multistrand connecting wire; solder pins; solder etc.

See  
SHOP  
TALK  
Page

## SOFTWARE

The software in the PIC, IC1, starts by obtaining the user's choice of program and session time from the Program Select pushswitches, then waits until instructed to start running the program. Once started, it loads a pair of values from a table held in the software and alternates rapidly between them, placing each in turn on the first seven bits of port B.

It increases one output period and decreases the other in 255 steps, so a gradual, smooth transition from the first value to the second appears to take place. Following this, it replaces the first value with the second, loads a new second value and repeats the process.

It does this with a total of 31 values, an initial one plus one for the end of each of the 30 steps that comprise a program. When the last value has been used, it goes to an "end" routine where it loops at 3-second intervals, bleeping each time, until the user switches off or resets it for the input of new settings.

All the time the main program is running interrupts change the state of port A bit 0 at a rate of 800 times a second to generate the 400Hz output. Servicing the interrupt routine takes only a few microseconds, a tiny fraction of the time spent running the main program, so its effect on this is not apparent.

## FLOWCHARTS

A flow diagram of the main program is shown in Fig.4. Following switch-on or reset, the program sets up the ports for user input, output bleeps and blocking of the clock signal to the variable frequency output. It then waits for a button to be pressed, and stores the resulting input value in a register. Valid button presses and releases are both verified by a 40ms software debouncing routine. The same procedure is used to obtain the value for session time, stored in another register.

The program then waits for a third button press, following which it sets up the ports for output as required and starts the interrupt routine for generating the 400Hz fixed frequency output. The first value is called from the table and placed in the register for the second value, this being because the program then goes to a repeating sequence where the value in the second value register is transferred to the first and a new value is read from the table and placed in the second. The output routine is then called to perform the apparent gradual transition between the two values.

Approx Cost  
Guidance Only

**£35** excluding case,  
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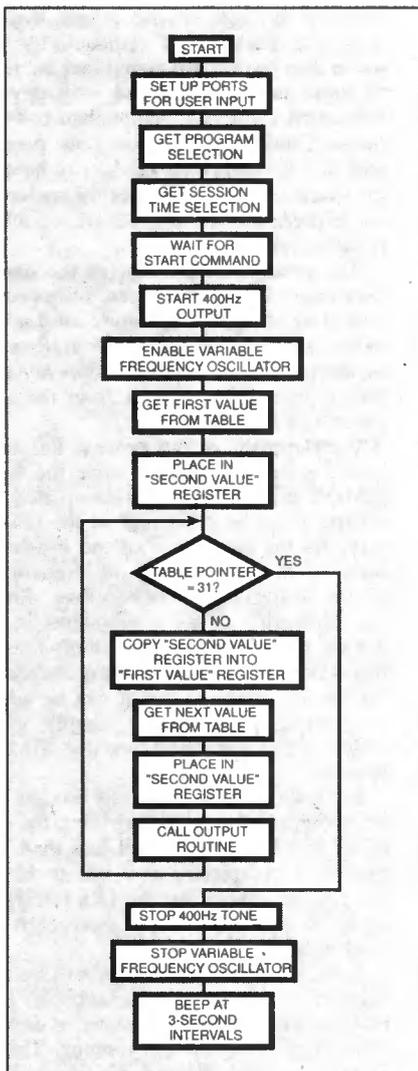
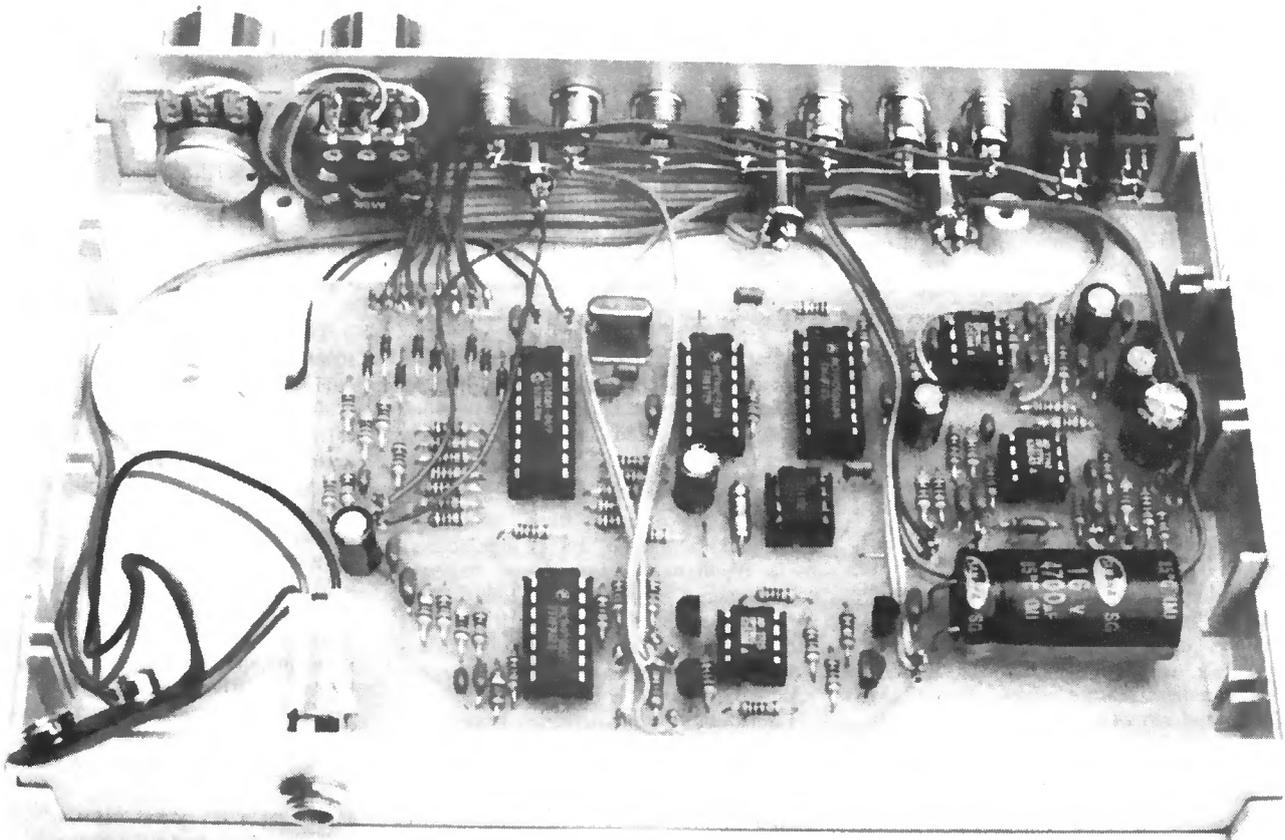


Fig.4. Flow diagram for the main program.

This sequence is repeated thirty times and each time the register holding the table value pointer is checked. When it reaches 31 the program exits this loop to the final routine, where it stops the interrupts, blocks the clock signal to stop the variable oscillator output, and goes into an endless long loop, beeping each time it goes around.

The flow routine for generating the smooth transition between the two values is shown in Fig.5. It starts by setting two "ratios", used for the dwell times of the two values. It then goes into three nested loops with two more sequential loops at the centre, using values derived from the user's Time input and a Scale value which sets the overall running time to the correct value.

The first program value from the table is copied to port B, "Ratio1" is copied to "Ratio", and the first inner loop provides a delay proportional to "Ratio1". Then the second value is copied to port B, "Ratio2" is copied to "Ratio", and the second inner loop gives the delay for "Ratio2".

These two operations are carried out for the number of times given by "Scale" multiplied by "Time", so it can be seen that switching between the two values always takes place at the same speed, just over 2kHz, regardless of the value of "Time".

Following this, "Ratio2" is increased by 1, "Ratio1" is decreased by 1, and the process is repeated. This happens until "Ratio1" reaches zero, when control returns to the main program to update the two values from the table.

The use of 255 discrete steps for each pair of values means that even at the slowest rate of change, for a running time of 40 minutes, the output voltage appears to change at over three steps per second, so a smooth change of output frequency is obtained.

This covers the circuit and program operation. Next month we conclude with the construction and testing of the unit.

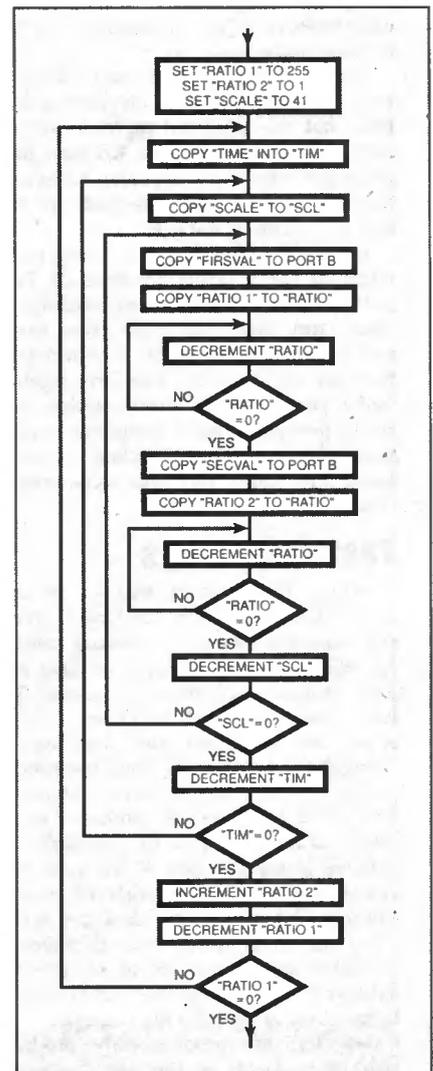


Fig.5. Program flow diagram for transition between two values.

# New Technology Update

*Ian Poole discovers that "test tube" takes on a new meaning for microelectronics, and that oxygenisation extends chip performance.*

**T**HERE are two ideas highlighted this month. The first is associated with minute connections required within microelectronics circuits. The second new development relates to the performance that needs to be achieved by integrated circuits today.

## Even Smaller

Miniaturisation in electronics is continuing at an ever-increasing rate. To achieve this, one of the main areas for research is naturally that of achieving smaller feature sizes within the integrated circuits. New developments in lithography and the like are all under investigation.

However, there are many other new and interesting ideas that are equally important to the miniaturisation process. In the years to come they will make large contributions to the increase in the level of integration.

Some of these ideas may seem far removed from the core electronics business, but this does not mean to say that they will not affect it. In the past many ideas that may have appeared to have no bearing on one area of technology have had an enormous impact.

In one area of research being undertaken at the Georgia Institute of Technology, nanotubes are being investigated. These tiny tubes are made from carbon and have inside diameters measuring less than ten nanometres! The investigations being performed on these minute tubes could ultimately have important applications in microelectronics where extremely small conductors and other structures are required.

## Test Tube Chips

Whilst the work is still in its early stages, the researchers have been able to put materials into the tubes and manipulate them. By doing this they have been able to induce chemical reactions. This has opened up new ways of thinking about the structures and they can be thought of as extremely small test tubes.

The first stage in producing conductors was to try to deposit a conductor on the inside of the walls of the nanotube. To achieve this both ends of the tube were opened. Silver nitrate ( $\text{AgNO}_3$ ) was allowed to fill the tube by capillary action. Then the silver nitrate was decomposed so that it formed metallic silver. This was achieved by heating the tubes with a beam from an electron microscope.

Initially, the process only produced tiny silver beads in the tube because a small pocket of gas separated each bead. The gas was under extreme pressure,

estimated to be over 1000 atmospheres. The ultimate idea was to enable minute conductors to be manufactured that could be used in integrated circuit manufacture.

## Electric Light

It has also been found that the nanotubes themselves act as conductors. In a phenomenon known as ballistic conductance, these minute tubes give very low values of resistance. It has also been shown that the heating effect caused by the current flow is much reduced upon what would normally be expected.

Enormous current densities have been seen, with values of  $10\text{MA}/\text{cm}^2$  being achieved. Had the current behaved in the normal manner then this would have heated the tubes to temperatures in excess of  $10,000^\circ\text{K}$ .

Investigations show that the current is flowing in a different manner to that normally experienced. In this case the current is flowing through the nanotubes as if it was light passing through an optical waveguide.

These effects have only been noted in nanotubes that are less than  $5\mu\text{m}$  in length. At greater lengths the ballistic conductance effect appears to be destroyed by the scattering effect of the electrons.

Whilst the maximum allowable length of these nanotubes may limit their usefulness, there will be many applications within microelectronics. In addition to this, further development may enable their applications to be extended. Despite the problems, nanotubes should be another technique that enables i.c. designers to increase the levels of integration.

## Silicon on Insulator

The idea of silicon on insulator (SOI) chips has been known for many years. However, they have not been as widely used as many would like. The problem has been in enabling them to be made in commercial volumes.

Now researchers at IBM have succeeded in developing a process that can be easily applied to a whole range of CMOS processes. In fact, the process has been qualified for their  $0.22\mu\text{m}$  CMOS process, and is being developed for their  $0.15\mu\text{m}$  technology. The new advance results from a process called *separation by implantation of oxygen* (SIMOX).

The advantage of SOI is that as the device itself sits on an insulating layer its high frequency performance is greatly improved. This results from two main effects. One is known as the "body effect" where the size of the substrate affects the performance. The other is in the reduction of

stray capacitance from components in the device to the substrate.

As a result, figures for SOI devices typically show a 35 per cent improvement in performance. This is not only useful for r.f. applications but also to give the increased speeds required by today's processors and associated chips.

In addition to the higher speeds, the SIMOX process as implemented by IBM offers the possibility of better low power devices. The reason for this is that the performance of SIMOX devices degrades less with voltage than do conventional CMOS devices. In tests carried out using SRAMs, SIMOX devices consumed less power for an equivalent access time.

## Cosmic Success

A final advantage is in the reliability of memory devices. On occasions, cosmic rays and background radioactivity can cause data errors. It is found that the level of these errors is reduced with devices fabricated using SOI rather than conventional CMOS i.c.s. In fact, the process was first developed for devices to be used in space. Here the levels of radiation are higher, and the degrees of reliability required are much greater.

The process itself involves the use of very heavy doses of oxygen, followed by annealing at high temperature until a thin oxide layer is formed. The overall result of the process is to give a thin layer of  $\text{N}^{++}$  material separated from the substrate by a thin oxide layer.

Development of the process has been hailed a success because once the basic SIMOX process has been completed the substrate can be processed in the normal way. As the generation of the insulating layer takes place during the preparation of the wafer itself, rather than during the fabrication of the components in the device, this can be undertaken off-line. In this way the fab lines are not disturbed. A further advantage is that it can be added to existing products, by simply using wafers that have undergone the SIMOX process.

In view of the fact that this process can be incorporated into existing lines, the cost of its introduction is much less than one needing a completely new line to be set up. This will mean that the i.c.s fabricated using the new process will soon reach the marketplace.

Also, the cost of the chips will be less than those requiring a completely new process with all the vast sums of investment to get them up and running. This is all good news for the end user who will be able to see improved performance for little added cost.



## Simulation Circuit Capture PCB Autorouting CAD/CAM

Imagine an electronics design system that lets you draw schematics onto the screen and then simulate them at the touch of a button. Now imagine pressing another button and seeing the schematic replaced with a PCB rats-nest. Pressing another button starts the autorouter, and finally you can click on File then Save As to create a complete set of CAD/CAM files.

Too easy? We hope so. Quickroute has always been designed first and foremost to be easy to use. That's why simulation, circuit capture, PCB autorouting and CAD/CAM support are all integrated into **one** package, so that you only have to learn **one** package.

But it doesn't end there. We have included a wide range of features in Quickroute to help you work effectively. For example our Gerber import facility lets you check your CAD/CAM files before sending them to your manufacturer.

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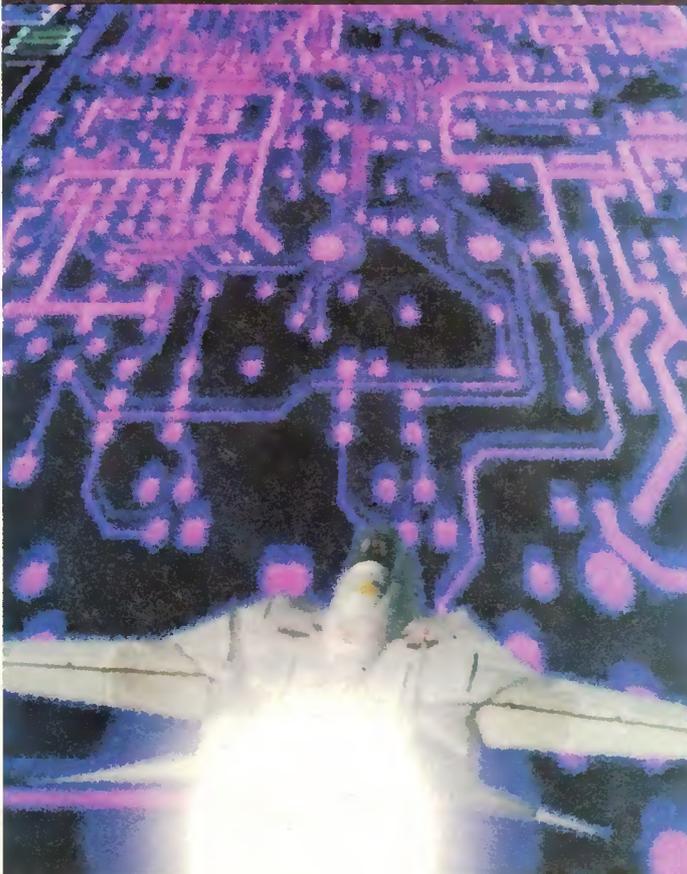
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# Electronics Principles 5.0

If you are looking for an easy and enjoyable way of studying or improving your knowledge of electronics then this is the software for you.

By Clive W. Humphris.

The screenshot displays the 'Wien Bridge Oscillator' window within the 'OSCILLATORS' section. It features a circuit diagram with an operational amplifier, resistors R1, R2, R3, R4, and capacitors C1, C2. The natural resonance frequency is 636.6198 kHz, and the frequency is forced to 1 kHz. Calculations on the left show:  $X_{C1,2} = \frac{1}{2 \times \pi \times F \times C1,2} = 1.5915k$ ,  $Z1 = Z_{R1,C1} = \sqrt{R^2 + X_{C1}^2} = 2.9636k$ ,  $Z2 = Z_{R2,C2} = \frac{R \times X_{C2}}{\sqrt{R^2 + X_{C2}^2}} = 1.3426k$ ,  $I = \frac{V_{in}}{Z1 + Z2} = 700\mu A$ , and  $V_{out} = I \times Z2 = 939.8mV$ . A control panel on the right allows setting 'Voltage Vin' to 3V and 'Frequency F' to 1kHz. The bottom of the window has buttons for 'Calculations', 'Topic Notes', 'Printing', and 'Wien Bridge Oscillator'.

"One rather good program that I've found is Electronics Principles. The range of electronics covered is very wide, from simple atomic structure to the workings of the latest microcontrollers.

I was very impressed ... it ran smoothly and without problems on several IBM PCs."

Tex Swann. Technical Projects Sub Editor. Practical Wireless magazine June 1998.

"Electronics Principles is a well thought out and comprehensive program that is also easy to install and stable in operation. It can be wholeheartedly recommended." Robert Penfold. Everyday Practical Electronics magazine. October 1998.

This window shows the 'ACTIVE FILTERS: RC Low Pass Active Filter' section. It contains text explaining that constructing low frequency passive filters often requires inductors, which are expensive and bulky. It describes a simple circuit with a roll-off of -20dB per decade. Below the text, there are formulas for period and frequency:  $\text{Period } t1 = 0.7 \times 0.00001 \times \dots$ ,  $\text{Period } t2 = 0.7 \times 0.0001 \times \dots$ , and  $\text{Frequency} = \frac{1}{0.07 + .175}$ .

The top window is 'OSCILLATORS: Astable Multivibrator' and the bottom window is 'TUNED CIRCUITS: Tuned Circuit Bandwidth'. The latter displays a graph of gain in dB versus frequency. The graph shows a resonance peak at 1.056 kHz. The x-axis ranges from 251.6134 kHz to 2.0632 kHz, and the y-axis ranges from -20 dB to 0 dB. Below the graph, parameters are listed: Capacitance = 100nF, Inductance = 250nH, Resistance = 166Ω, Resonance Frequency = 1.0565 kHz, Circuit Q = 15.5697, and Bandwidth @ 3dB = 63.662 Hz.

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## INTELLIGENT TV RECORDING

Is video recording of TV programs soon to become obsolete?  
Barry Fox reports.

At the recent *Live 98* show at Earls Court, London, one of the many panel sessions – Storage, a *Revolution on the Horizon* – gave a valuable snapshot of the future. Within two years set-top boxes will be using computer disk technology to store programmes automatically so that viewers can choose what they want to watch by content, without being shackled to the time they are broadcast.

Panelists Abe Peled (NDS), Simon Parnall (BBC), Simon Turner (Philips Research) and Jean Francois Jezequel (Canal+) all agreed that the cost of hard disk picture storage is now falling so fast (by a factor of a thousand over the last ten years) that within two years it will be cost effective for a set-top box to store many hours of programmes. By the Year 2010, at least 500 hours will be easy. The cost of MPEG-2 encoder chips will be down to \$40 by next year, so the “TV Anytime” box will work with analogue TV, too.

“It’s on our doorstep” says Parnall. “You can’t stop it” says Turner. “You’ve got about 18 months. Set-top boxes definitely will have storage in them.”

Even as they spoke, three US companies – Replay Networks of Palo Alto, TeleWorld of Sunnyvale and the Duck Corporation of New York – were promising consumer storage boxes for this winter. The Replay, TiVo and Duck devices will record around seven hours of programming. They cost around \$500 because they need a digital converter to work with analogue TV. All-digital boxes will need no converter and could be cheaper.

### ANYTIME BOX

The TV Anytime box will work like a server, programmed by its own experience to record whatever the viewer wants to watch, for playback whenever the viewer wants to watch it. At first the server will be Precious, and be very selective about what it records. For instance it can keep updating the news so that the latest is always on tap.

By 2005, falling costs will let the box be Adventurous. By 2010 it will have become Promiscuous, recording more or less everything, and leaving the viewer with the problem of deciding what to watch.

“It’s a paradigm shift from time-based to content-based viewing” says Peled. “A new non-linear generation is growing up”.

If the Anytime Box is set to playback while recording, the viewer can break off to answer the phone, and then continue to watch a few minutes behind or fast forward to catch up.

NDS has already worked out a strategy whereby programme viewing is free only for those who are willing to watch the adverts. Anyone who fast-forwards through the ad breaks will quite literally pay for it.

Simon Turner has another concern, which PC users will understand only too well. “It’s easy to store. But you have to apply your brain to throw things away. Hard disks get full and then people throw them away”.

IBM was showing some prototype hardware that is claimed to work on the TV Anytime principle. But it was a parasite event, off the exhibition site. IBM had no official presence at IBC.

## CODE HOPPER



Most of you will be familiar with Microchip as the manufacturers of the renowned PIC microcontroller family. You may be unaware, though, that they produce a variety of other interesting devices as well, including the KEELOQ Code Hopping Decoder family.

Their latest KEELOQ device has been developed for highly secure remote-keyless-entry (RKE) and access control applications. The HCS515 offloads all

timing and processing intensive functions from the system microcontroller.

The device provides a complete decoding solution, handling reception and validation of codes and recognising new transmitters. It combines high security and low cost to make it an ideal solution for applications such as automotive alarm systems and immobilisers, gate and garage door openers, burglar alarm systems and electronic door locks.

For more information, contact Arizona Microchip Technology Ltd., Dept EPE, Microchip House, 505 Eskdale Road, Winnersh Triangle, Wokingham, Berks RG41 5TU. Tel: 0118 921 5858. Fax: 0118 921 5835. E-mail: tech desk@arizona.co.uk. Web: <http://www.microchip.com>.

## MAN POWER?

A SAMPLE pack of 1.5V AA-size Energiser Advanced Formula batteries, plus a press release have been received. The latter states that these new batteries deliver unsurpassed performance in high-drain and standard devices, and that “no battery lasts longer”.

We are told that, compared to Energiser’s 1997 formula, the latest batteries (actually, they ought to be referred to as “cells” – but who bothers?) mean increased playing power of 61 more

camera flashes, 18 more minutes play with a motorised toy, 23 more pictures on a digital camera and 54 more minutes of talk time with a cellular phone.

Worthy improvements, indeed, but we are puzzled by some statements on the packaging that accompanied the batteries: “(Alkaline 0% Hg, Cd, Pb) 100% testosterone. Makes your device last longer”. Testosterone? Presumably, they have *man power* – an alternative to Viagra, perhaps?

# Dixon's Freeserve Net Software

Free internet access sounds attractive, but are there hidden snags?

Barry Fox outlines the evidence.

**D**IXONS wants to buy a foothold in the online market by radically changing the world model for Internet access. The British chain of electronics stores is giving away CD-ROMs which contain a version of Internet Explorer 4 that connects a PC to Dixons' Freeserve site ([www.freeserve.net](http://www.freeserve.net)), gives the user an E-mail name and then provides free unlimited access. In return each user has to answer personal profile questions on age, income and interests which will help Dixons target online sales offers.

Dixons already has an online shop site ([www.dixons.co.uk](http://www.dixons.co.uk)) but visitors can only access it after they have paid an Internet Service Provider around £12 a month in subscription fees. Launching Freeserve, Dixons' CE John Clare says he "knows of no shops that charge an entrance fee".

By design or accident Freeserve may hijack a PC, so that it can no longer use another Internet Service Provider with IE4, such as the Microsoft Network ([www.msn.co.uk](http://www.msn.co.uk)). If a user starts but does not finish the registration process, Freeserve blocks access to other ISPs until the process has been re-started and completed. Freeserve then makes itself the default for IE4, ousting other ISPs such as MSN.

## HELP CAN COST

Users will then need skill or help to restore their original settings. They can seek free help online ([www.freeserve.net/support/](http://www.freeserve.net/support/)) or pay £1 a minute to call Dixons Technical Helpline (0906 553 5600).

The user must go to Control Panel, Internet, Connection and Settings, then My Computer, Dial Up Networking, and right-click for Properties, to restore original settings.

IE4 will only support one setting as a default, so users must change these defaults every time they want to switch access between MSN and Freeserve. (Right-click on the IE4 icon, for Properties, Connection and Settings).

Access to MSN may still be "denied" because Freeserve uses a proxy server to improve response times by caching popular pages on the Dixons server.

The fix is to use View in IE4, Internet Options, Connections and unclick the Proxy Server tick which Freeserve has added.

Dixons will earn revenue by letting other companies sell their online services to Freeserve users. The Freeserve software will soon also be available for download from the same site. Dixons corporate web site ([www.dixons-group-plc.co.uk](http://www.dixons-group-plc.co.uk)) gives up to date details. So far it is available in the UK only.

# RADIO AMATEUR AWARD

THE Radio Communications Agency 1998 Young Amateur of Year Award has been won by 17 year old Mark Shepherd from Brighton.

Mark was presented with the first prize of £300 by the RA's Director of Spectrum services and he also received a certificate signed by Peter Mandelson, Secretary of State for Trade and Industry. He has also been invited to tour the Agency's Radio Monitoring Centre at Baldock, Herts.

Heavily involved with the organisation of the Amateur Radio Club at his school (Brighton College), Mark has many interests based on Amateur Radio. Packet Radio is a particular interest for him and he has spent a great deal of time and effort developing as a SysOp (System Operator) and running a BBS (Bulletin Board Station).

The Amateur of the Year Award is organised in conjunction with the Radio Society of Great Britain (RSGB) and aims to encourage young people into amateur radio.

For more information, contact The Radio Society of Great Britain, Lambda House, Cranbourne Road, Potters Bar, Herts EN6 3JE. Tel: 01707 659015.

## VALVE HERITAGE

THROUGH *Readout* we have been discussing the value of electronics "heritage". We were thus interested to receive a press release from the Bradford Public Relations Group ("Mission: To Promote Bradford") about young Ed Ross and his valve collection.

Ed probably has the largest collection of radio and TV valves in the UK and says that his passion for the devices, which began several years ago, was sparked off by reading electronics magazines and also from his father's collection of vintage radios.

Hailing from Shrewsbury, 18-year old Ed has just begun a three-year Network Information Management course at Bradford University. He has at least 3000 valves, obtaining them by scouring second-hand shops and surfing the Internet [rec.audio.tubes](http://rec.audio.tubes) news group for information and contacts.

Through the Net link, Ed met fellow enthusiast Dr Donald Klipstein, of a magnetics research company just outside Philadelphia, USA, who has his own valve museum. Ed's name now appears on a brass plaque in the museum, after he donated rare valves to Dr Klipstein.

## INTELLIGENT METERS



LASCAR Electronics have announced the introduction of their new family of intelligent digital panel meters, the C100 Counter, C110 Frequency Meter and C120 Timer.

Designed around a 6+3 character alphanumeric starburst display, these new microcontroller-based instruments include six 10mm high digits for measurement readings, and a 3-character display for indicating engineering units.

The front keypad provides access to function choices, and all set-ups, including calibration, are done in software. The meters have five open-collector alarm outputs and are able to communicate via built-in RS232 or RS485 ports.

For more information contact Lascar Electronics Ltd., Dept EPE, Module House, Whiteparish, Salisbury, Wilts SP5 2SJ. Tel: 01794 884567. Fax: 01794 884616.

# THE DVD DILEMMA

The security of digital video disc movie releases is being severely threatened.  
Barry Fox reports.

**H**ACKERS are making a mockery of Regional Coding, and copy protection, the two features of DVD which the Hollywood studios insist on as a condition for releasing movies on the new digital disc format.

Magazine adverts and a site on the Internet now offer a chip which enables European players to play North American discs, and make copies onto VHS tape. A new web site offers free advice on hacking DVD. It reveals that Japanese company Pioneer is now selling players which dealers can easily adjust so that they play discs from any Region.

DVD was conceived as a single standard digital video disc, which cut through the existing barriers between Europe and Australia, which use the analogue PAL TV system, and the US and Japan, which use NTSC. After the base standard or DVD was set, the Hollywood studios saw that it undermined their policy of staggered releasing. They want to save costs on making cinema film prints by releasing films in the US well ahead of other countries, which means they must also stagger video releasing.

So the electronic companies reluctantly tacked Regional Coding onto the DVD standard. Players are coded, and so are discs. Each bit of a 6-bit code represents one of six Regions. The US is Region 1, Europe is Region 2 and Australia Region 4. If the bits do not match, the player rejects the disc.

All players also contain a Macrovision encoder, which distorts the synchronisation pulses in the analogue video signal which the player sends to a TV set or VCR. A TV set can cope with the pulses, a VCR cannot. The encoder is switched on by a trigger signal which accompanies the Regional Code.

## European Views

Although DVD is now officially on sale in Europe, only a limited choice of discs is available and most are old titles.

European movie enthusiasts want access to the much wider selection of new movies available in the US. Hackers modified early players by disabling its Regional Code control chip. The movie studios countered by releasing discs which will only play if the chip is intact. Now the hackers have found a foolproof solution. They modify the player so that the user can set the Regional Code to suit whatever disc is to be played.

European company Techtronics ([www.techtronics.com](http://www.techtronics.com)) has announced Multimod, an off-the-shelf multi-purpose chip which the company says its "whizz kid" has programmed to put Regional Coding under control of the player's existing remote control. The chip costs around £40 and solders onto the main circuit board inside the player.

The same chip disables the Macrovision encoder by blocking the trigger pulses. So a European player can copy a North American disc onto tape.

"Thanx to Bevis and Danny for this great work" says a new web site ([www.twi.ch/~i7eberha/eng/codefree5-05eng.htm](http://www.twi.ch/~i7eberha/eng/codefree5-05eng.htm)) which uses detailed colour photographs to show how easy it is to hijack the Regional Coding and Macrovision circuitry on Pioneer's full range of DVD players.

Pioneer's factory in Japan has put three spare contacts in the circuit board inside each player. Engineers can use these points for testing. But simply connecting two of them with a blob of solder lets anyone set the Regional Coding of the player to any country of choice, by pressing keys on the remote control. Photographs on the web site also show how to disable the Macrovision encoder. "After this mod you will be able to play all movies without Macrovision" promises the text.

## Undesirables

Privately, the hardware companies admit that they did not want Regional Coding because they would sell more players if consumers had a wider choice of discs. But they dare not be seen to support hacking.

The UK's DVD Launch committee, which promotes the new format, says in carefully chosen words "We could not sanction any unauthorised change to the system".

This is *deja vu* for movie buffs. Ten years ago Pioneer kick-started the market for 30cm analogue Laser Discs in Europe with a similar tactic. Pioneer's model 1450 could play North American NTSC discs through a conventional European PAL TV set. This upset the Hollywood studios so badly that Pioneer never advertised the feature, or explained it in the instruction book. But the news spread like wildfire, and for at least a year Pioneer's dealers had a waiting list for 1450s.

Pioneer admits it is aware of the information on the Internet about its DVD players, and warns that users may damage their machines and void

the warranty if they tamper with the circuitry.

Dealers in the Far East are already doctoring Pioneer's players before sale. Techtronics offers to modify players for a service fee of £40, and is selling Panasonic players that have already been modified, at an all-in price of £400. Techtronics says its offices near Peterborough are so "busy" with modifications that it needs 48 hours to turn players round.

## Force of Destiny

The British Videogram Association represents all the studios which are releasing movies on DVD. Hacking was raised at the BVA's recent Council meeting. Says Director General Lavinia Carey "The studios think that as they release more titles in Europe, there will be less incentive to bypass regional coding. They see what is happening to copy-protection and no longer feel in control of their own destiny."

Although the BVA cannot stop people tampering with Regional Coding in players, and mail-ordering discs from the US, anyone who sells imported DVD movie discs in the UK contravenes the Video Recordings Act 1984. They risk two years in jail, and unlimited fines, for selling films that have not been classified by the British censors.

The Disney Studio refused to support DVD until it felt confidence in Regional Coding and copy protection. Says a spokesman for Buena Vista, the subsidiary company which releases Disney titles on home video "That's a tricky question". No further comment was forthcoming.

David Simmons, Macrovision's MD Europe, explains that in Europe, defeating copy-protection is a civil rather than criminal issue. In the UK it is covered by the 1988 Copyright, Designs and Patents Act. "Although the Act does cover devices designed to defeat copy-protection, the law was deficient. Companies that produce the copy protection systems cannot take action. Section 48-7 says it must be the copyright owner who acts. We have to resort to suing under patent law".

## NEW HAM BANDS

THE Radio Communications Agency has announced the date for future changes to the 10GHz amateur radio band. From 1 February 1999 the frequency allocation for radio amateurs using the terrestrial service is 10.00GHz to 10.125GHz and 10.225GHz to 10.475GHz. The amateur satellite allocation will remain unchanged.

## PACKET RADIO CLUB

MAXPAK, the Midlands AX25 Packet Radio Users Group have contacted us saying that they hold monthly meetings. If you are interested in more details, contact Edward Loach (G4ZXS) on 01902 741877 (evenings) or via web site [g4zxs@gb7max.#28.gbr.eu](mailto:g4zxs@gb7max.#28.gbr.eu). The Club is affiliated to the RSGB.

# FADING CHRISTMAS LIGHTS

**BART TREPAK**

*Use a PIC to provide sophisticated programs for your tree lights.*

**F**LASHING lights for Christmas trees and other festive ornaments have been with us ever since electric light bulbs replaced candles as the primary means of lighting up a Christmas tree. The original ones used a special lamp which contained a bi-metallic strip which heated up and broke an internal contact causing the whole chain to go out. With the current now interrupted, the strip would cool down causing the contact to be closed, lighting up the chain again.

This system is still used in many cheaper light sets but with technology being what it is, it was soon replaced by transistorised flashers and now microprocessor controlled ones are available which not only flash the lights but play a rather "tinny" selection of Christmas carols as well!

## FLASHY

Flashing lights can be very attractive and certainly add movement and interest to the display which is fine if you want to hang them in your window to impress the neighbours or people passing by. But, picture the classic Christmas scene:

You are sitting in a darkened room in your favourite armchair. In the hearth the log fire is blazing, the Christmas presents have been opened, the long lunch/dinner is over and, with a glass of brandy in your hand, you are watching the Queen's speech which you recorded earlier.

But you feel tense, a slight headache, nausea – and you haven't even taken a sip yet! Was it the turkey? No . . . the stuffing perhaps . . . or the extra helping of mince pies . . . and then it hits you.

It's those infernal tree lights flashing on and off with monotonous regularity or switching to some even more annoying chase pattern. What is needed is something more gentle, calming, to help you relax and get ready for Boxing Day and another chance to spend some more money at the sales!

This is not quite how the idea for this project was born but it should help to avoid this scenario. The circuit to be described has been designed not to flash the lights on and off but to gradually *fade* them up and down, providing a more soothing, relaxing display with no sudden changes in brightness thus avoiding the "disco effect".

Although designed primarily for Christmas tree lights, the circuit could also find uses in exhibition work or at more sedate gatherings (a lightshow at an afternoon tea dance perhaps?) or even as background lighting at a disco. A particularly effective display could be obtained by using three different coloured lights such as red, green and blue and project these onto a white wall to produce a constantly changing colour or rainbow effect.

## PROGRAM

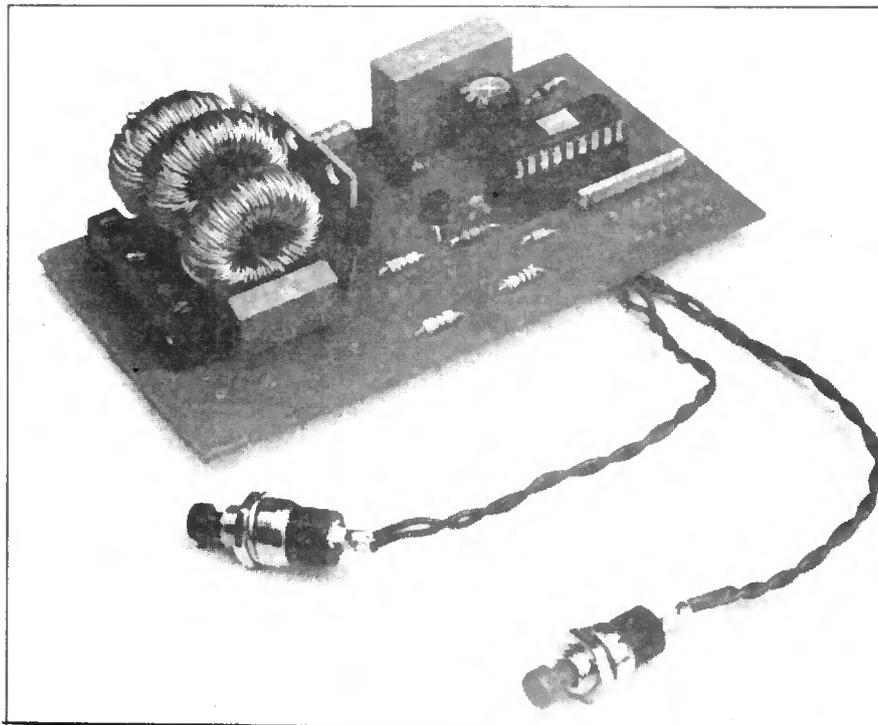
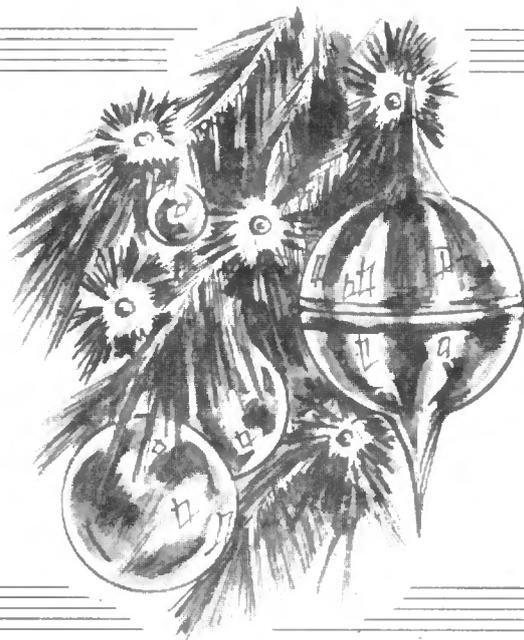
The project is based around a PIC microcontroller which means that virtually any program can be written to vary the intensity of the three channels of lighting over a period of time. One program has been written and is available free or can be purchased already programmed into the PIC chip (see later for details).

However, *EPE* readers who have followed the *PIC Tutorial* series (March to May '98 and now available on CD-ROM) will be able to write their own PIC programs and thus design their own light display.

The PIC is used to vary the output to three channels of lighting, each controlled by a triac. The circuit for the Fading Christmas Lights will be described later, after we have looked at the techniques employed to control the power to the lights.

## MICRO-DIMMING

The most common technique used to dim mains lights using a triac is called "phase-control" because the trigger pulse for the triac which switches the light is



applied at the same frequency as the mains but not in phase with it. Put simply, the trigger pulse is delayed with respect to the mains waveform.

The triac, once triggered then continues to conduct until the current through it is reduced to zero (which occurs at the end of each mains half-cycle) so that if the trigger pulse is applied early, near the beginning of the half-cycle, then the triac will conduct for almost the whole time, giving full brightness. While if it is delayed and only applied near the end of each half-cycle, then the triac will be off for most of the time, resulting in a low lamp brightness. Varying the delay between these two extremes will give varying levels of brightness.

Conventional light dimmers use a capacitor and resistor to produce the delay required and, by making the resistor variable, the amount of delay and hence the brightness can be manually controlled. In this application we want the brightness to vary automatically and we do not want to have to turn a potentiometer up and down to achieve this. The conventional way to do this would be to make the delay voltage controlled and apply a low frequency triangular or sine wave to the control input, which would cause the delay and hence the brightness to increase and decrease in sympathy.

A similar method could be used with a microcontroller but, being a digital device, it is far easier to produce a delay digitally rather than using voltage control. Delays in microcontroller circuits are very easily achieved simply by loading a counter with a number and then counting down until zero is reached.

The delay obtained will then depend on the rate at which the counting occurs (which is normally fixed and depends on the system clock) and the number originally loaded into the counter which can easily be varied by software. Thus if the system clock is adjusted to cause the counter to be decremented every 40µs for example, then by loading the counter with 250 (decimal), it will reach zero in 10ms, while if only 10 were loaded, the delay would be only 400µs.

## ZERO CROSSING

It is not enough, however, to simply provide a variable delay because to achieve the same brightness in successive half-cycles, the delay must cause the trigger pulse to occur at the same time in each half-cycle. So it must always start at the same time by being synchronised with mains waveform.

The best reference point to use is the point at which the half-cycle starts i.e. the mains zero crossing point. There are many zero crossing detector circuits available both in integrated circuit form and discrete designs but again it is simpler to use the microcontroller especially as this requires only one resistor.

The mains waveform is fed to one of the microcontroller inputs (port RA3 in this case) via a resistor which serves to limit the current to a safe value and the input port is read. During the positive mains half-cycle this will read high and during the negative half-cycle it will read low so that the instants at which a low reading changes to high or a high reading changes to low will be the zero crossing point.

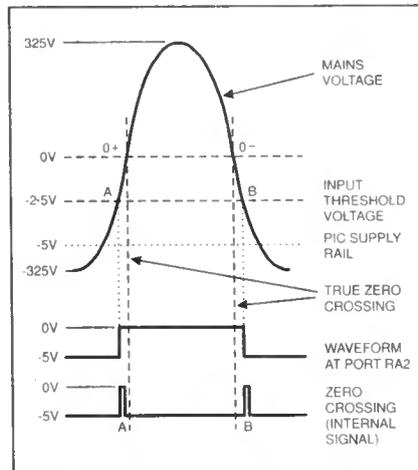


Fig.1. Zero crossing point asymmetry. Pulse A appears too early while B too late. Greatly exaggerated for clarity.

This is not strictly true because the input threshold (the voltage above which a logic high and below which a logic low is read), which is around half the supply voltage in CMOS circuits (i.e. 2.5V with a 5V supply), does not coincide with the mains zero voltage. This has the effect of making the positive zero crossing appear to occur slightly earlier and the negative slightly later than is the case as shown in Fig.1, which is greatly exaggerated for clarity.

This can cause asymmetry in the delay between positive and negative half-cycles and other more serious problems and one way around this would be to provide a  $\pm 2.5V$  supply for the microcontroller instead of a single-ended  $-5$  volts. Note that a *negative* supply is used in this design because triacs are more sensitive to negative triggering.

A simpler solution, however, is to introduce time delays into the program so that the crossings occur at the correct time, thus ensuring that any subsequent delay will start at the same time with respect to the true zero-crossing point.

## FADE AWAY

We now have a zero-crossing detector and a delay, albeit in software, so that all we now need to do is to switch an output port which will trigger the triac at the precise point to give any brightness required. To make the brightness ramp up and down we must arrange for the number which is loaded into the phase delay counter at each zero crossing to increase and decrease periodically. This is done by storing the number to be loaded in another counter which can be incremented over the period we want the brightness of the lamp to decrease and then decremented over the time period during which we want the brightness to increase.

This will, of course, cause the brightness to change in steps but, provided we make the steps small enough, the change in brightness level will appear smooth and continuous. In practice, 32 levels, which corresponds to a 5-bit counter, would probably be sufficient, but this design uses 7 bits and 120 levels.

Unfortunately, the relationship between the lamp brightness and the phase delay is very non-linear. This is because the lamp brightness depends on the power fed to the lamp (which is proportional to the area

under the sine wave for the period during which the triac is conducting) and, in Fig.2a, it can clearly be seen that the increase in power (shaded area) caused by advancing the triggering point around the middle of a half-cycle from  $t_4$  to  $t_3$  is much greater than the increase achieved by advancing it by the same amount from  $t_2$  to  $t_1$  near the beginning (or end) of the half-cycle.

This means that if the triggering delay is increased (or decreased) by equal amounts over a period of time, the lamp brightness will appear to change relatively slowly and perhaps imperceptibly at first, then fast around the mid-range of the half-cycle and finally slowly again as maximum (or minimum) brightness level is approached. To obtain a relatively linear variation in brightness with time, a correction must therefore be applied.

## APPROXIMATION

To obtain a perfect brightness versus trigger delay characteristic (Fig.2b) would probably require the use of a fairly extensive look-up table but experience shows that this is not really necessary and in practice a simpler approach can be used.

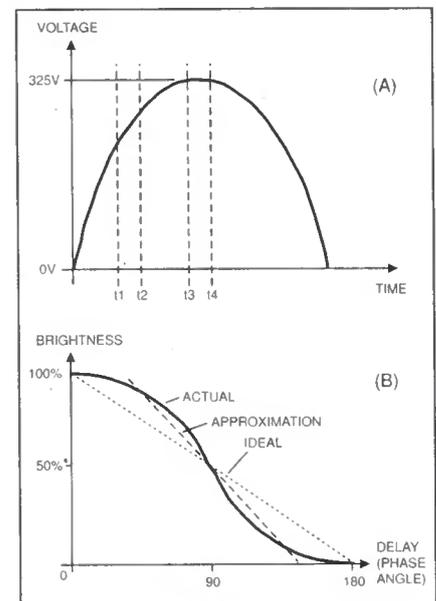


Fig.2. (a) Effect of changing trigger delay at different points in the half-cycle and (b) lamp brightness versus trigger delay.

The first thing to notice is that the beginning and end of every half-cycle contribute very little to the total power so that if triggering is restricted to the mid range very little of the brightness range of the lamp will be lost. There will be no noticeable decrease in the maximum brightness which will be achieved, while at the lowest brightness levels, the lamp is hardly glowing and producing virtually no light so that this portion can also be discarded. This immediately gives a large improvement in the characteristic because this centre portion of the brightness against trigger delay curve is more linear.

A further improvement can be obtained by altering the brightness faster at the extremities of the brightness range, where the brightness changes more slowly compared with that at the centre, by software. Thus if the number in the brightness register (which ranges between 0 and 120

in this design) lies between say 40 and 80; the rate of change is made half of that which occurs when the number to be loaded into the phase delay counter is outside these limits.

The brightness is therefore increased or decreased twice as fast at the beginning and the end of the half-cycle compared to the rate of change which takes place when the brightness is varied around the mid-portion. Together, these techniques give a visually almost linear variation in brightness.

## UP AND DOWN

Each of the three channels has its own brightness counter (BRG1, BRG2 and BRG3) and these are all varied at the same time and by the same amount so that they will all remain in step as the brightness is changed. All that is required to ensure that each channel ramps up and down continuously is to make sure that the channel continues dimming until minimum brightness is reached (by increasing the count in the respective brightness register) and then increases the brightness (by decreasing the count) until maximum brightness is reached.

The decision on whether to increase or decrease the count in each brightness register is taken after examining another register called, for want of a better title, the Dimming Direction Register (DMDR). Only the first three bits of this are used (one for each channel) with a set bit indicating that the brightness of the corresponding channel is to increase and a zero meaning a decrease.

These bits are then toggled when the brightness count reaches a maximum or a minimum, which ensures that the brightness begins to fall as soon as the maximum is reached and rise after the minimum has been reached. Loading the brightness and DMDR registers with suitable initial values then ensures the correct relative brightness of the respective channels as they are faded.

## SPEED

The speed at which the brightness ramps up and down is determined by how often the brightness registers are incremented or decremented. This is done with the aid of another counter, or rather counters as there are again three of these, one for each channel, which are called NCTR1, NCTR2 and NCTR3.

These counters are loaded with a number (held in another set of registers called NREG1 to NREG3) and count off a number of mains cycles before changing the value in the brightness registers in the direction determined by the DMDR register. Here again, a larger number in the NREG will mean that zero in the corresponding NCTR will be reached after a larger number of mains cycles resulting in a slower ramp and vice versa.

A simplified flowchart for the program is shown in Fig.3a and consists of the main program which detects the zero crossing and a number of subroutines which are called as they are required. Each subroutine performs a single function such as decrementing a counter and triggering the triac if required as shown in Fig.3b, the simplified flowchart for the dimming subroutine.

Table 1: Subroutine Functions

NAME	SUBROUTINE FUNCTION
DIMR	Dimming routine which decrements PHSCTR and produces trigger pulses when it is zero
PSET	Sets new brightness level for each output by increasing or decreasing the number in the brightness register and changing the direction of dimming as required. The rate of change of brightness is also linearised by the LIN subroutines which are called from this routine.
ZRX	Zero Crossing Subroutine switches off triac trigger outputs and reloads the PHSCTRs from the respective brightness registers (BRGs)
INPUT	Reads switches and alters the values stored in the NREGs which determine how often the BRG registers are altered
DELAY	Short delay used to ensure that trigger pulses cannot be produced until after the mains zero crossing

Each subroutine ends with a return instruction (RETLW) which ensures that after it has been executed, the program returns to the line after the one from which it was called and continues from this point. The function of each subroutine is described in Table 1.

## USER CONTROLS

The only input/output lines required for this unit are therefore RA3 for the mains signal from which the zero crossing timing is derived and three outputs RA0, RA1 and RA2 to trigger the three triacs. The only controls provided are two pushswitches connected to ports RB0 and RB1 which

are used to increase or decrease the speed at which the brightness changes. This is done by reading these ports and if either is high (switch pressed) incrementing or decrementing the number stored in the NREG registers. The range of values which the NREGs are allowed to assume is limited to prevent very slow or very fast ramps.

The switches are read in a subroutine called INPUT which is called once in every cycle, but this would result in the value in the NREGs changing so fast that even a short touch of the switch would cause the contents of the register to change from minimum to maximum, allowing virtually no control other than fast and slow. To slow things down a bit, the subroutine includes a counter which only allows the value of NREG to change once every 20 cycles.

## OVERVIEW

To summarise therefore, the brightness of a lamp can be controlled by the contents of the respective BRG register, while the speed and direction of the ramp is determined by the contents of the respective NREG and bit in the DMDR respectively. Since all of these registers are separate, each channel can be varied independently to produce any kind of display required.

Thus, by leaving the bits in the DMDR register cleared, for example, and reloading the brightness register with the maximum value each time the minimum is reached, a "sawtooth" brightness pattern will result with the channel fading down to minimum brightness at a rate determined by the contents of its respective NREG register, and then switching on to full brightness to repeat the process again. Similarly, by leaving the DMDR bit set the output would increase in brightness. One output could also be made to dim while the others increased in brightness at different rates.

Note that once the output brightness reaches maximum, if the DMDR bit remains set, the output will stay at this brightness and would only change if either the contents of the BRG register were altered or the corresponding bit in the DMDR was cleared. The same is of course true for outputs that have reached minimum brightness.

It is also possible to make outputs remain at some intermediate brightness level by switching the corresponding DMDR bit high and low each time the BRG register is altered. This will in effect cause the output to ramp up and down by an amount so small as to be hardly noticeable as a change in brightness.

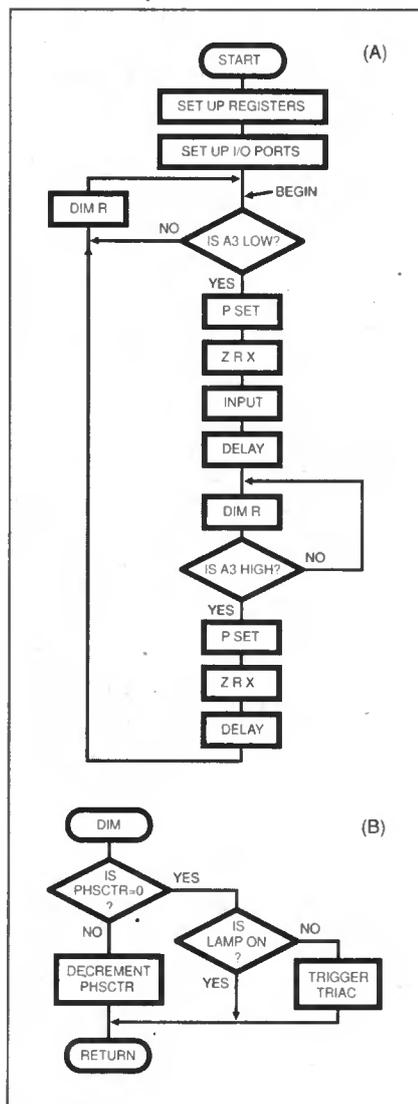


Fig.3. (a) Main program flowchart and (b) simplified dimming subroutine flowchart.

Alternatively, the program could be written in such a way that the contents of the BRG register are not altered when the brightness is to remain at one level. Using these techniques enables the brightness of one or more channels to be "frozen" if required while others continue to change at different rates and in different ways.

If there are many settings or patterns programmed, then a larger number of switches will be required to select them and, in this case, port B would need to be reconfigured to drive/read a keyboard and the INPUT subroutine re-written to do this. Perhaps the simplest way of implementing other lighting patterns would be to define a register which would store the number of the key which was last pressed.

The other patterns would be written as subroutines similar to the PSET subroutine and these could be called from the main program depending on which number was stored in the register. This is not difficult to do but it is beyond the scope of this article.

## CIRCUIT DETAILS

Having discussed the software, it is time to examine the hardware required to do this. The full circuit diagram for the Fading Christmas Lights is given in Fig.4.

As with most microcontroller projects the circuit is unremarkable, consisting of the PIC16C54 chip itself plus the usual clock and input port pull-down resistors. The frequency of the clock circuit is made variable by means of preset VR1 to enable the circuit to be set up (see later).

As mentioned, port RA3 is used to input the mains waveform for the zero-crossing detector and it will be noted that two resistors, R10 and R11, are used in series rather than one. This is because most resistors are rated at 250 volts which is too low for connecting directly across the mains, which has a peak voltage of around 325V.

The other three lines of port A are used

# COMPONENTS

## Resistors

R1	470Ω 0.5W
R2, R10	
R11	2M2 (3 off)
R3	4k7
R4 to R6	2k2 (3 off)
R7 to R9	220Ω (3 off)
RN	10k s.i.l. resistor network

See  
**SHOP  
TALK**  
Page

## Potentiometer

VR1	10k horizontal skeleton preset
-----	--------------------------------

## Capacitors

C1	470n Class X, 250V a.c.
C2	470μ elect. 16V
C3	22p ceramic
C4 to C6	10n Class X, 250V a.c. (3 off)

## Semiconductors

D1	4V7 500mW Zener diode
D2	1N4148 silicon diode
D3 to D5	red i.e.d. (3 off)

TR1 to TR3 2N3903 npn transistor (3 off)

CSR1 to CSR3 C206D triac (3 off)  
IC1 PIC16C54N programmed microcontroller – see *Shoptalk*

## Miscellaneous

L1 to L3 4mH 100W, 240V open toroidal choke (3 off)  
FS1 2A fuse and panel mounting mains fuseholder  
S1, S2 s.p.n.o. pushswitch 250V a.c. with plastic body – see text (2 off)

Printed circuit board available from the *EPE PCB Service*, code 215; fully insulated plastic case approx. 130mm x 65mm x 43mm; plastic p.c.b. mounting posts (4 off); p.c.b. mounting terminal blocks 2-way (4 off); strain relief grommets (4 off); mains cable; interconnecting wire; solder etc.

Approx Cost  
Guidance Only

# £26

excluding case & lights

to drive three transistors (TR1 to TR3) which in turn switch the three triacs controlling the lamps. Each transistor has an i.e.d. in its collector circuit which mimics the main lamp in brightness and these may be mounted on a front panel or left out if not required.

Phase control unfortunately generates large amounts of radio interference (r.f.i.) which must be suppressed if it is not to cause annoyance to nearby radio listeners and this is the function of the chokes L1 to L3 and capacitors C4 to C6 connected to the triacs. These components **MUST** be

correctly rated for this application – see the components list.

The circuit is powered directly from the mains (there being no good reason why it should be isolated from the supply) and a capacitor C1 (a Class X 250V a.c. capacitor) is used as a mains dropper in preference to a resistor. The a.c. voltage developed across the Zener diode D1 is rectified by D2 and smoothed by C2 to provide a nominal 4V negative supply for the PIC. The current consumption of the circuit is quite low as the triacs are pulsed rather than d.c. triggered.

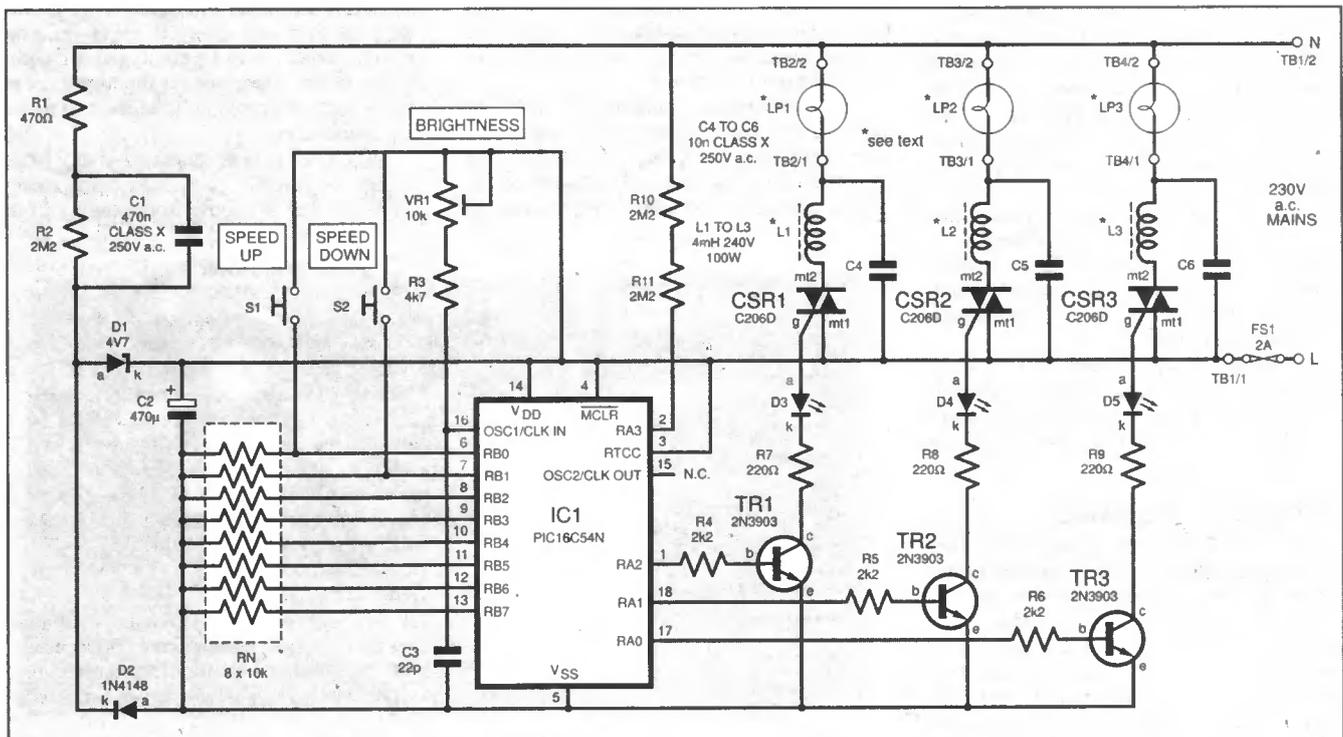


Fig.4. Complete circuit diagram for the Fading Christmas Lights. It is most important that this circuit must be housed in a fully insulated plastic case.

## CONSTRUCTION

It is important to realise that all parts of this circuit are at or near mains potential and under no circumstances should earthed equipment be connected to the p.c.b., nor should the unit be used whilst connected to the mains supply without being fully encased in a totally insulated plastic box – see later for details of this.

The circuit is built on a small, single-sided printed circuit board (p.c.b.). The component layout, together with full size copper foil master pattern, is shown in Fig.5. This board is available from the *EPE PCB Service*, code 215.

None of the components are unusual and should be available from most suppliers. Note that the PIC microcontroller must be programmed for this application and for those who do not have the facilities to program this device or prefer not to, a pre-programmed chip is available from the author – see *Shoptalk* for detail on this and on the availability of the software.

The pull-down resistors used in the prototype were from an 8-way resistor network which is a single in-line package with 9 pins, one for each resistor and a common. The common connection is marked by a dot on the body of this component and care should be taken to ensure that this is inserted into the circuit correctly with the dot adjacent to pin 5 of the i.c.

## TAKE CARE

The only other components worthy of note are the mains dropper capacitor C1 and the suppressor capacitors C4, C5 and C6 which *must* be rated at 250 volts a.c. Class X types, suitable for connection directly across the mains supply. Do NOT be tempted to use an ordinary 250 volt polyester type as these are normally rated at d.c. and could break down causing extensive damage to the rest of the circuit.

The triacs should also have a minimum voltage rating of 400 volts and have a low trigger current requirement (i.e. a sensitive gate) with a rating of 5mA being ideal. The C206D (which is a 400V device) is best as it also has a low latching current which is important when low power loads such as Christmas tree lights are to be used.

This triac can be used to control up to 750 watts of lighting provided it is mounted on a heatsink. Without a heatsink 100W would be more realistic, which should in any case be more than enough for most applications.

Note that the tab of this device is *not isolated* so that a mica insulating kit will also be required if a heatsink is to be used. The chokes should also be suitably rated to carry the lamp current.

## CIRCUIT BOARD

All the components except the two switches and the fuse are mounted on the p.c.b. and construction should follow normal practice with the lowest profile components such as resistors and diodes being mounted first. It is also a good idea to fit an 18-pin d.i.l. socket for the microcontroller rather than soldering it directly to the p.c.b. This is a CMOS device and although quite robust there is no point in tempting fate for the sake of a

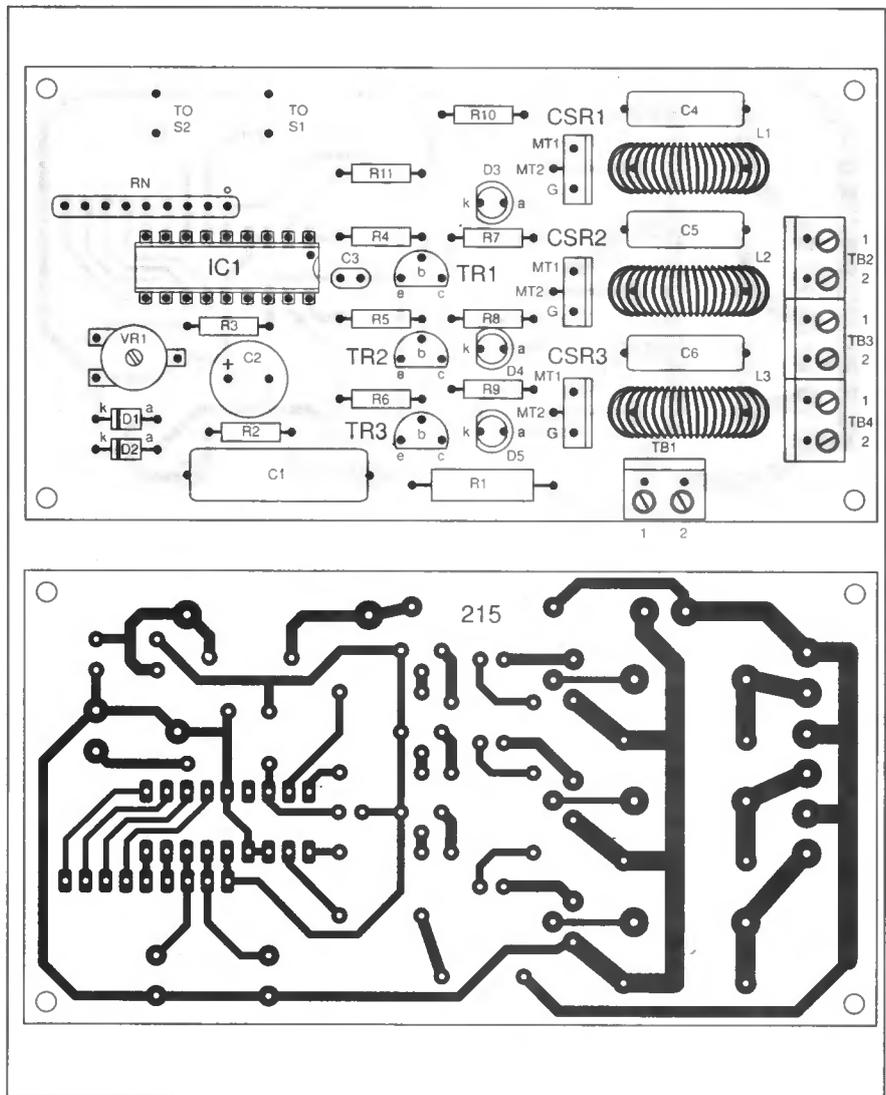


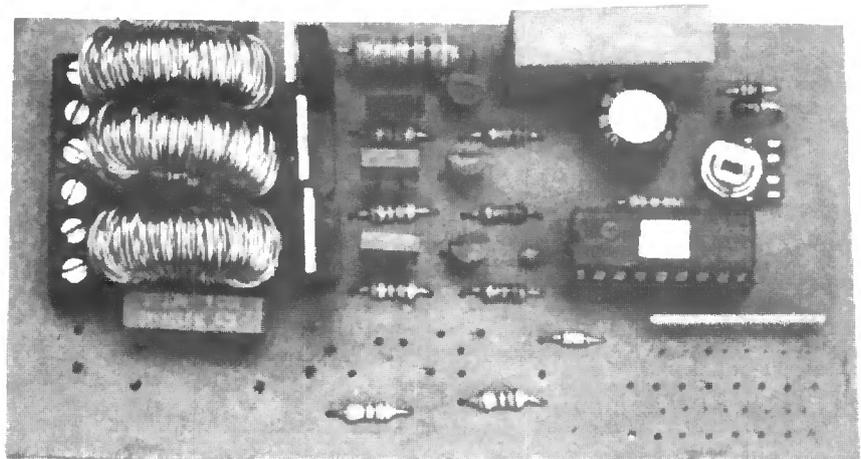
Fig.5. printed circuit board topside component layout and full size underside copper foil and master pattern for the Fading Christmas Lights.

few pence. The mains connection and connections to the lamps are made using screw terminal blocks which are also soldered onto the board.

The off board components will, of course, be panel mounted and connected to the board with flying leads. If the circuit is to be used exclusively with Christmas tree lights, these can be connected directly to

the screw terminals and strain relief gromets used in the case. If other lighting arrangements are to be employed a Bulgin 8-way mains connector (of the type used in many light chasers) could be used to make the connections.

The circuit may be mounted in any plastic box of suitable size, there being many on the market to choose from ranging from



Early prototype of the printed circuit board. Some of the components, namely the inductors and capacitors, have been repositioned and a mains rated terminal block included for the mains input lead.

the plain functional to the more attractive. The choice is left to the individual.

The circuit board should be mounted on plastic stand-off pillars (the self-adhesive ones are probably the easiest to use) and suitable holes should be drilled in the corners of the board for this.

### TESTING TIME

Once construction is finished check that there are no solder splashes on the board which could short out adjacent tracks. Do not insert IC1 yet.

The circuit **MUST** be mounted in a fully enclosed plastic case and no metal part should pass through the case (except of course for the mains wiring which must also be insulated in the normal way). This means that switches S1 and S2 **MUST** be plastic bodied types rated for mains insulation – see the components list.

**ON NO ACCOUNT SHOULD ANY OTHER CASE ARRANGEMENT BE USED FOR THIS PROJECT.** If you are in any doubt about your ability to build

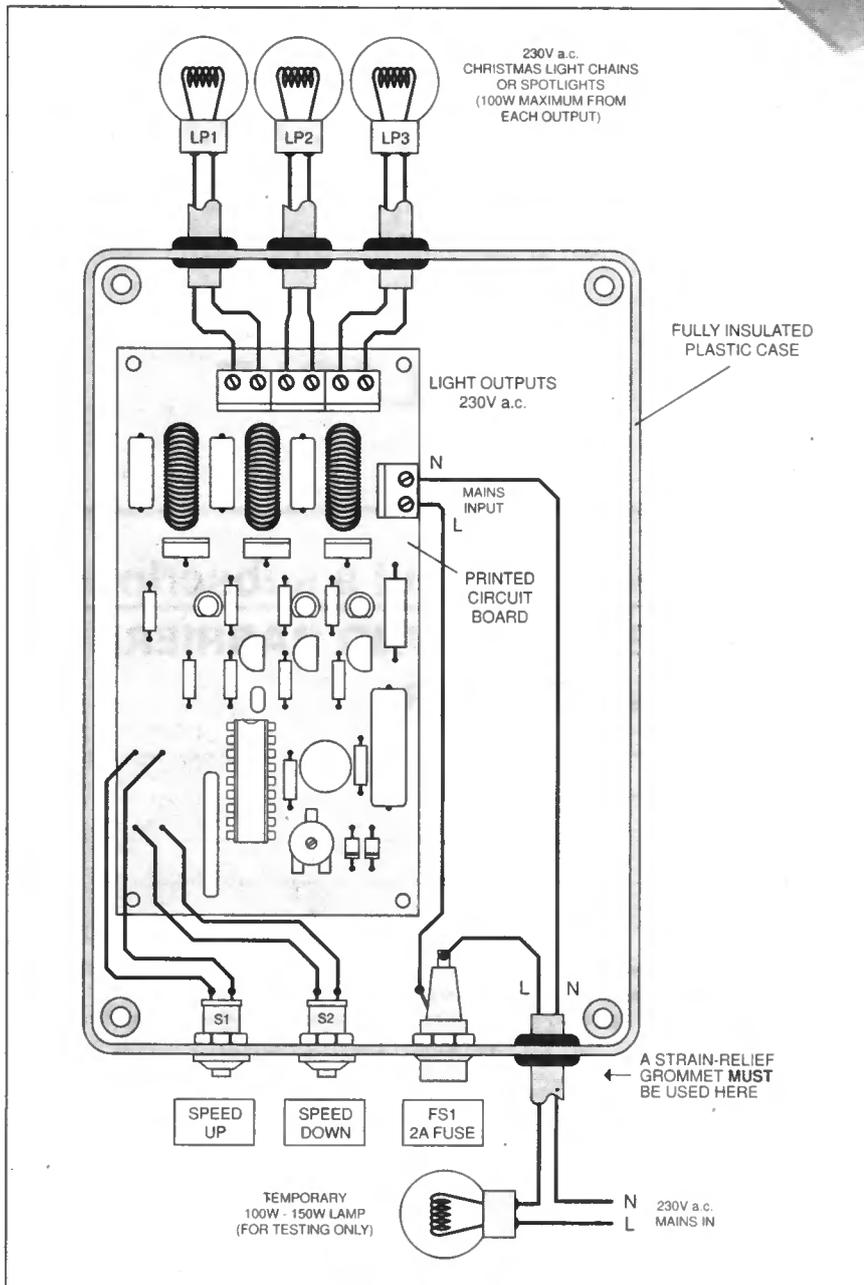
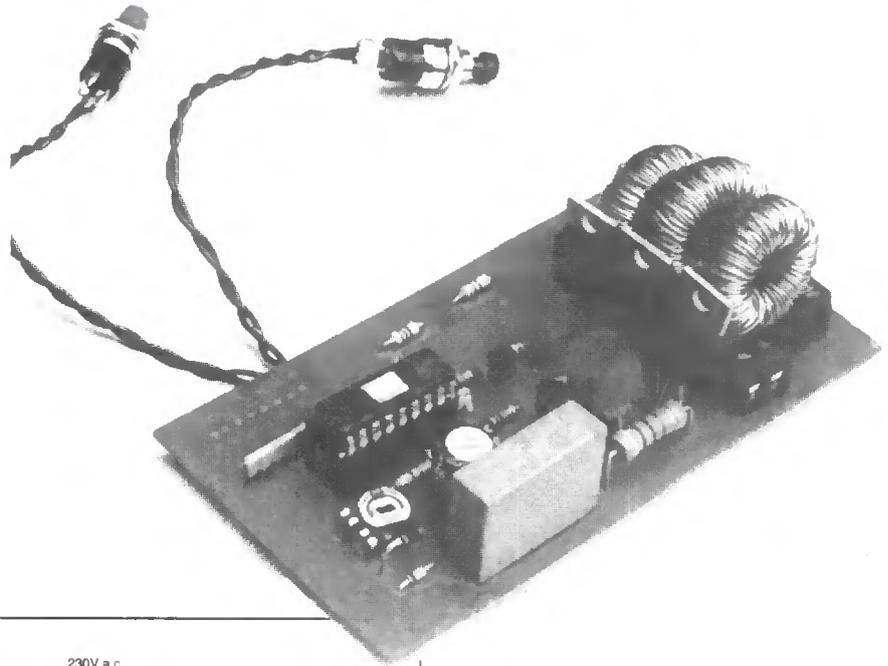


Fig.6. Component layout and interwiring inside the plastic case. Beware of mains voltage on the p.c.b. and **DO NOT** Earth any part of this circuit.

this mains project safely then consult a qualified electronics engineer.

Remember this circuit operates at mains potential, do not use it whilst it is connected to the mains unless it is fully cased as described above. **DO NOT EARTH ANY PART OF THIS CIRCUIT.**

### TEST LAMP

It is a good idea to connect a lamp of 100W-150W in series with the mains lead (as shown in Fig.6) at this stage to prevent loud bangs, blown fuses and perhaps some smoke should there be a short circuit somewhere. (Do not connect any lights to the outputs yet.) The worst that will then happen is that the lamp will light indicating that there is a fault somewhere.

Carefully check the voltage across pin 5 (negative) and pin 14 of the d.i.l. socket to ensure that it is at least 3.5V and not greater than 5.5V d.c. If all is well, **switch off** and insert the chip into its socket. The 100W lamp in series with the mains input may now be removed.

Connect suitable loads to the output terminal blocks, i.e. 15W to 100W lamps or three Christmas tree light chains and switch on the mains supply. The lights should all come on at different intensities.

Press switch S1 to increase the fade speed and adjust VR1 for minimum lamp brightness when one of the lamps dims to a minimum. Do not adjust to the point where the lamp switches off altogether as this will tend to spoil the effect. When the lamps are dimming satisfactorily, press S2 and check that the rate of dimming slows.

Once this has been done, the circuit will operate continuously at the rate set by pushswitches S1 or S2 and the only thing to do is to experiment with various lighting set ups to obtain the most pleasing effect. As mentioned, three spotlights in the three primary colours red, green and blue projected onto a white wall or ceiling provides perhaps the most interesting display but as beauty is in the eye of the beholder, you may have other ideas.



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ee40

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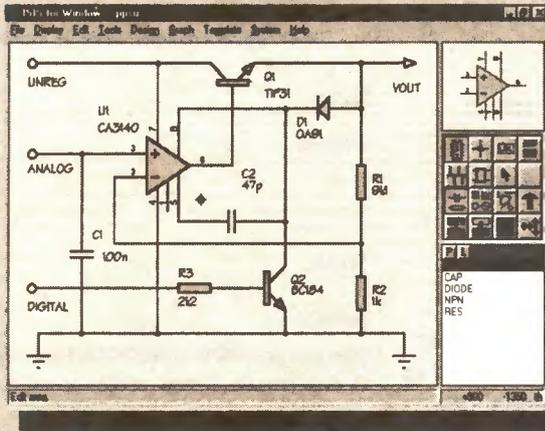
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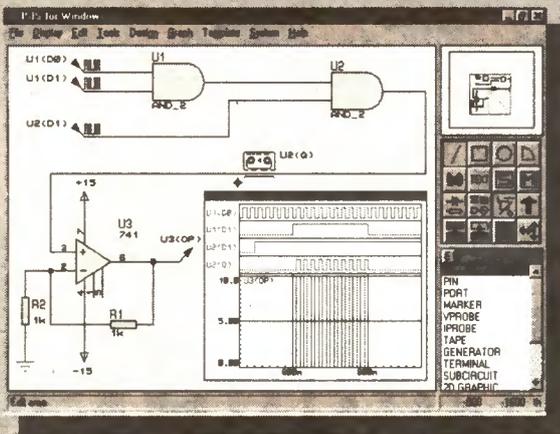
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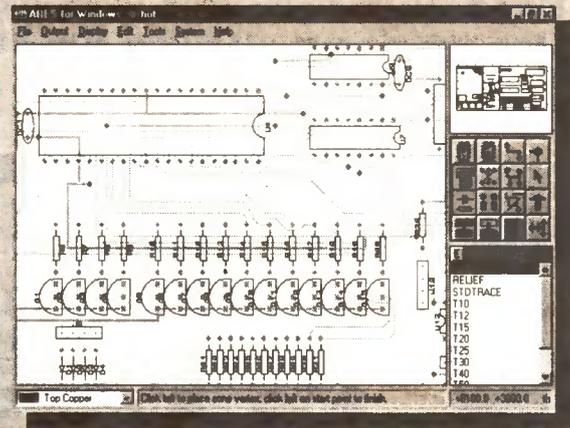
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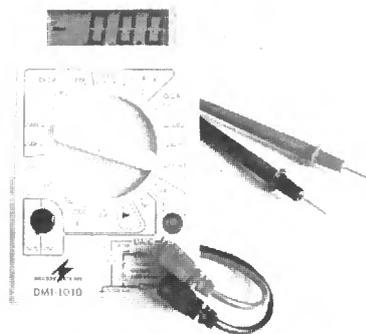
# READOUT

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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The DMT-1010 is a 3½ digit pocket-sized l.c.d. multimeter which measures a.c. and d.c. voltage, d.c. current and resistance. It can also test diodes and bipolar transistors.

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### UNINSTALLING PhizzyB DEMO

Dear EPE,

I had a look at your free CD-ROM given away with the November '98 issue and decided to uninstall the PhizzyB demo - WHAT A DISASTER - the uninstall program decided to do its job with a sledge hammer instead of a nutcracker removing important files (.DLL files) which my computer needed to run my most important programmes - Lotus and Wordpro. I think if I had had the programmer I would have strung him up.

Please pass on my disgust to your friends in America and let me know how I can get this B\*\*\*\* Bee out of my computer without messing things up.

I had to re-install PhizzyB to re-establish normality.

John Bird, via the Net

*We forwarded John Bird's missile (missile?) to Our Friends in America -*

Dear Mr. Bird,

It's Clive "Max" Maxfield here - one of the creator's of the PhizzyB. With regard to your message that *EPE* forwarded to us, as follows:

I'm very sorry to hear that you've been having problems, but I think you are being a little harsh towards us - especially with regard to your desire to "string us up". Let me explain...

When someone creates a program like the PhizzyB (and unless we're talking about an organization like Microsoft), that person doesn't actually create their own installation program. Thus, when we created the PhizzyB, we used a commercial tool (an "Install Shield") that takes all of our files and generates the "setup.exe" program we placed on the CD. Furthermore, this program automatically generates the

"Uninstall" utility that you use to remove the PhizzyB from your system. But wait, there's more...

In the past, when one created programs, those programs were often single humongous "chunks" of code. These days one tends to make use of dynamic link library (DLL) and object code extension (OCX) files. Like most programmers, when we created the PhizzyB, we generated some PhizzyB-specific DLLs, and we also made use of some standard Windows 95/98/NT operating system DLLs, plus some Visual Basic DLLs, and so forth.

When the setup.exe program runs, it checks to see what DLLs are on your system. We can usually assume that the operating system DLLs are there, but we can't guarantee say the Visual Basic DLLs, and the only way the PhizzyB-specific DLLs would be there is if you previously installed this little rascal. The end result is that the setup.exe file checks to see what you've got and what you're missing, and then installs any absent components.

On this basis you might assume that the Uninstall program would know exactly what it has to remove from the system, but life is a little more complex than this. Suppose, for example, that you now decide to load a "super duper" graphics utility that you just purchased, and let's further assume that this utility uses one of the same Visual Basic DLLs that the PhizzyB already loaded onto your system. In this case, the setup.exe for your new graphics program will see that this DLL already exists and won't bother loading it - so now this DLL is being used (shared) by two programs.

There are three ways for an Uninstall program to work:

(a) It can remove all of the DLLs it loaded without asking you

(b) It can leave all of the DLLs it loaded without asking you

(c) It can query you as to what you want to do about the DLLs

In practice option (a) is almost never used, because you run into the problems that you experienced. Options (b) and (c) are pretty much equally common. Option (b) has the advantage that inexperienced users aren't presented with questions that are too complex for them to handle, while option (c) has the advantage that it gives more experienced users more control. Unfortunately, as occurred in your case, the option we used - option (c) - does mean that less experienced users can run into problems.

As a general rule of thumb (and like many users), if I am uninstalling any piece of software and am asked about whether I wish to remove a DLL that I'm not sure about, I always choose to leave it on my system.

If you re-run the "Uninstall PhizzyBD" option, you will see that at some stage during the installation it does start saying things like "xxxxx.DLL is a shared file, do you wish to remove it anyway?" Again, as a rule of thumb, if you aren't 100 per cent sure what you're doing, it's generally a good idea to select the "NO" option in these cases.

A little later you will be prompted as to whether you wish to remove the PhizzyB's directories. In this case the Uninstall will prompt you for each of the PhizzyB's directories in turn, and you can feel free to instruct it to delete these directories in their entirety. Once again, we could have simply caused the Uninstall utility to automatically remove these directories without prompting, but more experienced users may wish to keep certain directories containing data files they've created, so we decided that it was preferable to give people the ability to control their own destiny.

So you can uninstall the PhizzyBD as described above, or as a "quick and dirty" alternative, you can simply delete the C:\PhizzyBD directory and all of its contents. Note that this route will still leave the PhizzyBD and Uninstall PhizzyBD entries in your "Start -> Programs" menu. In order to remove these entries, you'll need to use "Start -> Settings -> Taskbar" to bring up the Taskbar Properties dialog, then select the "Start Menu" tab, then the "Remove" button, and then select the items you wish to remove.

Once again, I'm sorry that you've experienced these problems, and I hope that these notes have helped to resolve your questions. Hopefully you'll now agree that "stringing us up" is perhaps not as warranted as you first believed :-)

Please feel free to E-mail me at <http://maxmon.com> if you have any other issues.

Clive "Max" Maxfield

## ★ LETTER OF THE MONTH ★

### GLOBAL TUNING

Dear EPE,

I was interested in Philip Miller Tate's and Harold Chamberlain's letters in *Readout* September '98.

My interest is largely centred on radio. I am a "kitchen table" constructor, of Scottish descent, and have, like Harold C, limited funds. I have 20-odd home-made radios scattered around the place, and if the cost is more than a fiver each, I think of another and cheaper way of making them.

This restricts me in some ways, but Robert Penfold showed me the way many years ago and I was lucky because I bought Denco coils when they were 50p each, and were still around. I have moved on to Toko coils and i.c.s, but the best radios I have, covering everything up to 30MHz, are made from discrete transistors and Denco coils from circuits dated 1976/7.

I have reception pins on a world map in every country, and I don't think there is a better way to encourage the "re-appraisal of our heritage" than by making radios. The hairs on the back of my neck still prickle (as they did when I received the first transmissions

on a crystal set) when I receive an amateur thousands of miles away on a radio made from a few still obtainable discrete components and a length of wire to a tree in the garden.

I am not going to pay £200 for a digital radio. In my ignorance I suspect that all these will be is a front end digital-to-analogue converter which I can make for very little. So I would be obliged if *EPE* would publish a circuit for a digital radio. Thank you!

Peter McBeath,  
Morpeth, Northumberland

*Frankly, at present we believe that it would not be possible to build a digital radio from conventional components any more cheaply than using the specialist chips designed for the purpose. However, whilst the cost of such chips remains high, with the current emphasis on digital broadcasting in general, it seems likely that the cost should eventually plummet. It would then be more realistic to ask regular contributors or other readers to offer us a circuit for possible publication.*

*However, if anyone knows of any low-cost devices already on the market, tell us!*

### B.A.E.C. SAVES MONEY!

Herbert Howard of the British Amateur Electronics Club also responded to Harold Chamberlain's letter in *Readout* September '98. To cut short a rather lengthy story, Herbert contacted Harold and told him that by joining the B.A.E.C. he could avoid high postage charges, and in doing so easily save his subscription to the Club. Harold has joined!

So could you - contact J. F. Davies, Secretary B.A.E.C., 70 Ash Road, Cuddington, Northwich, Cheshire CW8 2PB.

## COMPUTER FREE ZONE?

Dear EPE,

I have taken *PE/EE* for 25 years, but feel that you place too much emphasis on computers. If I wanted a computer magazine I would buy one quite specifically. The fact is that not only can I not find stand-alone projects of a non-computer or PIC nature in *EPE*, but cannot find this at all in any electronics magazine.

I have nothing against computers in general and use them at work for teaching purposes, to help people with learning difficulties. The fact stands, though, that I do not have a computer at home and am sure that the same applies to many readers. Surely there is room for a magazine which avoids them? If you force-feed any creature on even the best food, it will lack the nutrients contained in all the other foods.

Every sincerity intended.

**Adrian Hoare,  
Morpeth, Northumberland**

*The above is a precis of the comments made in two letters from Adrian, to whom Editor Mike replied directly.*

*In a nutshell, computer related articles are amongst the most popular projects in recent years.*

*We do publish a great many non-computer projects, as a browse through the Annual Index in this issue will prove. We are an "electronics" magazine and we try to cover all aspects of electronics - a field which very heavily includes computers as well as the more "conventional" circuit applications, which are too numerous to itemise.*

*However, we listen to what readers tell us and, as always, want you all to keep us informed of your likes and dislikes. Adrian, your comments are taken in the good faith in which they were intended.*

## PASCAL?

Dear EPE,

Having read *EPE* for a couple of years, I wish to thank you for the help that you give me in increasing my interest and knowledge in this hobby. My favourite parts are *Ingenuity Unlimited*, *New Technology Update* and *Interface*.

A subject I would like to raise is that of the main programming language you use. Since I am quite familiar with other languages (I am in my third year in the BSc IT course, specialising in Computer and Communications Engineering), I find BASIC an old-fashioned and inefficient programming language due to the fact that it is interpreted rather than compiled.

My suggestion is to move to a higher programming language, proposing PASCAL. This is an easy to use language with a readable syntax. It is also compiled and results in much faster code, and PASCAL units are readily available to be used.

**Joseph A. Zammit,  
Balzan, Malta**

*In fact, a number of programming languages are used in our projects from time to time: three variants of BASIC (GW-BASIC, Quick-BASIC and QBASIC), various forms of C (occasionally), assembler for 8051 and family, assembler for 8086 and family, and, of course, assemblers TASM and MPASM for PICs. So far as we recall, we have never been offered software written in PASCAL, and somehow doubt that many readers are actually familiar with it. Nor have I ever had working experience of it. Nonetheless, we would be interested to know what other readers feel about PASCAL - and I'll extend the question to include opinions on C and its variants.*

*Also, how many of you have access to Visual Basic? Is it something that we should include in our repertoire? I bought it a while back, but have not yet delved into it. If enough of you know how to use VB and would like projects written for it, it would give me (and others, perhaps) an incentive to become familiar with it.*

*Give us answers please!*

## MAINS SAFETY

Dear EPE,

Two aspects of the *Mains Socket Tester* (Sept '98) concern me.

The first is the fact that there is no protection for this mains operated device. If there were a fault within the tester it would rely on the fuse or circuit breaker at the consumer unit to operate. This would be at least 30 amps rating and would result in considerable damage to the tester at a time when it was being plugged in, with consequent risk of injury to the operator.

A possible solution to this would be to build the device in a separate case and connect it with a short length of cable and a 13A plug-top fitted with a 1A fuse. Alternatively, consider using 5A fuse-wire (in a PVC sleeve) to connect between the plug connection and the circuit board.

My second concern is misleading indication of satisfactory earthing. Whilst the device will give correct indication for a good Earth or no Earth, it will give false re-assurance for a poor Earth. If the resistance of the Earth conductor is 1000 ohms, say, the device will still indicate a good Earth although such an Earth is of little use as any fault current will be insufficient to operate the circuit fuse.

The solution is to connect a resistor of, say, 22 kilohms 3 watts between Live and Earth. This will check the integrity of the Earth conductor by passing a small current to Earth during the test. This current will allow the tester to indicate correctly but should be low enough to not operate any Earth leakage protection.

**John Fenton,  
Garstang, Lancs**

*We referred this letter to Bart Trepak, the author, who replied:*

I have used an identical mains dropper circuit on many occasions in the past, including on circuits which are and have been permanently connected to the mains, and have never yet experienced any fault of the nature you describe.

This is, of course, not proof that such a fault could not occur and the obvious one is of the capacitor breaking down. The capacitor specified is designed and rated for such applications and a fault of this type is, therefore, unlikely. However, if it should occur, the capacitor is designed in such a way that the metalisation on the dielectric around the point where the breakdown has occurred will vaporise, thus restoring the integrity of the capacitor.

This self-healing characteristic is common to all capacitors rated for direct connection across the mains and would occur in a time much shorter than it would take a normal fuse to blow. Even if this were not the case, resistor R1 would not last very long (being rated at only 0.25W) and would fail open circuit, therefore acting as a fuse.

In general, any circuit can always be improved by considering what would happen if this or that component failed and fitting protection components, but in the end the designer has to consider what is the likelihood of such a failure.

There is, of course, nothing wrong with a "belt and braces" policy especially where mains voltages are concerned and those who feel that a "piece of string" is also called for can add a fused plug as you suggest, but my experience is that unless a high speed fuse is fitted, the circuit, if it is to fail, will fail with the components blowing first and protecting the fuse.

Your suggested modification for indicating a poor earth is interesting and although I have not tried it, this would no doubt be a useful additional feature. It should, however, be remembered that the circuit is not intended to provide a comprehensive test of the mains supply but simply to indicate that the correct connections had been made. As mentioned in the article, the circuit would not reveal an error in confusing the Neutral and Earth but this, like a high resistance Earth (as opposed to a disconnected Earth), is a much more unlikely fault.

**Bart Trepak**

## L OF A PROBLEM

Dear EPE,

I have a problem with the *Single or Dual Tracking PSU* of April '98.

The trouble is with the tracking part of the circuit and I find that all the voltage is across the positive side (8.7V) and only 1.2V/1.3V across the negative side when the output is set to 10V on Single. Varying the voltage via VR1, I still obtain the same 1.2V/1.3V across the negative side, with all the other voltage dropped across the positive side.

What might be the cause of the problem?

**Mark Sammons,  
Alvaston, Derby**

*The above is an extract from a much lengthier letter from Mark in which he quoted all sorts of other voltage readings as well.*

*It seemed to us that the problem lay with the TR3/TR5 path and that the voltage across them was the sum of their base-emitter drop voltages (the said 1.2V/1.3V), suggesting that TR3 was incorrectly inserted.*

*Speaking to Mark by phone, he assured us that TR3 was inserted correctly according to the published layout diagram. Puzzlement at our end! Then the penny dropped - was the correct version of TR3 being used? The specified device is a BC212L (note the L suffix). It transpired that Mark had inadvertently purchased the ordinary BC212 (without the L suffix).*

*Unfortunately, the two versions have different pinouts and although physically Mark had his transistor aligned as published, the pins were electrically in the wrong order. Problem detected and cured - reorientating the BC212 so that its pins were in the correct holes; not too much contortion!*

*The moral of the story is that identically numbered transistors having an L suffix cannot be used in place of those without, unless they have their legs reorientated. A better solution, of course, is to ensure that you buy the L version when it is called for.*

*Whereas some transistors, such as the BC108 for example, are available with suffixes of A, B, C or none at all and all have the same pinout notation, those having L versions available do not.*

*In the former case, the suffix indicates the transistor's gain range, with the latter it indicates the pinout variant. Beware!*

## STATESIDE OK

Dear EPE,

Recently I became a subscriber to *EPE* after several years of spotty newsstand service (and many requests for back issues). Over the course of those years, I have also subscribed to several other electronics-related periodicals, both in the UK and here in the USA, and have concluded that yours is the best overall enthusiast/education publication.

I part-time teach/assist at a local technical college and a local radio/electronics club. Other teachers, students and enthusiasts to whom I have shown your magazine seem to agree with this conclusion. I suspect this is in part due to your apparent close ties to various educational institutions.

Your constructional projects (even the more advanced ones) seem to yield a high rate of success upon completion, even by complete novices. I believe this is a result of a level of diligence/thoroughness-of-detail not exercised by similar publications. I find the level of your tutorial material (*Teach-In* plus *Lab Work*) to be exceptional, and the *PIC Tutorial* series is fantastic - best I've ever seen!

**Bob Schoonmaker,  
Woodside, New York,  
via the Net**

*Thanks for your appreciative comments and your suggestions. We are all convinced of the necessity to encourage education in electronics and to try to explain things in detail suited to various levels of reader experience.*

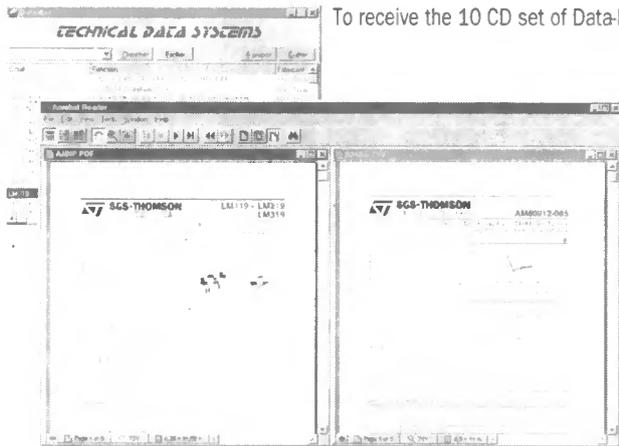
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## DID YOU MISS THESE?

### JULY '97

**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.

### OCT '97

**PROJECTS** ● PIC Water Descaler ● Remote Control Finder ● Multi-Station Quiz Monitor ● Rechargeable Handlamp.  
**FEATURES** ● Ingenuity Unlimited ● It's Probably Murphy's Law ● Interface ● Circuit Surgery ● Kanda PIC Explorer Review ● Network

### NOV '97

**PROJECTS** ● Portable 12V PSU/Charger ● Case Alarm ● Auto-Dim Bedlight ● *EPE* Time Machine.  
**FEATURES** ● Satellite Celebration ● Ingenuity Unlimited ● TEACH-IN '98 – An Introduction to Digital Electronics-1 ● Techniques – Actually Doing It ● Circuit Surgery ● Net Work ● Free Greenwell Catalogue.

### DEC '97

**PROJECTS** ● Safe and Sound – Security Bleeper ● Active Microphone ● Car Immobiliser ● Mini Organ.  
**FEATURES** ● TEACH-IN '98 – An Introduction to Digital Electronics-2 ● Circuit Surgery ● Interface ● B<sup>2</sup> Spice Review ● Ingenuity Unlimited ● Alternative and Future Technologies-1 ● Net Work – The Internet ● Free Giant Data Chart – Formulae.

### JAN '98

**PROJECTS** ● Disco Lights Flasher ● Simple M.W. Radio ● EPE Virtual Scope-1 ● Surface Thermometer.  
**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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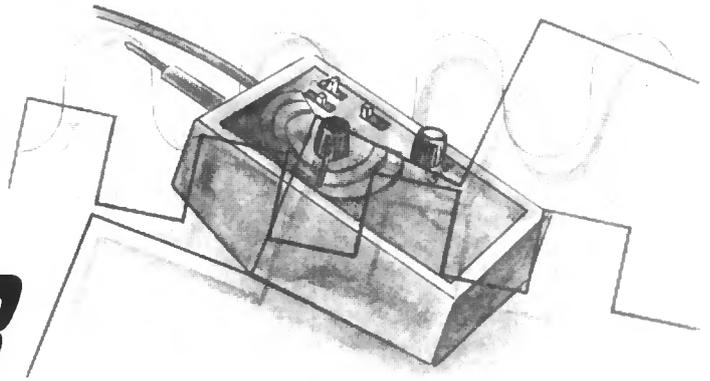
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M12/98

# HANDHELD FUNCTION GENERATOR

BRIAN ADKINSON



*A truly pocket-sized instrument, with three switched ranges covering 50Hz to 20kHz.*

IN DESIGNING this little project the aim was to build a hand-held audio generator with a few more features than those normally found on the simple "probe" type designs. Injectors of this sort generally fall into one of two main categories.

On the one hand there is the very basic square wave type. In its discrete form it usually consists of little more than a multi-vibrator using a couple of transistors, the output being taken from the collector of one of them.

The frequency might be a nominal 1kHz or so. Often there is no control over the output level and this might be anything up to 9V peak-to-peak depending on the batteries used.

## IN COMPARISON

Apart from a few specialised tests requiring a square wave the shortcomings of this type of injector are many. The square wave contains harmonics – lots of them. These are fine if you also want to use the injector to pump a signal through an r.f. stage working at 50MHz! But for audio circuit testing they can be a distinct disadvantage, causing crosstalk and breakthrough between stages.

Using one of these injectors, while fault-finding in the pre-amp stages of an amplifier, the author actually managed to get a weak but audible output from the speaker, only to find that the power to the amplifier was turned off! Confusing indeed!

Finally, a square wave source cannot be used in tests for distortion. Using a square wave signal source when trying to trace distortion, such as "clipping", is completely mind bogglingly difficult if not practically impossible.

The second type of injector is a little more elegant, producing a sine wave output instead with, perhaps, the added refinement of an output attenuator. To keep things simple the frequency is again usually fixed at (say) 1kHz.

The sine wave might be derived from a Wien bridge, twin-T or phase-shift oscillator. Carefully designed all are capable of giving a low distortion output which is really better than that needed for a simple probe type injector.

## FUNCTIONAL DESIGN

It was decided early on in the development of the Handheld Function Generator that it should provide a reasonable quality sine, triangle and square wave output with continuous coverage over most of the audio range. Also included is a switched and variable output attenuator.

To further increase its versatility the output is via a small audio "power" type i.e. With the output level set at maximum this allows the unit to drive low impedance loads, such as loudspeakers, directly.

This could prove useful when testing speaker wiring etc. in home and car audio systems. The power available is only a few tens of milliwatts but by selecting the square wave output, and adjusting the generator to a suitable frequency, a surprisingly loud output can be obtained.

Finally, additional fixed outputs are available from the sine, square and triangle signals. One or more of these could be connected to the circuit under test as well as say, an oscilloscope, a.c. millivoltmeter or frequency counter. In fact, where an

## Specification

**Useable Frequency Range:** From below 50Hz to over 20kHz, in three overlapping ranges

**Output Waveforms:** (Output levels measured with fresh batteries fitted)

**Variable** – Sine and Square wave. 0-300mV and 0-3V pk-pk

**Fixed** – Sine and Square at nominal 500mV pk-pk

**Triangle** at nominal 1.5V pk-pk

**Sine wave Distortion:** Better than 5 per cent

**Power Source:** 3V (2 x N-cells)

**Power Consumption:** 5mA quiescent, rising to around 50mA at full output into an 8 ohm load

Full size Function Generator fits easily in the palm of the hand.

accurate output level or frequency is important, connection to one of these will be a necessity.

Although the Handheld Function Generator is fairly comprehensive in its features – see Specification panel – it must be stressed that it has not been possible to miraculously squeeze the quality and features of a “full-blown” instrument into such a tiny case. There are, of course, a number of trade-offs; for example the output amplitude, and to a lesser extent, frequency are dependent on supply voltage.

With only 3V available a regulated supply was considered impractical. Also, the distortion level of the sine wave is somewhat higher than that of a “professional” generator. Even so, the unit should still find use in a number of applications where moderate distortion is of little consequence, such as in frequency response and gain measurements in amplifiers, filters etc. and in general purpose fault finding.

The additional fixed outputs and neat design of the case allow it to work as a quite useable bench instrument as well. The generator is powered by two inexpensive N-cells which will give many hours of service under normal use.

## HOW IT WORKS

The main signal generator section is a Schmitt oscillator. This is a fairly simple circuit and one in which the frequency can be altered quite easily. The Schmitt oscillator is an adaptation of the more familiar Schmitt trigger circuit, see Fig.1.

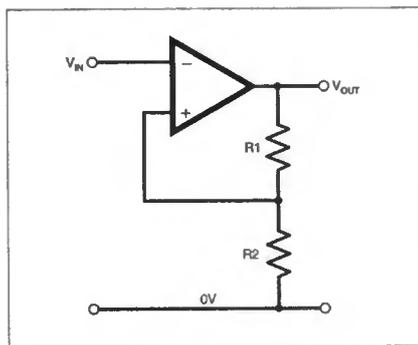


Fig.1. Schmitt trigger circuit.

In the Schmitt trigger a signal of slowly varying amplitude is converted or “cleaned up” into one with a predictable output amplitude. Signal levels below the set upper and lower trigger points are ignored. When configured using an op.amp the upper and lower trigger threshold points are set by resistors R1 and R2.

The basic circuit exhibits a large degree of hysteresis or “backlash” which considerably improves noise immunity. The upper and lower trigger points are affected, to a degree, by the supply voltage and this would, ideally, be stabilized.

An inverting Schmitt trigger can be converted to a Schmitt oscillator by connecting a resistor, R3, from the output back to the inverting input, and a capacitor C from this point to ground (0V), as shown in Fig.2. The resulting output is a high quality square wave with, additionally at the inverting input, a “triangular” wave.

The ramp of the triangle waveform is actually exponential in shape and is produced by the charge and discharge of capacitor C through resistor R3 as the output switches alternately between  $-V_{cc}$  and  $+V_{cc}$ .

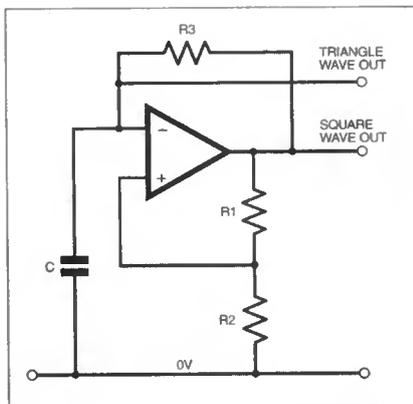


Fig.2. Circuit arrangement for producing a Schmitt oscillator.

Assuming resistors R1 and R2 are the same value, say 5k $\Omega$ , then the period or frequency is set by the values of R3 and C.

Frequency will then equal:

$$\frac{1}{2.2 \times C \times R3} \text{ Hz}$$

Again, assuming R1 and R2 are the same value, then the amplitude of the triangular wave will be roughly two thirds of the difference between  $-V_{cc}$  and  $+V_{cc}$ .

## CLIPPING

In the Handheld Function Generator it is the triangular wave that is used as the basis for the sine wave and for this reason a fairly linear ramp is needed in order to minimise distortion. If resistors R1 and R2 are given suitable values the trigger level of the oscillator can be adjusted to produce a triangle wave of smaller amplitude. This means that a smaller and hence more linear part of the exponential curve can be used, with a resultant output nearer to a true triangle.

The sine wave itself is produced through the simple but rather crude technique of “clipping” the triangle waveform to produce a more sinusoidal shape. In practice this is done by feeding the triangle waveform into a pair of signal diodes connected in inverse parallel, the non-linear conduction characteristics of the diodes progressively modifying the applied waveform.

## CIRCUIT DESCRIPTION

The full circuit diagram for the Handheld Function Generator is shown in Fig.3. Resistors R1 and R2 form a potential divider to generate the 0V rail, necessary for the correct operation of IC1. IC1a and its associated components perform the function of a Schmitt oscillator.

Capacitors C3, C4 and C5 set the three frequency ranges A, B, and C. The coverage of these is approximately: 45Hz to 400Hz; 350Hz to 4kHz and 3.5kHz to 20kHz respectively.

The upper limit on each range is partially limited to that which can be comfortably resolved, bearing in mind the small size of the scale and control knob. Also, the scale is non-linear and becomes more cramped towards the high frequency end.

On the prototype, the actual upper frequency limit reached on Range C was 33kHz. The exact coverage of each range will depend upon the tolerances of the individual capacitors used.

The frequency on each range is set by control VR1, with resistor R3 acting as an end stop limiter. This resistor prevents stalling of the oscillator and excessive distortion when VR1 is set to minimum resistance. The output on Range C tends to be slightly higher than the others so resistor R7 and capacitor C6 are switched in to correct this.

Overall, the output amplitude remains substantially flat from 40Hz to 15kHz with a linear roll-off beyond this point. If an accurate level is needed, for say frequency response tests, then it would be prudent to connect an A.C. Millivoltmeter or Oscilloscope to the SK2 output.

## COMPONENTS

### Resistors

R1, R2,	
R10	4k7 (3 off)
R3, R14	3k3 (2 off)
R4	68k
R5, R8,	
R13, R16	10k (4 off)
R6	2k2
R7	100k
R9	15k
R11, R12	150k (2 off)
R15	680 $\Omega$
R17	10 $\Omega$
R18	1k

All 1/8W 5% carbon film

### Potentiometers

VR1	100k horizontal modular carbon control (see text)
VR2	1k vertical modular carbon control (see text)

### Capacitors

C1, C2	220 $\mu$ sub-min. radial elect. 6.3V, 5mm lead spacing, 7mm high (2 off)
C3	330n polyester layer
C4	33n polyester layer
C5	2n2 polyester layer
C6	330p plate ceramic
C7	470n polyester layer
C8	100n polyester layer
C9	100p plate ceramic
C10	non-polarised (see text for value)

### Semiconductors

D1, D2	1N4148 signal diode (2 off)
D3	3mm red flashing I.e.d. (see text)
IC1	7621DCPA CMOS op.amp
IC2	TDA7052 low-voltage power amp

### Miscellaneous

S1, S3	3-way double-pole sub-min., p.c.b. mounting, slide switch (2 off)
S2	2-way single-pole sub-min., p.c.b. mounting, slide switch
SK1, SK2	3.5mm stereo screened chassis jack socket (2 off)
B1	1.5V N-cell (2 off)

Printed circuit board available from EPE PCB Service, code 213; miniature sloping-front case, size 77mm x 44mm x 28mm (max); probe tip; N-cell p.c.b. battery clips (2 sets); dual-gang shaft for VR1 and VR2 (2 off); miniature crocodile clip; multistrand connecting wire; solder etc.

Approx Cost  
Guidance Only

**£21**  
excluding batt.

As well as providing a small amount of gain, IC1b buffers the triangle output at pin 2 of IC1a. This gain is needed as the triangle wave produced is of insufficient amplitude to correctly drive the triangle to sine wave converter diodes D1 and D2. These diodes need at least 600mV to conduct, although in practice they will begin to conduct at below 500mV. The high value given to resistor R11 was found to give the best shape to the sine wave.

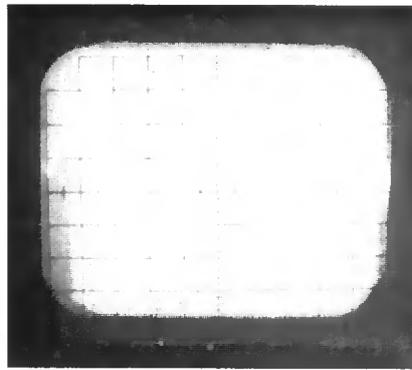
Capacitor C8 isolates the two diodes from any d.c. offsets present at the output of IC1b or input of IC2. Anything more than a few hundred millivolts will cause a d.c. bias to be applied to one of the diodes with resultant non-symmetrical clipping. Capacitor C7 prevents any d.c. offset reaching the input (pin 2) of IC2. (IC2 input is referenced to the negative line (-V) not 0V).

Resistors R12 and R13 form a potential divider to reduce the input level into IC2 to a suitable value. The actual level arrived at is designed to cause a very "soft" clipping action in IC2 which improves the sine wave shape slightly. This clipping action increases marginally as the battery voltage falls, but is partially offset by the reduced input level to IC2.

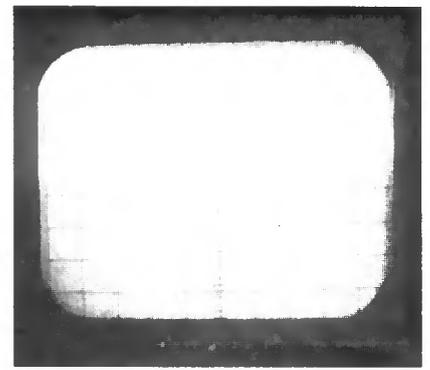
The square wave output is produced when switch S2 is closed. This connects resistor R10 in parallel with resistors R11 and R12 and causes IC2 to be driven hard into clipping. Earlier attempts at making use of the square wave available on pin 3 of IC1a yielded no better results than the simple method finally adopted.

## OUTPUT

A bridge form of output stage is used by IC2 to generate relatively high power levels at low supply voltages. The bridge



A 1kHz triangle waveform taken at IC1b pin 7.



A 1kHz sinewave output taken from IC2 pin 8.

configuration gives a negligible d.c. offset across the output (pins 5 and 8) and in normal applications a coupling capacitor is not needed.

However, for a signal generator an output coupling capacitor is necessary as it isolates the output from any d.c. that might be present in the equipment under test. Also, a capacitor here protects the equipment under test from the earth return path via resistor R17 and control VR2. Note that the output pins of IC2 are effectively "floating" and neither should be earthed to the -V rail.

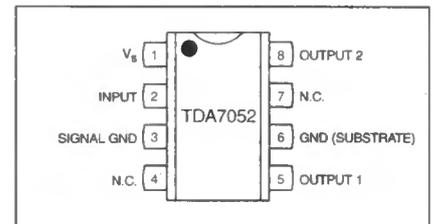
Resistor R17 merely limits the available output power, in the event of a short circuit across the probe tip, with the attenuator switched out (S1b closed) and VR2 set to maximum. Resistors R14 and R15 form the potential divider for the fixed 500mV output to socket SK1.

To conserve battery life a Power On I.e.d. (D3) is included as a reminder that the unit is switched on. In the prototype a high brightness flashing I.e.d. was used, the only type the author has any chance of noticing!

## COMPONENTS

It is important to use only the specified components for this project. The general performance, and in particular the sine wave purity, will be adversely affected if different resistor values are substituted for any of those around IC1a and IC1b or R11, R12.

Some alternative components may simply not fit on the board. In particular the electrolytics C1, C2 which must be no more than about 7mm in diameter.



Pinouts for the TDA7052.

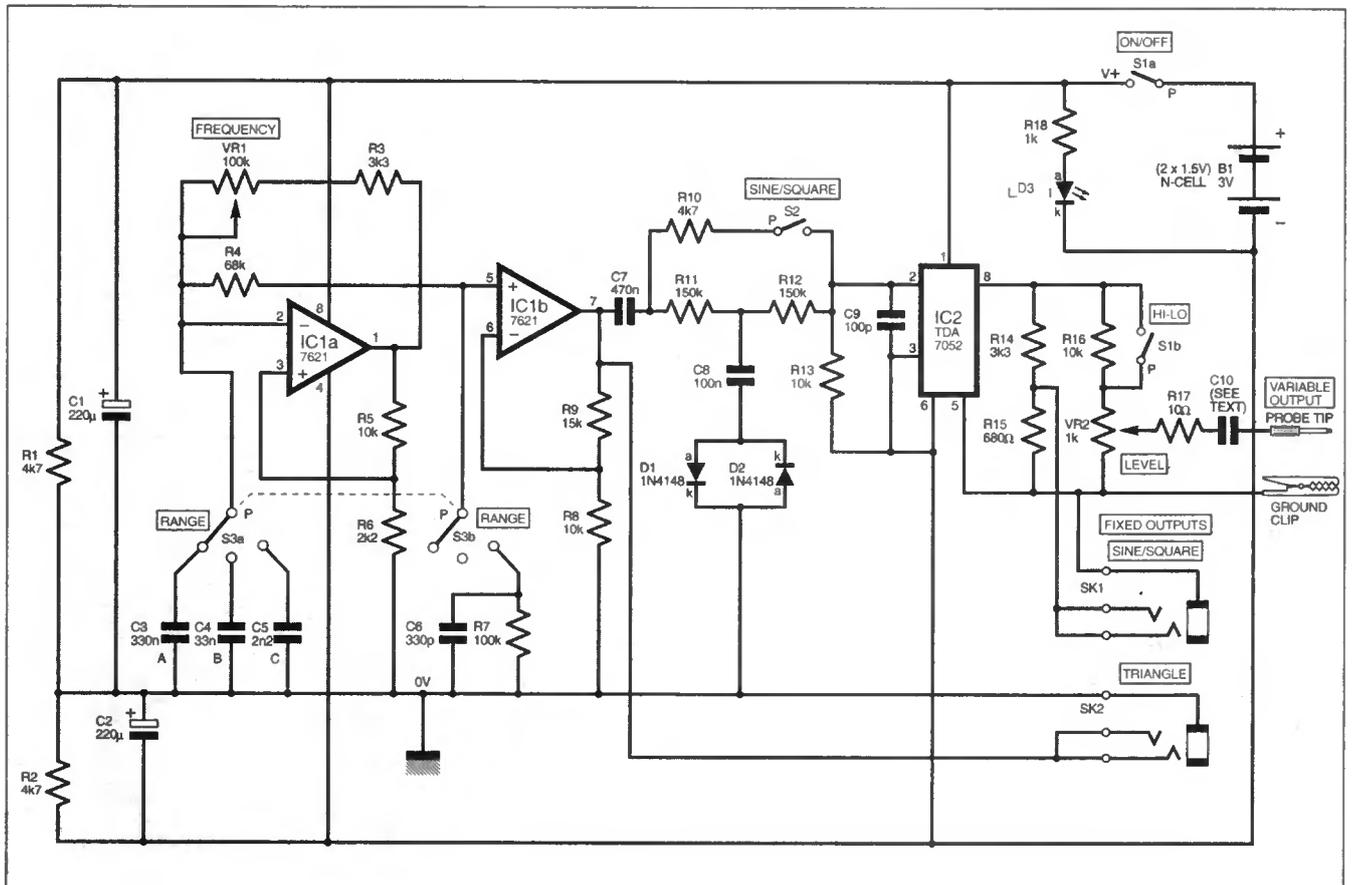


Fig.3. Complete circuit diagram for the Handheld Function Generator.

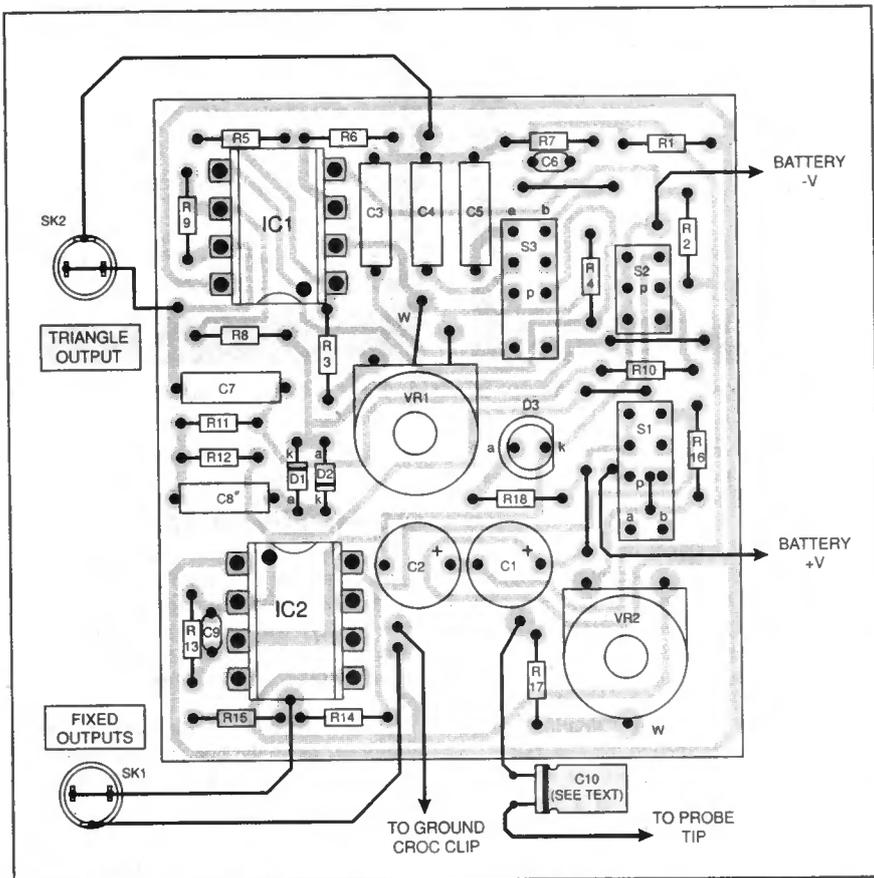


Fig. 4. Twice-size printed circuit board topside component layout, together with interwiring connecting leads. Connections to SK1 and SK2 should be made from the back of the p.c.b. or the board can be drilled in an unpopulated area and the wires passed through the holes. The final size copper foil master pattern is shown top-right.

Only use the specified op.amp (a 7621) in IC1 position. Although some are quoted as working at a 3V supply they either work poorly or not at all below 3V. (Which must be allowed for as the batteries discharge). The spec. on the ICL7621 indicates a minimum supply voltage of  $\pm 1V$ .

There are a number of alternative control shafts available for the controls used for VR1 and VR2. The longer shaft is recommended as it has a serrated section at the end for better grip. Because it is designed to go through two pots, to make a stereo control, it is longer than needed and therefore the excess should be cut off flush with the board.

### OUTPUT CAPACITOR

For normal use the output coupling capacitor C10 should be a non-polarised or bi-polar type. A  $10\mu F$  50V capacitor was fitted in the prototype. This value is more than adequate for feeding the output of the generator into medium to high impedance loads. However, to drive a low impedance load such as a loudspeaker a much higher value, say  $470\mu F$ , would normally be used.

As mentioned in the circuit description, a bridge type output like the one used in IC2 actually needs no coupling capacitor at all. When using the generator to check out speakers and their wiring the effect of a low value capacitor is to greatly reduce the lower frequency output.

However, with the level at maximum and square wave selected, fast edged spikes or pulses are generated. Although these are not a true representation of the output of the generator they are still useful in producing a very loud and distinctive output.

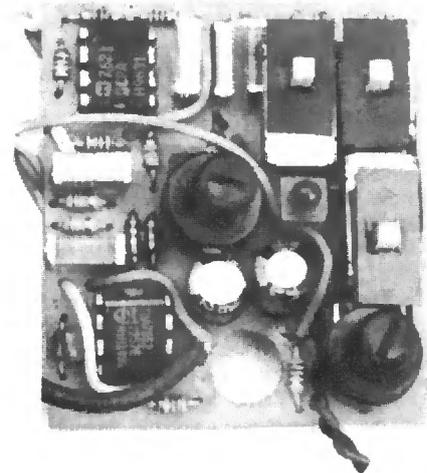
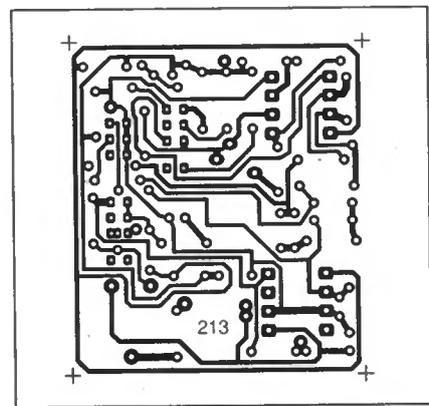
If there is a requirement to use the generator to test low impedance loads without this low frequency limitation then C10 can be shorted out. A separate subminiature s.p.s.t. switch could be fitted in the case opposite the two sockets in order to facilitate this. To avoid possible damage to IC2 or the equipment under test, it would be important to remember to return this switch to its "normal" position before using the function generator for general test work.

### CONSTRUCTION

Due to its compactness, great care will be needed when building the Handheld Function Generator. The positions of switches S1, S2, S3, presets VR1 and VR2 require accurate placing on the printed circuit board in order to line up correctly with the front panel holes and cut outs.

All the components except capacitor C10 and the two output sockets SK1 and SK2 are mounted on one small printed circuit board (p.c.b.) while a separate miniature p.c.b., containing spring contacts, holds the batteries. A twice-size component layout, together with a full size foil master, is shown in Fig. 4. This printed circuit board, including batt. board, is available from the EPE PCB Service, code 213.

The use of a battery board (Fig. 5) was necessary as a double N-cell battery holder could not be made to fit into the case. The outside sections of each battery clip will have to be broken off otherwise they will not fit into the battery compartment. These are quite brittle and by using fine-nosed pliers a single bend at the bottom of the clip should break off each "ear" leaving just the contact.



Component layout on the completed circuit board.

The batteries should still stay in position as they fit fairly tightly in the case but any tendency for them to pop out of the contacts can be reduced by taping them together before insertion in the holder. Before soldering in the four battery contacts the solder lugs should first be bent flush with the circuit board. If this isn't done the case back will not close properly.

### MAKING CONTACT

The slide switches S1, S2, and S3 are raised off the circuit board by connector sockets on each pin. These sockets come

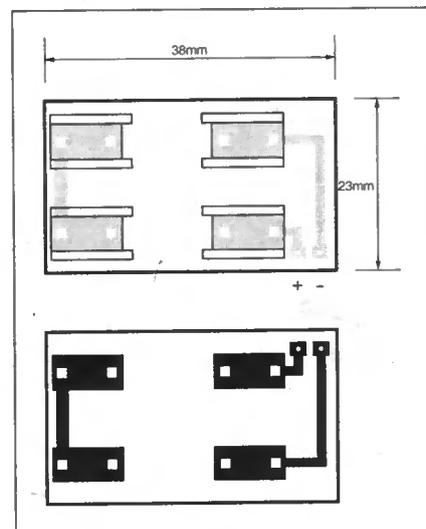


Fig. 5. Suggested battery p.c.b. dimensions and foil master.

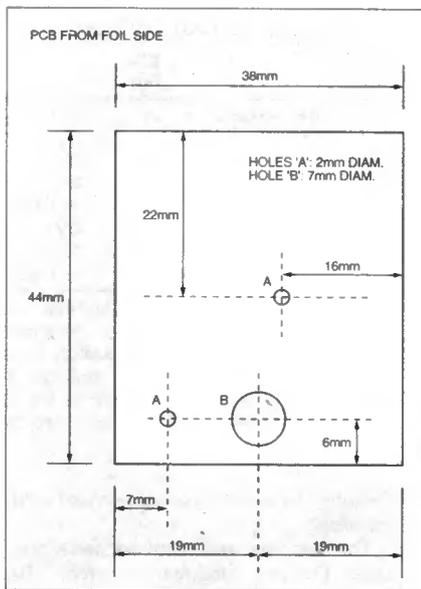


Fig. 7. Circuit board drilling details for the control spindle shafts (A) and the case centre pillar (B).

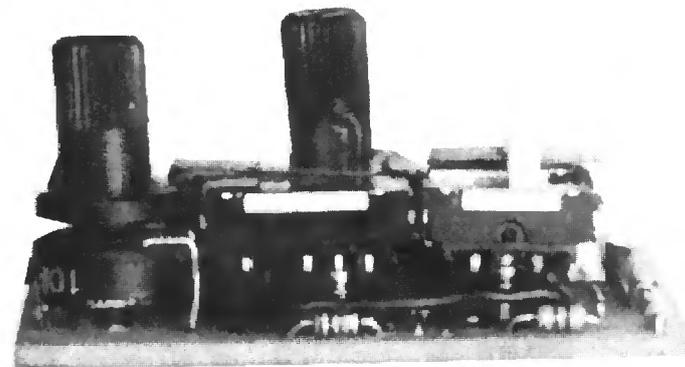
as a 32-way strip, each socket being cut off as required using a sharp knife.

As the sockets have an insulating shroud, the minimum pitch between pins is 2.54mm. The switches, however, have a lead pitch of just 2mm. To overcome this problem the connector socket fitted to the middle of each group of three switch pins needs to have its shroud cut away, as shown in Fig. 6.

Note, that while VR2 is a standard vertical preset VR1 is not listed as a vertical type in the 100k value. (Note that

unusually "horizontal" and "vertical" in this case refer to the control shaft and not the mounting.) Therefore, it is necessary to mount VR1 horizontally (with the shaft vertical), bend the two outer legs to go through the board and then extend the centre wiper pin with a short length of wire before soldering this to the p.c.b.

As some of the wire links and resistors sit under the switches these should be soldered in place first. The lead from the



Side view of the finished p.c.b. showing the switch mounting sockets.

output capacitor C10 and the earth lead can be soldered directly to the printed circuit board, but the four leads to sockets SK1 and SK2 need to pass through the board first. For these suitably sized holes should be drilled through the p.c.b. at convenient points, taking care not to drill through any of the copper tracks! See Fig. 7.

The circuit board needs to be held tightly against the front panel so that it cannot move when the switches are operated. Rubber blocks or similar glued to the rear section of the case can serve this purpose.

### CASE PREPARATION

When making the oblong cutouts for switches S1, S2 and S3, it was found that the easiest way to do this was to first drill two or three small holes (about 2mm), cut between them with a sharp knife to

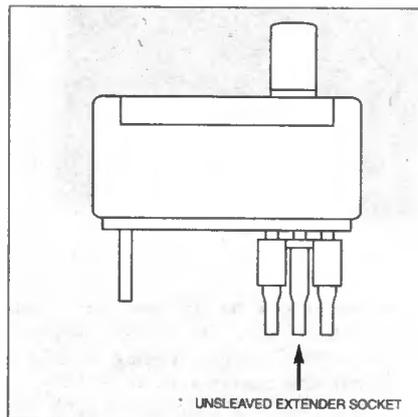


Fig. 6. To cater for the switch pin spacing the centre connector socket has its insulating shroud removed.

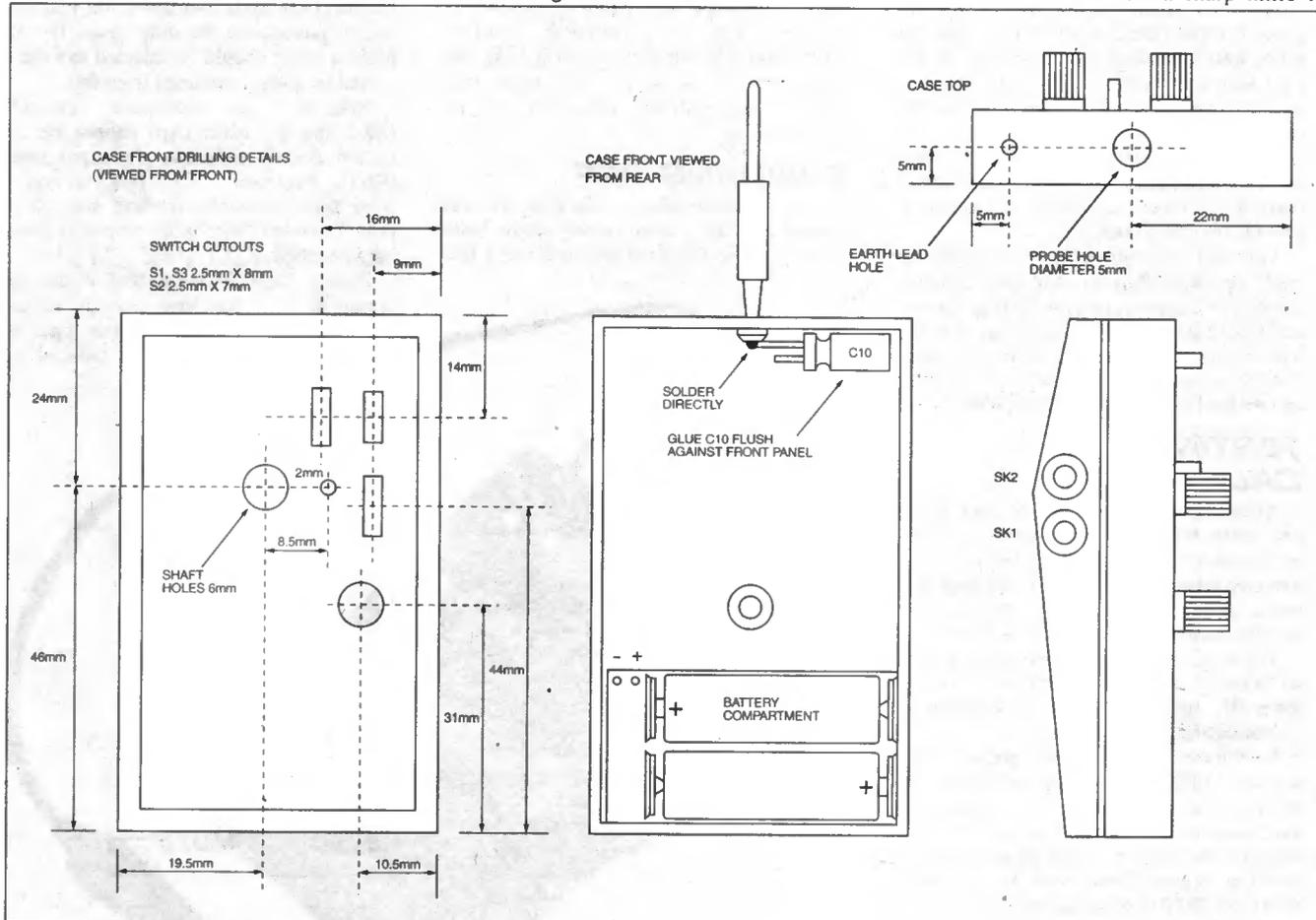
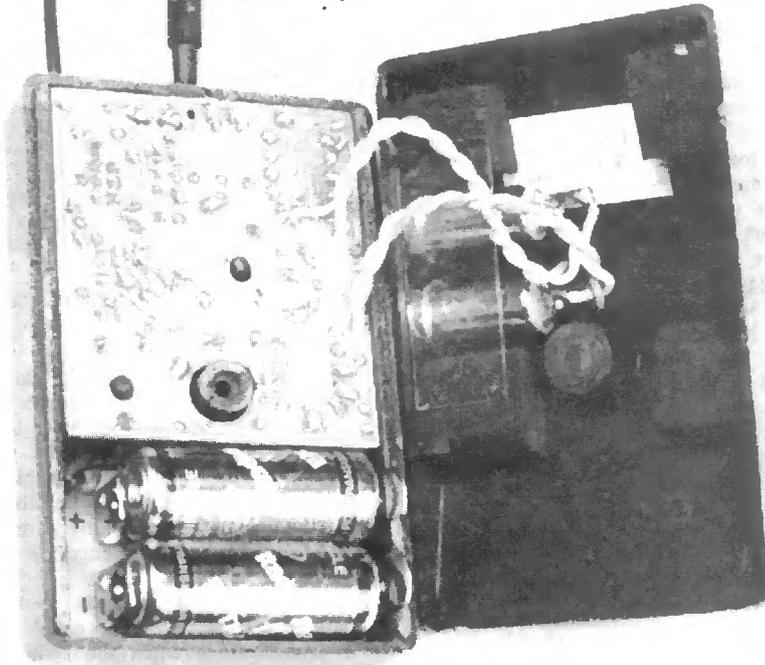


Fig. 8. Case dimensions and drilling details, including top drilling for probe and "croc" lead. The output sockets are positioned in the side wall of the case lower section.

Layout of components inside the completed unit showing wires to the output sockets. Note the plastic strip preventing the p.c.b. tracks from shorting on the screened jack sockets.



make a slot and then insert a flat needle file to enlarge the cutout to the correct shape. The approximate positioning of these cutouts is indicated in Fig.8.

The probe comes in two parts; the tip itself and an insulating cover. Solder a thick piece of solid-core wire to the tip before pushing the cover on. This piece of wire needs to be as stiff as possible to stop the probe from wobbling when in use. Glue the probe into the centre hole in the top of the case then cut the wire off about 1mm or so from the base and solder one end of capacitor C10 to it, see Fig.8.

A pair of 3.5mm stereo sockets is used for SK1 and SK2. The two centre connections on each socket are soldered together to provide two mono outputs.

Various combinations of test leads can be made up depending on individual requirements. For example, two phono plugs at one end would provide an identical signal to the left and right channels of a stereo amplifier. Another possibility could be a phono plug on one lead and crocodile clips on the other.

## TESTING AND CALIBRATION

After checking the board for dry joints and solder bridges, the 3V supply can now be connected. Before doing this a milliammeter wired in series with one lead will prove useful in determining whether there are any drastic problems with the board.

The total quiescent current drain should lie between about 4mA and 6mA. If this reads OK then a check can be made for an output signal.

Switch to Range B, set presets VR1 midway, VR2 to maximum and switch S1 to Hi. Select the square wave output. A loudspeaker or earphone can now be connected to the probe to check for an output; if working properly this will be at about 800Hz to 1000Hz or so and very loud.

If nothing is heard refer to the test voltage Table 1 to aid with troubleshooting. Remember that all voltages relating to IC1

are referenced to 0V (use the "earth" connection from the triangle output for this) while voltages relating to IC2 are referenced to battery negative (-V).

The frequency coverage of each range should agree approximately with the prototype, even allowing for varying tolerances of capacitors C3, C4 and C5. An Oscilloscope or Frequency Counter is the best way to accomplish accurate calibration although even with this the smallness of the scale will mean that only an approximate indication can be obtained.

## FINISHING OFF

The case as supplied is black so this was painted grey using a car primer spray. Each of the three scales were drawn using a fine



Table 1: Test Voltages

IC1 Pin		IC2 Pin	
1	0V ±50mV	1	+3
2	0V ±50mV	2	0V
3	0V ±50mV	3	0V
4	-1.5V	4	N/C
5	0V ±50mV	5	+1.5V
6	0V ±50mV	6	0V
7	0V ±50mV	6	N/C
8	+1.5V	8	+1.5V

Voltages taken with a standard 10 megohm impedance Digital Voltmeter. Supply voltage +3V. Range switch S3 set to range B. Other control settings not important. IC1 readings relative to 0V rail. IC2 readings relative to battery negative (-V).

(0.6mm) permanent marker pen and a circle template.

The lettering and numbers were put on using Letraset rubdown transfers. These worked out rather expensive as the very small lettering used (1.7mm) appears to only be available in large sheets. With a little patience a perfectly acceptable job can be done using just the fine marker pen. These pens can be obtained from Art and Craft suppliers.

The scale pointer is formed from a solid piece of fairly thick wire that is simply pushed into a pre-drilled hole in the knob on preset VR1. Don't forget to set VR1 fully at one end of its travel before drilling the hole, so that it corresponds with the end of the scale.

## IN USE

As the extreme upper limit of each range becomes cramped and distortion increases, due to changes in the duty cycle, the next highest range should be selected and the required frequency obtained from this.

Note that the sine/square "grounds" (SK2 and the earth clip) cannot be connected directly to the triangle output ground (SK1). However, these outputs can be used simultaneously, feeding separate inputs, provided there is no common ground between them.

Finally, bear in mind that if the generator is used for long periods of time driving low impedance loads battery life will be reduced substantially.

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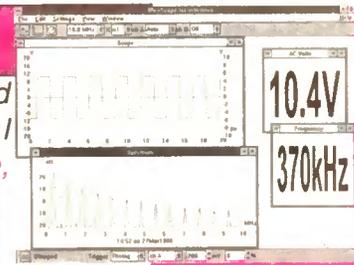


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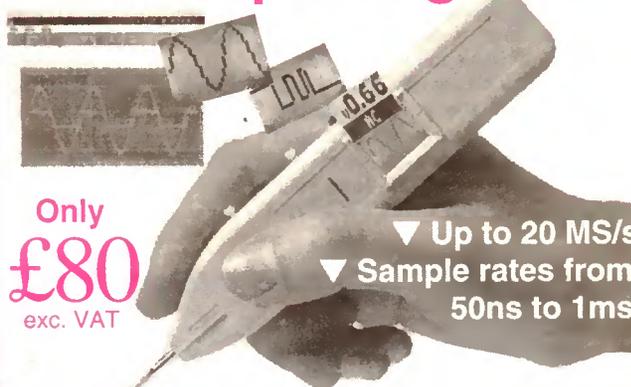
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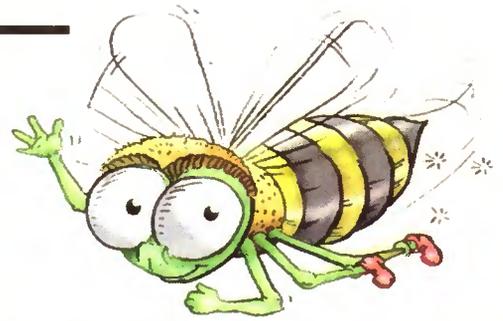
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## PhizzyB COMPUTERS



### Part 2: Simple Input/Output Devices

Clive "Max" Maxfield and Alvin Brown

**W**ELCOME to the second instalment of a really unique and exciting electronics and computing project. This series of articles will be of interest to anyone who wants to know how computers perform their magic, because it uses a unique mix of hardware and software to explain how computers work in a fun and interesting way.

This series doesn't assume any great technical knowledge, although an understanding of fundamental electronic concepts would certainly be an advantage. You do need, though, to have had some experience at assembling components onto a printed circuit board. You should also be moderately familiar with using a PC-compatible computer.

**H**ELLO there! Last month we introduced you to the phantasmagorical and pedagogical PhizzyB Simulator. If you're new in town, *PhizzyB* stands for *Physical Beboputer*, a unique combination of hardware and software which creates a computer tutorial, demonstration and application system.

You can program a "virtual" PhizzyB on-screen by using the PhizzyB Simulator Software running on your Windows 95/98/NT personal computer. Then you can download your program to the real thing, the hardware PhizzyB which connects via a null-modem cable to a serial port on your computer (which must either be COM1 or COM2).

The hardware PhizzyB can then be made to operate in the real world, performing a range of useful tasks using a versatile array of input and output ports.

A demonstration copy of the PhizzyB Simulator was provided on the free CD-ROM accompanying last month's *EPE*. If you missed that great event, all is not lost because you can still order your very own copy – see this month's *Back Issues* page.

Also last month, Alan Winstanley described how to build a real PhizzyB from the ground up. If you're not really into electronics, we have good news – you don't need to be too much! This series is specially written for those who wish to know how computers really work. Essentially, all you need to know is how to solder neatly and recognise components. Alternatively, you can purchase ready-assembled PhizzyBs – see later.

In this issue, Alan explains how to construct two very simple input/output (I/O) devices, which can be used to test the PhizzyB's external I/O ports. For our part, we will be describing a suite of introductory programs that will both exercise these devices and teach you more about how the PhizzyB and PhizzyB Simulator work.

Note that you can perform all of these experiments using only the PhizzyB Simulator, but they're a lot more fun if you have a real PhizzyB to play with as well.

One last point before we start. If you invoke your PhizzyB Simulator and select the **Help** → **Search on Help Contents**

pull-down menu command, you'll discover how to access the *PhizzyB User Manual Volume 1*, which you can peruse on-screen and also print out for your later reading pleasure.

Amongst other things, this document shows you how to use some of the PhizzyB Simulator's tools and utilities, including the Assembler, Memory Walker display and CPU Register display. If you haven't already done so, we strongly recommend you read this manual (it's only about 30 pages long) and perform the experiments therein before plunging head-first into the rest of this article.

#### EXPERIMENT 1A

##### Testing ports \$F010 and \$F030

Use **Start** → **Programs** → **PhizzyB** → **PhizzyB** to invoke the PhizzyB Simulator with the *full version* CD-ROM in your CD drive (or use **Start** → **Programs** → **PhizzyBD** → **PhizzyBD** if you're still playing with the *demo* copy of the simulator).

Remember that the large board at the bottom of the screen represents the main PhizzyB (see Fig.1); however, the large board you can see at the top of the screen represents an expansion card for use in future projects.

Now use the **Tools** → **Assembler** command (or the "building block" icon) in your PhizzyB Simulator to activate the assembler and enter the program shown in Listing 1. You'll also find it handy to check last month's article for a refresh.

It's not necessary to worry about entering spaces to make it look identical to Listing 1, but the commands must be typed accurately as shown. Incidentally, the text after the hash (#) marks is merely to help with understanding.

As you'll see, the first thing we do is to assign labels to the internal input port at address \$F010 (which, you may remember, is the one connected to the 8-bit switch) and the two external input ports at addresses \$F011 and \$F012.

Similarly, we assign labels to the internal output port at address \$F030 (the

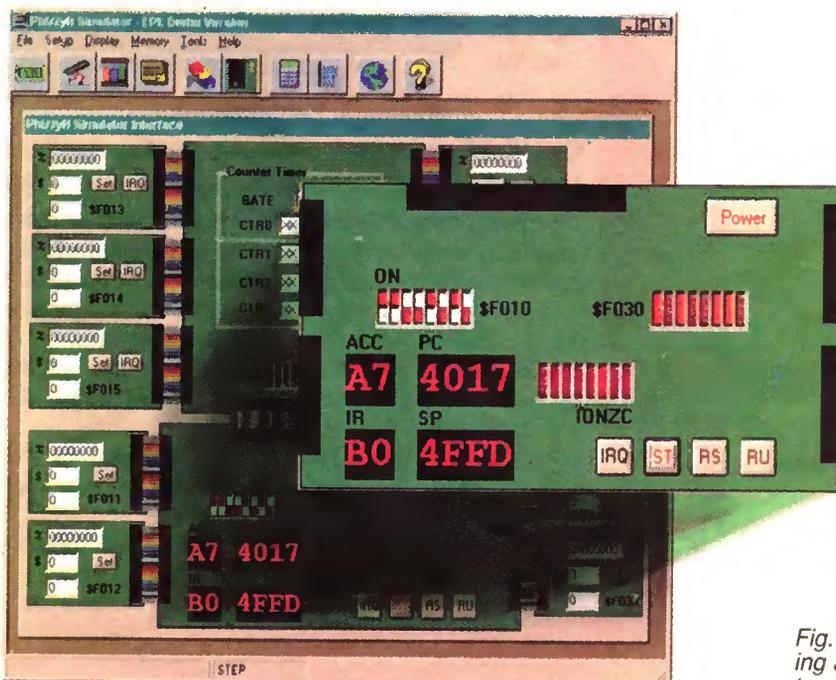


Fig.1. The PhizzyB Simulator interface, representing a real PhizzyB interconnected by ribbon cables to a variety of expansion boards.

one connected to the 8-bit l.e.d. display) and the two external output ports at addresses \$F031 and \$F032. In fact we're only going to use the **INPORT0** and **OUTPORT0** labels in this experiment, but we'll be using the others a little later.

The **.EQU** directive means *equates to* and this assigns the value shown to the corresponding label. (Note that the use of labels and **.EQU** directives is introduced in the *PhizzyB User Manual Volume 1*.)

Following the constant label declarations is the **.ORG** directive, which sets the start address of the program to \$4000 (this is the first location in the PhizzyB's RAM – see last month's article for more details on this).

Next we declare an address label called **LOOP**. We use an **LDA** (*load accumulator*) instruction to load the accumulator from the 8-bit switches connected to input port \$F010, then we use an **STA** (*store accumulator*) instruction to store the contents of the accumulator to the 8-bit l.e.d. display connected to output port \$F030.

Finally we use a **JMP** (*unconditional jump*) instruction to jump back to the label **LOOP**, at which point we start to do everything all over again.

Once you've entered this program, use the assembler's **File -> Save As** command to save this file as **aaexpl.asm**, then use the assembler's **File -> Assemble** command (or click the appropriate toolbar icon) to assemble this program, which will cause the assembler to generate a machine code file called **aaexpl.ram**. You'll hopefully see the message "Your file was assembled without error!" at the bottom of the Assembler/Editor window.

Continue to play with these switches until your appetite is sated, then click the Reset ("Rs") button to let the simulator take a rest.

## EXPERIMENT 1B

### Using the real PhizzyB

In order to perform this experiment, you must already have the fully constructed hardware PhizzyB. Also, you need to be in possession of a full version of the PhizzyB Simulator on CD, because the demo copy does not contain the PBLink utility required to download programs to the real PhizzyB (you can purchase a full-blown PhizzyB Simulator from *EPE* as detailed later).

If you don't have a real PhizzyB, you can proceed directly to Experiment 2 (although it probably wouldn't cause you irreparable damage to read this anyway).

But before we start, if you invoke your PhizzyB Simulator and use the **Help -> Search on Help Contents** command, you'll discover how to access the *PhizzyB User Manual Volume 2*. Amongst other things, this document describes how to install the PhizzyB hardware and configure and use the PBLink software.

If you haven't already done so, we strongly recommend that you read this manual (it's only about 20 pages long) and perform the experiments therein before hurling yourself into the rest of this experiment.

OK, before you do anything else, be sure to use a null-modem cable to connect your PhizzyB to either the COM1 or COM2 port on the back of your PC (see this month's *Circuit Surgery* for more details on null-modem cables).

**Run** command (or click the appropriate toolbar icon) to achieve the same effect. Hence you can control the PhizzyB from your computer keyboard, or by using the corresponding switches on the circuit board.

As with the simulator, nothing seems to be happening initially, but once again the program is furiously racing around and around reading from the 8-bit switches and writing to the 8-bit l.e.d. display. Try flipping one or more of the 8-bit switches (on the real PhizzyB of course) and observe the corresponding bits respond on the 8-bit l.e.d. display (note that the real PhizzyB actually has a 10-bit l.e.d. display, but only the right-hand eight-bits are used).

Once your flipping frenzy has run its course, you can either press the Reset ("Rs") button on the real PhizzyB, or you can use the PBLink utility's **Control -> Reset** command (or click the appropriate toolbar icon) to achieve the same effect.

## EXPERIMENT 2

### Testing input port \$F011

Restore the assembler to its normal size (if you previously closed the assembler then activate it again and use it to open file **aaexpl.asm**), then use its **File -> Save As** command to save your program under the new name of **aaexp2.asm** (thereby creating a duplicate of the program).

All we're going to do in this experiment is to modify the **LDA** instruction such that it now reads from **INPORT1** (the input port at address \$F011):

**LOOP: LDA [INPORT1]**

Now use the assembler's **File -> Assemble** command to assemble this new program, followed by the simulator's **Memory -> Load RAM** command to load the resulting **aaexp2.ram** machine code file into the simulator's memory, then click the simulator's **Run** button to execute this new program.

Try clicking the PhizzyB Simulator's 8-bit switches. Not surprisingly, nothing happens, because our new program is no longer reading from this input port. Instead, the program is now reading from the *external port* at address \$F011.

If you look at the simulator's interface, you'll see a representation of a small circuit board at address \$F011 (Fig.2). This is a generic device that we can use to represent almost anything we might wish to connect to this port (we'll discuss this aspect of things in more detail in future articles).

Note that this generic input device has three fields. The top-most field is prefixed by a "%" character, which is used to indicate that this field represents a binary value. The middle field is prefixed by a "\$" character, which indicates a hexadecimal value. The bottom field doesn't have a prefix, which means this field represents a standard decimal value.

Use your mouse to select the top field, enter a binary value of 00110101, and click the board's **Set** button. The act of clicking the **Set** button formally presents the new value to the input port, at which point our program can see it and light the corresponding l.e.d.s on the 8-bit display.

### Listing 1

```

INPORT0: .EQU $F010    #Assign a label to input port $F010
INPORT1: .EQU $F011    #Assign a label to input port $F011
INPORT2: .EQU $F012    #Assign a label to input port $F012
OUTPORT0: .EQU $F030   #Assign a label to output port $F030
OUTPORT1: .EQU $F031   #Assign a label to output port $F031
OUTPORT2: .EQU $F032   #Assign a label to output port $F032

        .ORG $4000     #Set start address to $4000
LOOP:   LDA [INPORT0]  #Load accumulator from input port
        STA [OUTPORT0] #Store accumulator to output port
        JMP [LOOP]     #Jump to label LOOP and do it again
        .END

```

Minimise the assembler to get it out of the way, then click the **Power** button on the PhizzyB Simulator interface to power-up the simulator. Use the simulator's **Memory -> Load RAM** command to invoke a dialog offering a list of the programs that are currently available. You'll see the new **aaexpl.ram** file in the scrolling list on the left-hand side of the display, so double-click this entry to add it to the right-hand list.

Now click the dialog's **Load** button to load the contents of **aaexpl.ram** into the simulator's memory, then click the simulator's **Run** ("Ru") button to execute the program.

Initially, nothing seems to be happening, but in fact the program is furiously racing around and around reading from the 8-bit switches and writing to the 8-bit l.e.d. display. Click one of the 8-bit switches and note the corresponding l.e.d. light up on the output display. Note that the switch actuators are coloured *red* on the simulator.

Note that the PhizzyB's PBLink utility uses COM2 by default. If you are already using your COM2 port for something else, then you can connect your PhizzyB to COM1, but you'll have to configure the PBLink utility appropriately (this process is discussed in the *PhizzyB User Manual Volume 2*).

Now connect the PhizzyB's power supply, and note that the various displays briefly flash in exactly the same way as did the simulator's displays. Use the simulator's **Tools -> PhizzyB Interface** command to invoke the PBLink utility.

Next use the PBLink utility's **File -> Open** command to load the newly-created **aaexpl.ram** file, then use the **File -> Download** command (or click the appropriate toolbar icon) to download this program to your PhizzyB.

In order to run this program on the hardware PhizzyB, you can either press the **Run** button on the real PhizzyB, or you can use the PBLink utility's **Control ->**

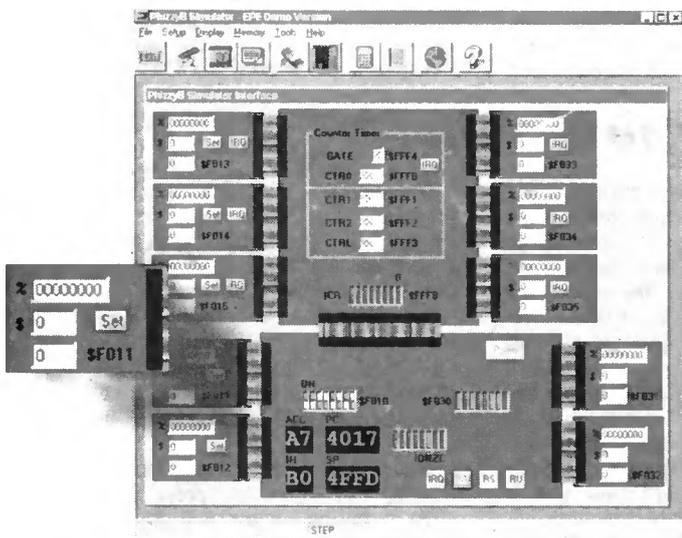


Fig.2. Generic input device at port \$F011.

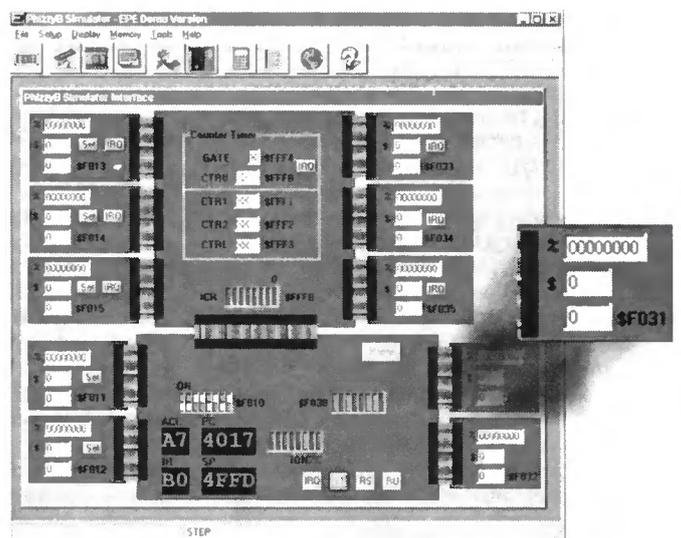


Fig.3. Generic output device at port \$F031.

Also, clicking the Set button causes the hexadecimal and decimal fields on the board to be updated with their equivalent values. In fact you can enter your data into whichever field is the most appropriate for whatever you're trying to represent at the time; for instance, entering %11111111 produces \$FF or decimal 255. Experiment by entering a few more values, then click the simulator's Reset button.

In order to demonstrate this particular program on the real PhizzyB hardware, it's necessary to construct a real I/O board as described in this month's constructional article. A multi-purpose generic I/O board is described which enables you to fabricate simple input and output circuits and then connect these to the appropriate PhizzyB ports using a ribbon cable connector.

The idea behind the following experiments is to test the operation of the input and output ports of your constructed PhizzyB, using a simple switch input and simple l.e.d. bargraph output, each built on a PhizzyB I/O board.

Now would be a really good time to connect a real 8-bit switch to the PhizzyB's external input port at address \$F011 (it's good practice to power down the PhizzyB while you're connecting external devices). Then power up the PhizzyB, use the PBLink utility to open your **aaexp2.ram** file and download it to the PhizzyB, and press the PhizzyB's Run button.

Try flipping each of the 8-bit switches in turn and note the corresponding l.e.d. lights up on the 8-bit display (the bottom switch corresponds to the right-most l.e.d., and so forth).

In fact, the top-most switch (numbered 1) is the Most Significant Bit (MSB). The bottom-most switch (numbered 8) is the Least Significant Bit (LSB). This matches the numbering scheme of \$F010 on the main PhizzyB board, where switch number 8 on the right is the LSB, to tally with the l.e.d. display \$F030 in which the right-hand l.e.d. is the LSB of the binary value displayed.

Don't forget to reset your PhizzyB when you've finished.

### EXPERIMENT 3

#### Testing input port \$F012

Use the assembler's File -> Save As command to now save your **aaexp2.asm**

program under the new name of **aaexp3.asm**. Next modify the LDA instruction such that it reads from **INPORT2** (the input port at address \$F012) and assemble this new program.

Follow the remaining instructions from Experiment 2, but this time test the input port at address \$F012.

### EXPERIMENT 4

#### Testing output port \$F031

Use the assembler to open the original **aaexp1.asm** program and save it under the new name of **aaexp4.asm**. This time we're going to modify the STA instruction such that it now writes to **OUTPUT1** (the output port at address \$F031):

STA [OUTPUT1]

Now use the PBLink utility to open **aaexp4.ram** and download this program to the PhizzyB. Press the Run button, and ensure that everything is working correctly in the real world (note that the left-most switch on the 8-bit switch device corresponds to the bottom-most l.e.d. on the described output board, and so forth).

### EXPERIMENT 5

#### Testing output port \$F032

Save your **aaexp4.asm** program under the new name of **aaexp5.asm**. Now modify the STA instruction such that it writes to **OUTPUT2** (the output port at address \$F032) and assemble this new program.

Follow the remaining instructions from Experiment 4, but this time test the output port at address \$F032.



a	b	y
0	0	0
0	1	0
1	0	0
1	1	1

(a) 2-input AND



a	b	y
0	0	0
0	1	1
1	0	1
1	1	1

(b) 2-input OR



a	b	y
0	0	0
0	1	1
1	0	1
1	1	0

(c) 2-input XOR

Fig.4. The AND, OR and XOR logic gates.

Assemble this new program, use the simulator's Memory -> Load RAM command to load the resulting **aaexp4.ram** machine code file into the simulator's memory, then click the simulator's Run button to execute the program.

Try clicking the PhizzyB Simulator's 8-bit switches and observe that nothing happens on the 8-bit l.e.d. display, because we're no longer writing to this port. Instead, the fields on the generic output board connected to the external port at address \$F031 update to reflect whatever value is currently on the switches (Fig.3).

Experiment by entering a few more values, then click the simulator's Reset button. Once again, if you have a real PhizzyB, now would be a real good time to connect the simple 8-bit l.e.d. output device (see this month's constructional article for details) to the PhizzyB's external output port at address \$F031.

### EXPERIMENT 6

#### AND instruction

Digital computers are constructed using large numbers of primitive logic gates, three of which are known as AND, OR, and XOR (Fig.4).

In the case of the AND (Fig.4a), the output "y" is only "True" (logic 1) if both inputs "a" and "b" are True, otherwise the output is "False" (logic 0).

By comparison, in the case of the OR (Fig.4b), the output "y" is True if either "a" or "b" are True. In fact, this type of OR should more properly be called an *inclusive-OR*, because the input combinations that cause "y" to be True include the case where both "a" and "b" are True.

Contrast this with the XOR or *exclusive-OR* (Fig.4c), in which "y" is only True if just one input is true, and which therefore excludes the case where both of the inputs are true.

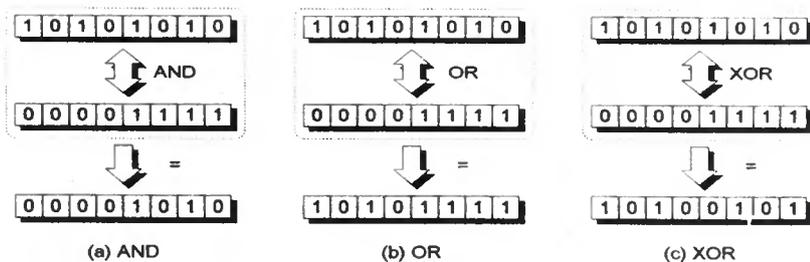


Fig.5. The AND, OR and XOR instructions.

The reason this is of interest to us is that a computer's Central Processing Unit (CPU) supports a set of instructions known as *logical instructions*, so-called because they perform essentially the same logical operations as do our primitive gates (Fig.5).

Remember that the PhizzyB predominantly works with chunks of data that are 8-bits wide, which is why this figure features 8-bit quantities. These logical instructions may be referred to as *bitwise operators*, because they perform their magic on a bit-by-bit basis.

In the case of the AND, for example, bit[0] of the first field is ANDed with bit[0] of the second field to generate bit[0] of the result, bit[1] of the first field is ANDed with bit[1] of the second field, and so forth.

In order to see these instructions "in the flesh" as it were, bring up the PhizzyB's assembler and enter the program shown in Listing 2.

If you have a real PhizzyB, connect the simple input switch to the external port at address \$F011 and use the PBLink utility to download your **aaexp6.ram** file to the PhizzyB. Then check that the AND instruction works the same way in the real world. (Don't forget to press the PhizzyB's Reset button when you've finished.)

### EXPERIMENT 7 OR instruction

Use the assembler to save **aaexp6.asm** to **aaexp7.asm**, change the AND instruction to an OR, assemble this new program to generate the corresponding **aaexp7.ram** file, and load this file into the simulator's memory.

Run this program and use the values shown in Fig.5b to test that the OR instruction functions as expected. Experiment with some other values until you're happy that the OR holds no further mysteries, then click the simulator's Reset button.

Similarly, if you set the external port to a binary value of 11111111, then whatever value you set on the 8-bit switches is inverted. Examine the truth table in Fig.4c and the illustration in Fig.5c and make sure that you understand why this is so. (Don't forget to reset both the simulator and the real PhizzyB when you've finished.)

### NOT, NAND, NOR AND XNOR

The ability to invert a value by XORing it with another value of all 1s can be very useful, particularly in the case of the PhizzyB. In addition to the AND, OR and XOR as discussed above, many CPUs support a NOT instruction that inverts the contents of the accumulator (that is, swaps the 0s for 1s and vice versa), and also the NAND, NOR, and XNOR instructions, which stand for *Not AND*, *Not OR* and *eXclusive NOR*, respectively.

However, when we designed the PhizzyB we wanted to make it as simple as possible, so it only supports the AND, OR, and XOR instructions. But turn that frown upside down into a smile, because all is not lost and your quality of life is not going to suffer.

As we've seen, we can effect the same functionality as a NOT instruction by XORing the contents of the accumulator with all 1s. Let's call this a *pseudo-NOT*. It therefore follows that we can implement a NAND by performing an AND followed by a pseudo-NOT, and similarly for the NOR and XNOR functions.

### CPU STATUS REGISTER

In Part 1 we noted that the PhizzyB's CPU contains an 8-bit register called the *accumulator* (ACC), which it uses to store (accumulate) intermediate results. In fact the CPU also contains another register called the *status register*, where the bits forming the status register are commonly referred to as *status bits* or *status flags* (Fig.6).

Due to the fact that we may require to load the status register from the memory (or store its contents in the memory), it is usual to regard this register as being the same width as the data bus (eight bits in the case of the PhizzyB).

However, the PhizzyB only actually employs five status flags, which occupy the five least-significant bits of the status register. This means that the three most-significant bits of the register exist only in our imaginations, so their non-existent contents are, by definition, undefined.

This month we are only going to consider two of the PhizzyB's status flags: the negative (N) flag and the zero (Z) flag.

#### Negative (N) flag

The negative (N) flag, which is also called the *sign flag*, typically contains a copy of the most significant bit in the accumulator following an operation on the computer.

This flag is called the *negative flag* because a logic 1 in the most-significant bit of the accumulator indicates a negative number (this assumes that the value in the accumulator is being regarded as a signed, two's complement value - we'll discuss signed numbers next month).

#### Listing 2

```

INPORT0: .EQU $F010    #Assign a label to input port $F010
INPORT1: .EQU $F011    #Assign a label to input port $F011
OUTPORT0: .EQU $F030   #Assign a label to output port $F030

        .ORG $4000     #Set start address to $4000
LOOP:   LDA [INPORT0]  #Load accumulator from input port 0
        AND [INPORT1]  #AND the contents of the accumulator
                        #with the value from input port 1
        STA [OUTPORT0] #Store accumulator to output port
        JMP [LOOP]     #Jump to label LOOP and do it again
        .END

```

Save this file as **aaexp6.asm**, assemble it to generate **aaexp6.ram**, use the **Memory -> Load RAM** command to load **aaexp6.ram** into the simulator's memory, and click the Run button to execute this program.

Now enter the value 10101010 into the external input port at address \$F011 (don't forget to click the Set button) and set the 8-bit switches (input port address \$F010) to reflect a binary value of 00001111. Observe that the 8-bit l.e.d.s show a binary pattern of 00001010 as was predicted in Fig.5a.

Swap the values between the two input ports and observe that the result remains the same. This is because the AND function is "commutative," which means that the result of the operation is not affected by the order in which we specify the input values (this is also true for the OR and XOR functions).

Experiment with different values until you're confident you understand how this flavour of the AND instruction works, then click the simulator's Reset button.

As usual, if you have a real PhizzyB, download **aaexp7.ram** and test this program in the real world (don't forget to press the PhizzyB's Reset button when you've finished).

### EXPERIMENT 8 XOR instruction

You know the drill by now! Use the assembler to save **aaexp7.asm** to **aaexp8.asm**, change the OR instruction to an XOR, assemble this new program to generate the corresponding **aaexp8.ram** file, and load this file into the simulator's memory.

Run this program and use the values shown in Fig.5c to test that the XOR instruction functions as expected. As usual, if you have a real PhizzyB, download **aaexp8.ram** and test this program in the real world.

Note that if you set the 8-bit switches to a binary value of 11111111, then whatever value you enter on the external port is inverted (all the 0s are changed to 1s, and vice versa), as can be seen on the 8-bit l.e.d. display.

## Zero (Z) flag

The zero (Z) flag is predominantly used to indicate whether or not the accumulator contains a value of zero following an operation on the accumulator. However, we should note that this flag is also used to indicate the presence or absence of a zero condition in the *index register* following **INCX** (*increment index register*) or **DECX** (*decrement index register*) instructions.

The zero flag is also used to indicate whether or not two numbers are equal following a **CMPA** (*compare*) instruction.

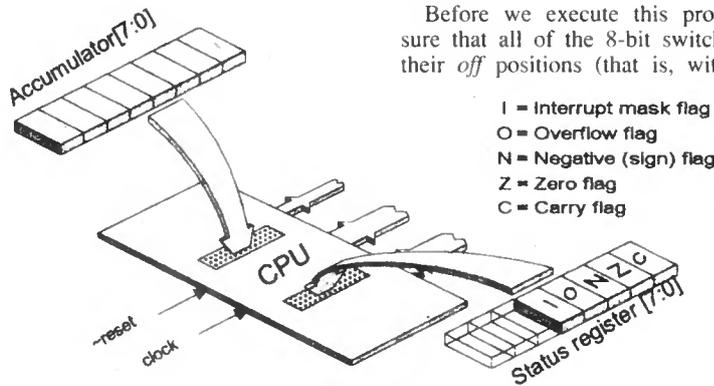


Fig.6. The Status Register I.e.d. display used on the hardware PhizzyB.

Note the 8-bit I.e.d. display just to the right of the 7-segment displays on the simulator interface. The 5-bits marked "I", "O", "N", "Z" and "C" reflect the current contents of the corresponding flags in the status register. With regard to these flags, we also need to be aware of a convention as follows:

- A status flag is said to be *set* if it contains a logic 1, which is used to indicate a True condition. For example, if the zero flag is set (contains a logic 1), this indicates that: *It's True to say that the current value stored in the accumulator is zero* (that is, all of the bits in the accumulator contain logic 0s).

- A status flag is said to be *cleared* if it contains a logic 0, which is used to indicate a False condition. For example, if the zero flag is cleared (contains a logic 0), this indicates that: *It's False to say that the current value stored in the accumulator is zero* (that is, one or more of the bits in the accumulator contain a logic 1).

Unfortunately, this convention can appear somewhat counter-intuitive (especially in the case of the zero flag) and it takes a little effort to wrap your brain around it the first time you see it, but you'll find that it really does make a lot of sense once you get into the swing of things. Trust us on this, have we ever lied to you before? (Don't answer that!)

## EXPERIMENT 9

### Zero and negative flags

Activate the PhizzyB's assembler, open your original **aaexp1.asm** file, save this file under the new name of **aaexp9.asm**, then assemble it to generate the corresponding **aaexp9.ram** file. Before you do anything else, use the assembler's **Window -> View Listing File** command to look at the corresponding *list* file **aaexp9.lst** (Fig.7).

*List* files are discussed in more detail in the *PhizzyB User Manual Volume 1*. For

our purposes here, we need only note that the **LDA** instruction occurs at address \$4000, the **STA** appears at address \$4003, and the **JMP** ends up occupying address \$4006.

Use the simulator's **Memory -> Load RAM** command to load the contents of **aaexp9.ram** into the simulator's memory. As you will recall, this program loops around loading the accumulator with the value on the 8-bit switches connected to the input port at address \$F010, and writing these values to the 8-bit I.e.d. display connected to the output port at address \$F030.

Before we execute this program, ensure that all of the 8-bit switches are in their *off* positions (that is, with the red

- I = Interrupt mask flag
- O = Overflow flag
- N = Negative (sign) flag
- Z = Zero flag
- C = Carry flag

bits towards the bottom). Now, as opposed to using the Run button, click the simulator's Step ("St") button instead. This causes the simulator to step through the first instruction which loads the value on the switches into the accumulator.

Note that the *program counter* (PC) 7-segment displays now show a value of \$4003, which is the address of the next instruction to be executed (the **STA** in this case). More importantly, the zero (Z) flag on the 8-bit status register display has lit up to indicate that the accumulator now contains a zero value.

Click the Step button again, which causes the value in the accumulator to be stored to the 8-bit I.e.d.s at output port \$F030 (the reason nothing seems to happen is that the accumulator contains zero of course). Note that the PC displays update to show a value of \$4006, which is the address of the next instruction to be executed (the **JMP**). Now click the Step button one more time, which executes the **JMP** instruction and returns us to address \$4000.

Click the right-most switch on the 8-bit switch, and note that nothing happens to the zero flag because we haven't loaded this value into the accumulator yet. Now click the Step button to execute the **LDA** instruction, and note that the zero flag is extinguished, because the accumulator now contains a non-zero value.

Click the Step button once more to execute the **STA** instruction, and observe the

right-most bit on the 8-bit I.e.d.s at output port \$F030 light up. Then click Step once again to execute the **JMP** instruction, which again returns us to address \$4000.

Now click the left-most switch on the 8-bit switch and click the Step button to load this new value into the accumulator. Remembering that the negative (N) flag typically contains a copy of the most significant bit in the accumulator following an operation on the computer, it should come as no great surprise to see that the negative bit lights up on the status register display.

Experiment by setting other values on the 8-bit switch and stepping through the program until you are confident that you understand how these two flags function (insofar as the context of this experiment). Assuming that you have one, it would be a good idea to download this program to your real PhizzyB and to repeat this experiment in the real world. Don't forget to reset the simulator and the PhizzyB when you're done.

## EXPERIMENT 10

### Conditional jumps

Fear not my braves, because this is the last of our experiments for this month (phew!). One of the main reasons that computers are so powerful and versatile is that they have the ability to determine future actions based on the results of previous operations.

The way in which this works is that the CPU understands special instructions called *conditional jumps*. This means that these jump instructions will only occur if specific conditions are True, and these conditions are based on the values of the status flags.

Remembering that we're only considering the zero (Z) and negative (N) flags at the moment, there are four conditional jump instructions associated with these flags:

**JZ** = *jump if zero* (jump if the zero flag is True/logic 1)

**JNZ** = *jump if not zero* (jump if the zero flag is False/logic 0)

**JN** = *jump if negative* (jump if the negative flag is True/logic 1)

**JNN** = *jump if not negative* (jump if the negative flag is False/logic 0)

To understand how this works, we're going to write a simple program that reads a value from the 8-bit switches connected to the input port at address \$F010, and writes this value to the 8-bit I.e.d.s connected to the output port at address \$F030.

But there's a twist, because if the left-most switch is *on* (which means that it's connected to a logic 1), then we're going to invert the value (swap 0s for 1s and vice versa) before we write it to the 8-bit I.e.d.s.

```

00008                .ORG    $4000
00009 4000 91 F0 10  LOOP:  LDA    [INPORT0]
00010 4003 99 F0 30      STA    [OUTPORT0]
00011 4006 C1 40 00     JMP    [LOOP]

```

Fig.7. Part of the *list* file for program **aaexp9**.

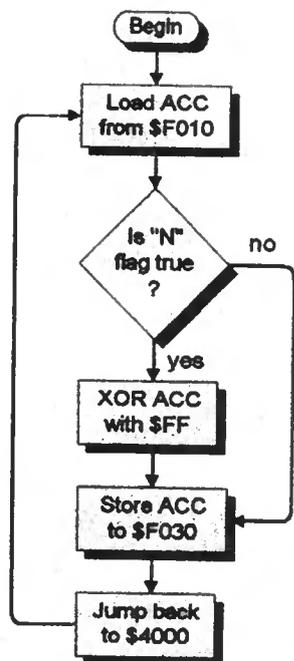


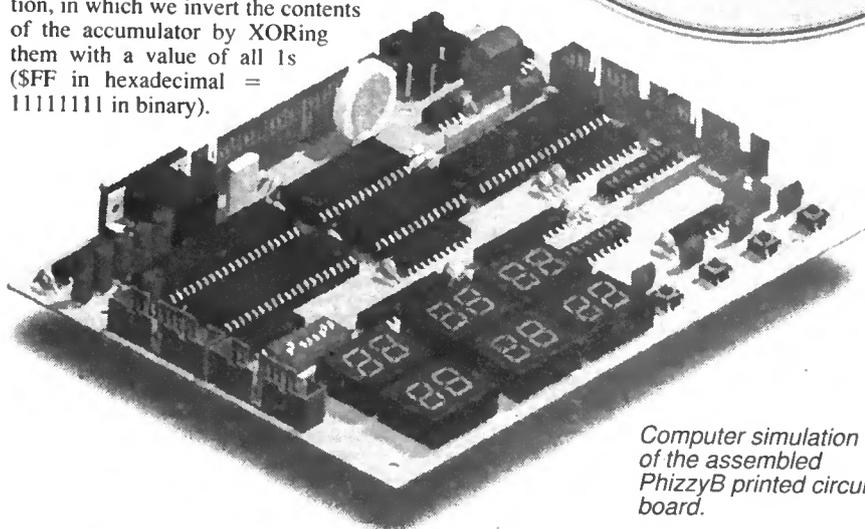
Fig.8. Flowchart for program *aaexp10*.

Consider the flowchart in Fig.8 and compare it to the code in Listing 3. As per some of our earlier programs, the first thing we do is to load the accumulator with the value on the 8-bit switches. The act of loading the accumulator automatically updates the zero and negative status flags.

For the purposes of this particular program, we want to check to see if the most-significant bit in the accumulator is a logic 1. We know that the negative flag is a copy of the most-significant bit in the accumulator, so all we really have to do is to check the value of this flag.

If the negative flag is False (contains a logic 0), then all we want to do is to store the value in the accumulator to the output port driving the 8-bit l.e.d.s. But if the negative flag is True (contains a logic 1), then we want to invert the value in the accumulator before we store it.

One way to achieve this is to use a JNN (*jump if not negative*) instruction, which will jump to a specified location if the negative flag contains a logic 0. However, if the negative flag contains a logic 1, then the JNN will fail and the program will simply proceed to the next instruction, in which we invert the contents of the accumulator by XORing them with a value of all 1s (\$FF in hexadecimal = 11111111 in binary).



Computer simulation of the assembled PhizzyB printed circuit board.

### Listing 3

```

INPORT0: .EQU $F010    #Assign a label to input port $F010
OUTPORT0: .EQU $F030  #Assign a label to output port $F030

.ORG $4000           #Set start address to $4000
LOOP:    LDA [INPORT0] #Load accumulator from input port 0
        JNN [STORE]   #If N=0 jump to label STORE
        XOR $FF       #.. otherwise invert contents of ACC
STORE:   STA [OUTPORT0] #Store accumulator to output port
        JMP [LOOP]    #Jump to label LOOP and do it again
        .END
  
```

Enter the program shown in Listing 3 into the assembler, save it under the name of *aaexp10.asm*, assemble it, load it into the simulator's memory, and run it.

Experiment by placing different patterns on the 8-bit switches and observe that whenever the left-most switch is in its *on* position, the resulting pattern appearing on the 8-bit l.e.d.s is the inverse of the pattern on the switches. When you are happy that this is so, download this program to the PhizzyB and ensure that it functions the same way in the real world.

## HOMework AND FURTHER READING

You probably feel pretty confident that you're on top of things at the moment, but it's always easy to do something when you're following someone else's instructions, so let's see just how much your confidence is justified, shall we?

Starting from scratch, create a program that loops around loading the accumulator with values from the 8-bit switch. Depending on whether the left-most switch is *off* or *on*, AND or OR the value in the accumulator with whatever value is present on the input device connected to the external port at address \$F011. Then display the result on the output device connected to the external port at address \$F031.

Now use the simulator's **Help** -> **Search on Help Contents** command to activate the online help, and then select the item in the main page marked *The Official Beboputer Microprocessor Databook*. We strongly recommend that you read its *Appendix D*, because this Appendix contains a rather useful introduction to the Beboputer's (and hence the PhizzyB's) assembly language.

## RESOURCES

The following items are available from the *EPE PCB Service* at the Editorial address (prices include VAT and P&P):

Full working version of the PhizzyB CD-ROM £14.95

Pre-programmed PhizzyB micro-controller £14.95

PhizzyB printed circuit board, £14.95

The two amazing books referred to last month, *Bebop Bytes Back* and *Bebop to the Boolean Boogie*, are available from the Direct Book Service (see their pages elsewhere in this issue).

## THERE'S MORE

Next month we will introduce the carry (C) and overflow (O) flags, unsigned and signed binary numbers, and the stack and subroutines. The accompanying constructional project will show you how to build a simple liquid crystal display (l.c.d.) output board, and we'll be using our new found knowledge of subroutines to create a program to drive this little rascal.

Last, but not least, we'll introduce a little PhizzyB programming competition, the winner of which will receive a year's free subscription to *EPE*. Until then, we remain ... fond of ice cream! Best regards, Max and Alvin.

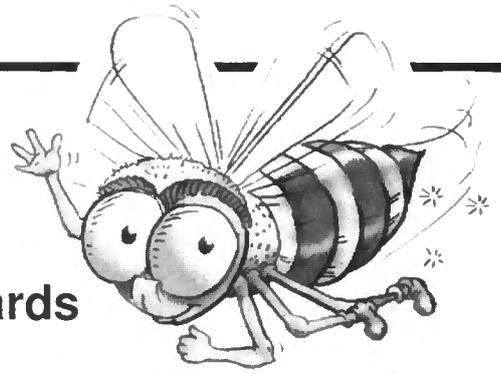
Be sure to check out this month's constructional article, which follows next.

## BEE-LINE

Max and Alvin would love to hear from you via their web site: <http://www.maxmon.com>.

# PhizzyB COMPUTERS

## Construction – Input and Output boards



Alan Winstanley

*Adding outside world communication options – input control switches and an l.e.d. bargraph.*

**I**N Part 1 last month, we introduced the PhizzyB Simulator software, which runs on an IBM-compatible PC computer under Windows 95/98/NT. The constructional details for the real hardware PhizzyB were also provided.

This month's practical article describes a simple prototyping I/O (input/output) board which can be used to connect external circuits directly to your hardware PhizzyB. This test board allows sensor transducers, switches and other components to be interfaced directly with a PhizzyB.

Apart from introducing some assembler and programming techniques, one of the purposes of the experiments in Part 2 is to confirm that the I/O ports on your PhizzyB really do work. They can be tested simply by connecting a bank of switches to an input port, and an l.e.d. array to an output port.

By downloading the relevant .ram program from the PC to your PhizzyB, you can soon show that the I/O ports are functioning as expected. Then, by changing the program and reloading the corresponding .ram file, you can swap the I/O circuits to other ports and prove that they operate correctly, as well.

Further down the road, we will be introducing a variety of applications which utilise the I/O ports of your PhizzyB.

It is again highlighted that the PhizzyB is a commercial product and the purpose of this series is to construct and use the software and hardware to emulate the operation of a real computerised control system.

Outline circuit diagrams of the I/O modules are provided here, but otherwise the operation of the PhizzyB computer is beyond the scope of this educational series.

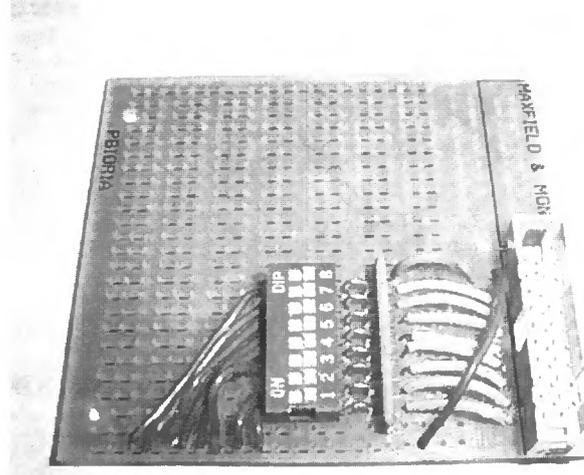
### MULTIPURPOSE I/O BOARD

A specially-designed PhizzyB I/O board is available which can be cut into four sections (see Fig.1). Each section can carry a 20-way connector next to the prototyping area and is suitable for both input and output add-on circuits. The 20-way connector is hooked over to a PhizzyB input or output port using a ribbon cable.

Having divided the board into quarters (see later), there is one important difference between them, which is that a single continuous row of tracks (often called a "busbar") may either be at the top of a section ("A") or at the bottom ("B"). This "A" and "B" notation helps to ensure that the "correct" board is utilised by readers, as determined by where the busbar actually is.

The four boards can each be used for either input or output experiments. Constructors should ensure they use the "correct" board section to correspond with our drawings.

It is perfectly feasible merely to cut the board in half (rather than into four) and use each section independently, as we did in this month's experiments – see photos. Spare sections can be



Assembled Simple Switch Input board.

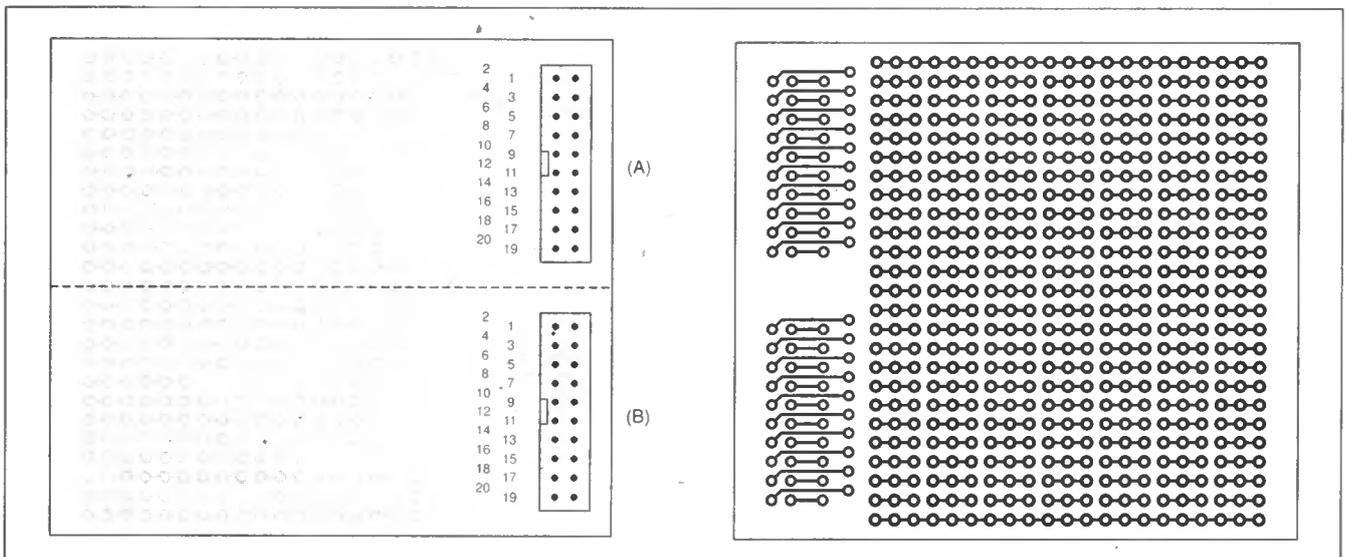


Fig. 1. Two sections of the 4-sectioned PhizzyB I/O board: (left) component side view, (right) trackside view.

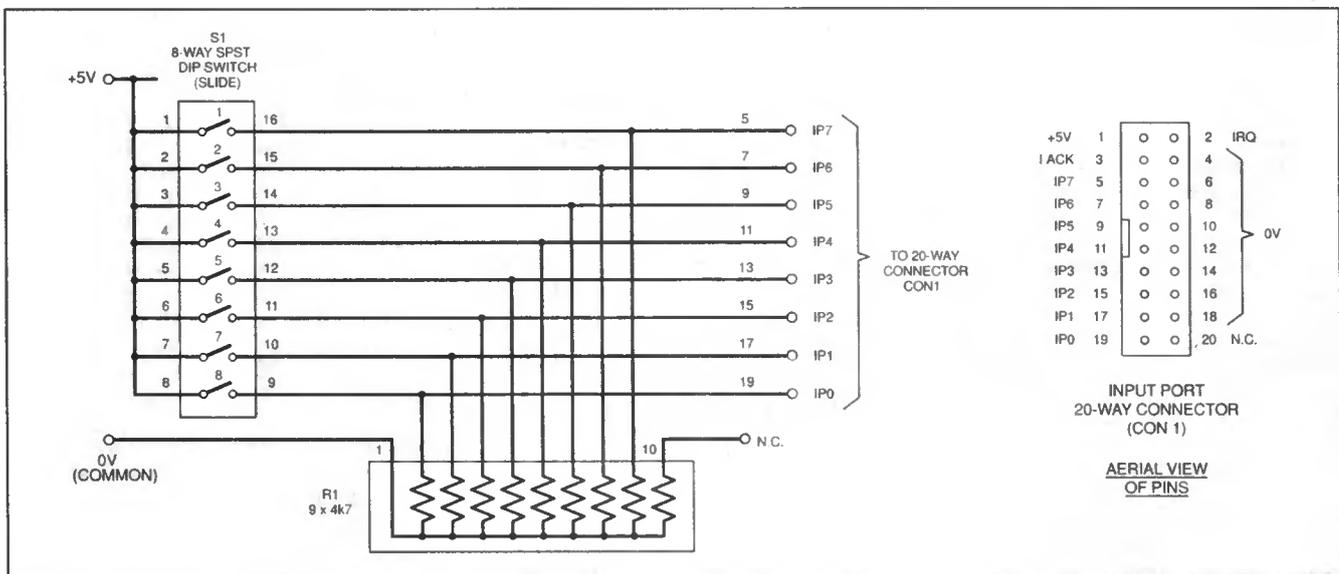


Fig.2. Circuit diagram for the Simple Switch Input board, plus 20-way input connector pinout details.

used for other prototypes at a later date, so nothing goes to waste. Whatever method you adopt, please remember to check the "busbar" before you commence soldering.

We will provide all the constructional and interwiring details, and it is all fairly straightforward. It is emphasised, though, that some of the soldering is somewhat delicate, so a fine-tipped iron and a steady hand are needed. However, if you constructed your PhizzyB successfully, you should have no problems assembling these add-on boards.

## INPUT SWITCHES BOARD

The circuit diagram for the Simple Switch Input test board is shown in Fig.2. This consists of an 8-way dual-in-line (d.i.l. or d.i.p.) switch, S1. You will see that the inputs to all eight switches are wired to +5V via pins 1 to 8, and their outputs run directly to a 20-way connector that links over to the PhizzyB (IP0 to IP7).

The switches can be closed to connect their corresponding outputs to +5V (representing a logic 1 to a real PhizzyB input port). So, by closing all eight switches, you would input the binary number 11111111 to a PhizzyB – always assuming you've programmed it properly to read from that input port!

Furthermore, all the switch outputs are connected via a 4k7 (4.7 kilohms) resistor network (R1) to 0V. This is a way of ensuring that the input lines IP0 to IP7 are usually tied low to 0V and are never left "floating" (unconnected to anything). The resistor network is self-contained within a single-in-line (s.i.l.) package.

Commence construction by cutting a new I/O board into its four sections. Start by cutting along the middle row of holes specially provided to help with this. Use a "Junior" hacksaw or (e.g.) a Dremel cutting disc, and slice the board to produce two boards.

You may then proceed to further divide these boards into two if desired, in which case it's a good idea to label each one as an "A" type or "B" type board. Type "A" boards have the busbar at the top, type "B" have it at the bottom (with the IDC connector facing to your right when

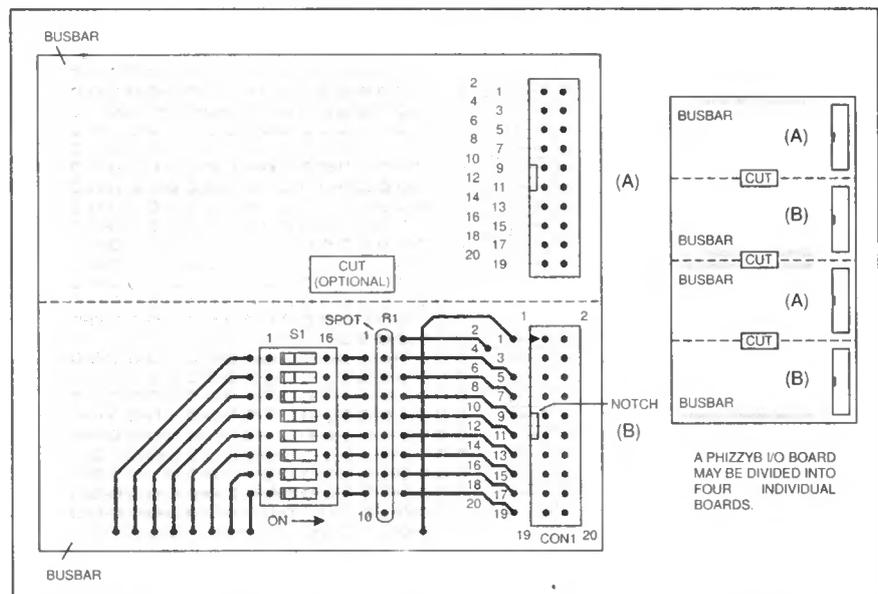


Fig.3. Component layout and connections for the Simple Switch Input board. Note that section "B" is used (the cutting details are shown on the right).

## COMPONENTS

### Resistors

R1 4k7 9-resistors s.i.l. module (Bourns 4610X-101)

R2 150Ω 9-resistor module (Bourns 4610X-101)

### Semiconductors

IC1 74LS540 or 74ALS540 octal buffer

BAR1 10-segment d.i.l. red l.e.d. bargraph

### Miscellaneous

S1 8-way s.p.s.t. d.i.l. switch

CON1, CON2 20-way IDC non-latching box header (2 off)

PhizzyB I/O board type "B" (2 off) – cut from 4-section I/O board (see text), available from the *EPE PCB Service*, code 216 (I/O Board); 20-way 0.05-inch IDC connector (4 off); 20-way 0.05-inch IDC cable, approx 30cm; solid-core hook-up wire; solder etc.

Approx Cost  
Guidance Only

£17

looking at the top side of the board – non-track side). File the board edges smooth.

Two "B" type boards are used for this month's demonstrations.

Start assembly by soldering the 20-way IDC header into position on a type "B" board. Look closely to locate pin 1 of the connector, referring to the notches on the moulding, or look for a small arrowhead to denote pin 1. (See Fig.3.)

The connector should be level against the board – use a small piece of Scotch tape (or similar) to hold it in place temporarily during soldering. Each solder joint should take one or two seconds only and use only 2mm or so of fine gauge solder (e.g. 22 s.w.g.). Take extreme care to ensure that you do not bridge adjacent joints with excessive amounts of solder.

Next, solder into place the d.i.l. switch, followed by the s.i.l. resistor. Position the components in the suggested locations as shown in Fig.3. The resistor array has a polarity marking, with pin 1 (the "common" pin for the nine internal resistors – one resistor is unused) signified by a dot. Ensure it is orientated correctly.

Close inspection of the board reveals that its copper track pattern is formed into

"triplets" – a matrix of pads, each being three holes connected together. There is also one continual copper track (the busbar referred to earlier), which can be used as a power supply "rail" (for +5V in this case).

It will be seen that it is necessary to join neighbouring triplets together in places by using short jumper wires, formed from single-core tinned copper wire, or using insulated wire if there is a likelihood of neighbouring wires touching each other. Usually, solid-core tinned copper wire can be formed into shape with pliers, often obviating the need for insulation. Wiring should be effective but doesn't need to look very tidy – you will be doing quite a lot of prototyping like this in the future!

Use solid-core jumper wires to interconnect all the components as shown. The numbering pattern for the 20-way connector is also given, and jumper wires are used to link the components to the input lines IP0 to IP7 on the connector, as well as to +5V and 0V power lines. Closely inspect the soldering after assembly, looking for short-circuited joints or "dry" (bad or unsoldered) joints.

### IDC CONNECTOR

A 20-way 0.05-inch pitch ribbon cable is used to link the external I/O boards to the main PhizzyB hardware. This uses an industry-standard IDC (insulation displacement connector) to produce an extremely reliable connection: instead of trying to solder to the wires, the wire's insulation is pierced by sharp metal "teeth" and an electrical contact is then made to the conductor within, exactly like 3M "Scotchlok" connectors are used for car wiring – only infinitely smaller, and twenty abreast!

The IDC connectors used on the prototype were also made by 3M, incidentally, but there are plenty of other brands available. (IDC connectors are used universally in modern personal computers, to interconnect disk drives to the motherboard etc.)

The general orientation of the required IDC lead is illustrated in Fig.4. Note that:

1. A "bump" polarises the connector – this matches a notch in the 20-way header soldered on the printed circuit boards
2. A tiny arrowhead is moulded into the IDC connector to indicate pin 1
3. A red stripe on a (grey) ribbon cable indicates pin 1 as well.

So that the interconnection is properly orientated and pin 1 on the input board links to pin 1 on the PhizzyB input port, the notches of the connectors must be

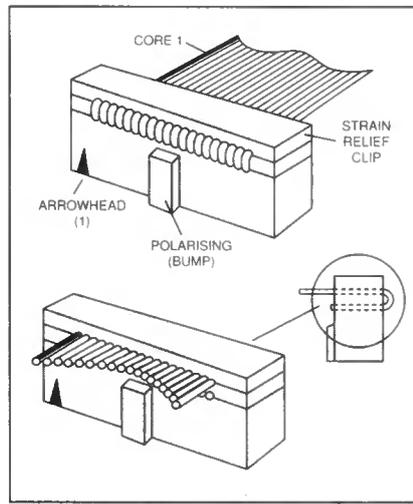


Fig.4. IDC connector assembly.

orientated as per Fig.4. Cut the ribbon cable to length (say, six inches – about 15cms) with very sharp scissors to make a clean cut.

Feed the end of the ribbon onto the connector's "teeth" and press down the top section just to grip the wire. A strain relief clamp is applied to the cable afterwards, but because the ribbon is doubled back over the plug and clamped down with the strain relief, the cable must initially be fed into the connector from the *opposite* direction – see diagram. (If you get it wrong, don't worry, because IDC connectors can usually be prised apart again and remade.)

It takes a surprising amount of pressure to fully squeeze the connector together to pierce the insulation. Don't worry – the connectors are very accurately made and are remarkably strong! The prototype leads were tightened together using a small bench vice, but any improvised method which applies uniform pressure will be suitable.

Then double-over the ribbon and push on the strain relief clip to secure everything. Repeat the procedure for the other end of the cable: you will see that the polarising "bumps" on both connectors face the same direction. You should then repeat this procedure for a second cable, which is needed for the output board, the construction of which is described next.

### OUTPUT BOARD

The basic circuit diagram of the L.E.D. Bargraph Output Board is shown in Fig.5. It contains a dual-in-line integrated circuit (a 74LS540 or 74ALS540 octal buffer) which is used as a current amplifier to

drive l.e.d.s directly through current-limiting resistors.

The chip should be treated as static sensitive, so anti-static precautions are wise (see last month's constructional article for further guidance). It is recommended that you use a 20-way *narrow-type* d.i.l. socket to mount it, although the prototype chip was soldered directly to the board having double-checked its position first.

Use another type "B" board and solder the 20-way header into position, checking again for polarity, see Fig.6. Continue with the 10-l.e.d. bargraph array – pin 1 is annotated with a dot or other marking and correct polarity is important.

The s.i.l. resistor (R2) should be polarised as before, with pin 1 being denoted by a spot on the body. A series of short jumper wires is needed to hook together the components, and these can again be formed from short pieces of tinned-copper wire.

Then use insulated jumper wires to carefully hook over from the integrated circuit to the corresponding pads adjacent to the 20-way header. Again the solder pads of the 20-way header are offset in a particular order and close attention should be paid to the layout used.

After completion, scrutinise all wiring very closely and then insert the chip into its socket (if used) looking for a notch or dimple to signify pin 1 (see Fig.2 in last month's constructional article).

### PhizzyB CONNECTION

In order to use the I/O boards with your PhizzyB, simply hook them to the main single-board computer using the two ribbon cables. Power up the PhizzyB and then download the relevant .ram files which accompany each demonstration.

Press the "Run" button on the PhizzyB to execute the program, and use the d.i.l. switches to "write" binary numbers to the PhizzyB input port, and see what happens on the l.e.d. display.

Move the I/O boards to the other ports and execute the corresponding programs, in order to confirm that the I/O ports on your PhizzyB operate as expected. Be sure to use the relevant .ram program corresponding to each I/O port being demonstrated.

If you have any problems, we recommend that you:

- Closely inspect the soldering, looking for dry (incomplete) joints, or solder bridging adjacent strips on the prototyping boards
- Look for wires soldered into the wrong locations, especially at the 20-way headers – it is easy to make a mistake

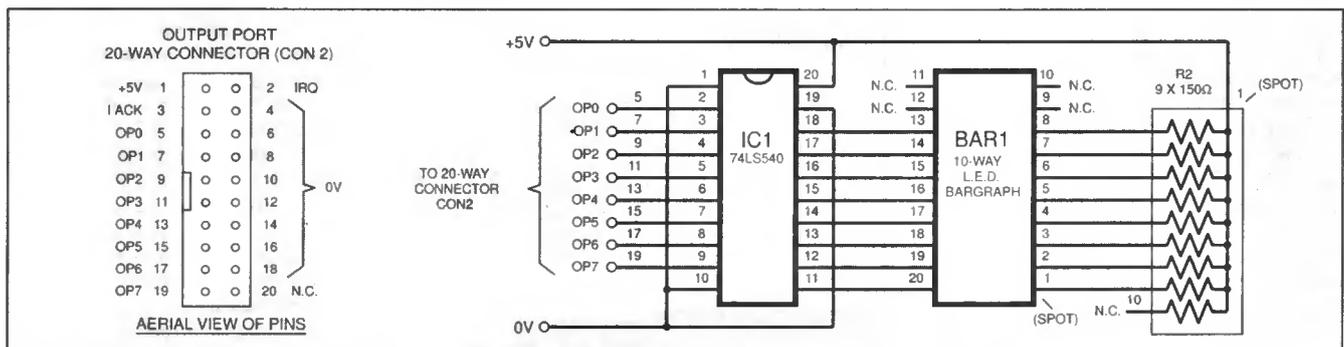


Fig.5. Circuit diagram for the L.E.D. Bargraph Output board, plus 20-way output connector pinout details.

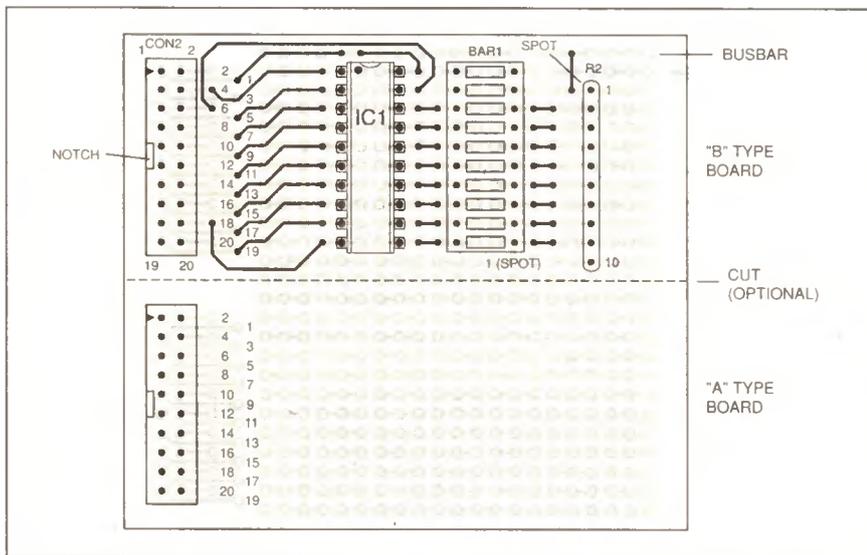


Fig.6. Component layout and connections for the L.E.D. Bargraph Output board. Note that a "B" section is used.

## RESOURCES

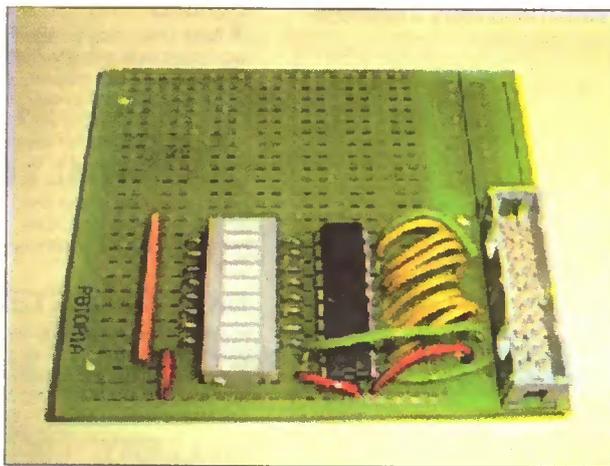
The following items are available from the *EPE PCB Service* at the Editorial address (prices including VAT and P&P):

- 4-section PhizzyB I/O board £3.95
- Full working version of the PhizzyB CD-ROM £14.95
- Pre-programmed PhizzyB microcontroller £14.95
- PhizzyB main p.c.b. £14.95

A kit of parts for the PhizzyB I/O circuits described here in Part 2 (including the board) is available from Magenta Electronics.

Magenta also supply kits and ready-built units for the main PhizzyB as described in Part 1:

- Kit £131.95 incl. VAT plus £3 P&P
- Ready-built £149.99 incl. VAT plus £3 P&P
- Computer lead £3.99
- Plug-top p.s.u. £3.99



Assembled L.E.D. Bargraph Output board.

## PHIZZYB

This series is written for those wishing to learn what makes computers really tick. The unique PhizzyB (Physical Beboputer) by Maxfield & Montrose Interactive Inc. combines both software and hardware to interact between the on-screen demonstrations and the advanced practical hardware – the PhizzyB – connected to your PC serial port.

Remember that this series is not aimed purely at electronics enthusiasts, but also computer users and others wishing to train in or learn about computer operation. Not a lot of previous electronics experience is required, basically just an ability to solder and recognise components.

Even if you have no particular electronics experience, then provided you can solder neatly using a fine-tipped soldering iron, there is an excellent chance that you will be able to solder the hardware together and that it will work first time.

- Inspect for any specks or pieces of swarf, solder or wire offcuts which have become stuck amongst the soldering
- Try to compare the simple circuit diagrams against your actual wiring boards
- Check for correct orientation of parts and pin numbers
- Check the correct program is being used – open the Simulator assembler and re-assemble if necessary.

### HELP!

Remember that if there are any queries or problems, the authors are on hand to help. For constructional queries you can contact Alan Winstanley by E-mail ([alan@epemag.demon.co.uk](mailto:alan@epemag.demon.co.uk)) or by post c/o the Editorial address.

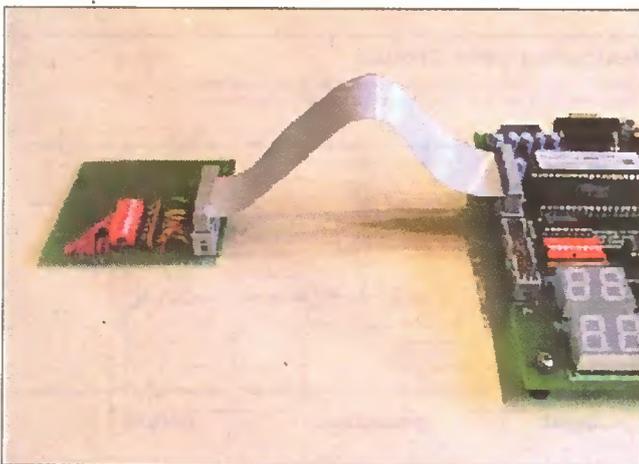
You can also check the web site of Maxfield & Montrose Interactive Inc. on <http://www.maxmon.com> where Max and

Alvin can be contacted in relation to the PhizzyB Tutorial. Tell them how they're doing – they're itching to hear from you!

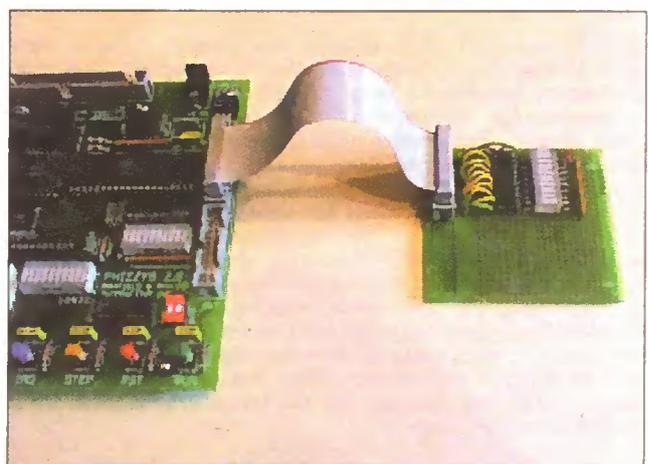
Next month, we describe how to add a liquid-crystal display to your PhizzyB.

### BUZZ THE CHAT ZONE

The *EPE Chat Zone* on our web site is now open s a way for readers to exchange information, views, hints and tips in virtually real time. <http://www.epemag.wimborne.co.uk/wwwboard>



Assembled switch input board connected to PhizzyB.



Assembled l.e.d. output board connected to PhizzyB.

# Everyday Practical Electronics are pleased to be able to offer all readers these **ELECTRONICS CD-ROMS**

**TWO APPLICATIONS ON ONE CD-ROM**

## **ELECTRONIC CIRCUITS & COMPONENTS + THE PARTS GALLERY** by Mike Tooley

### **ELECTRONIC CIRCUITS & COMPONENTS**

*Electronic Circuits & Components* provides an introduction to the principles and application of the most common types of electronic components and shows how they are used to form complete circuits. The virtual laboratories, worked examples and pre-designed circuits allow students to learn, experiment and check their understanding as they proceed through the sections on the CD-ROM. Sections on the disk include:

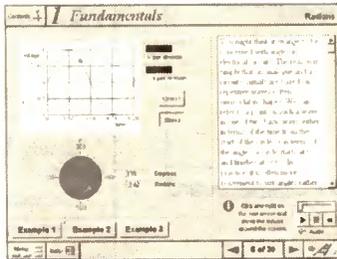
- Fundamentals:** units & multiples, electricity, electric circuits, alternating circuits.
- Passive Components:** resistors, capacitors, inductors, transformers.
- Semiconductors:** diodes, transistors, op.amps, logic gates.
- Passive Circuits**
- Active Circuits**

### **THE PARTS GALLERY**

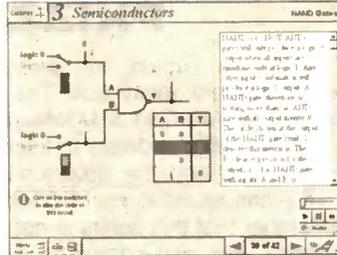
Many students have a good understanding of electronic theory but still have difficulty in recognising the vast number of different types of electronic components and symbols. *The Parts Gallery* helps overcome this problem; it will help students to recognise common electronic components and their corresponding symbols in circuit diagrams. Selections on the disk include:

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- Components Quiz**
- Symbols**
- Symbols Quiz**
- Circuit Technology**

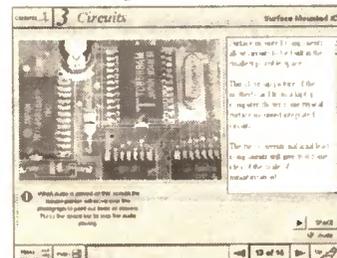
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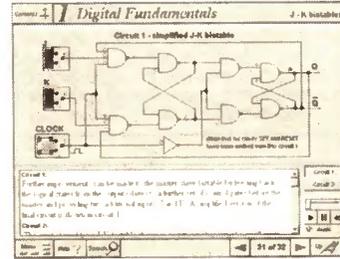
Logic laboratory



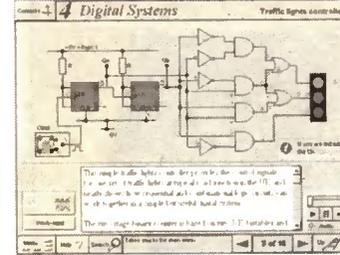
Circuit technology screen

## **DIGITAL ELECTRONICS** by Mike Tooley

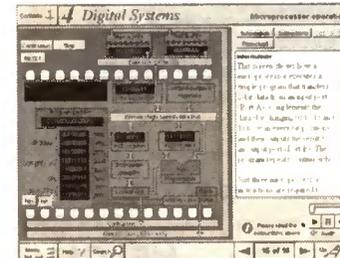
*Digital Electronics* builds on the knowledge of logic gates covered in *Electronic Circuits & Components*, and takes users through the subject of digital electronics up to the operation and architecture of microprocessors. The virtual laboratories allow users to operate many circuits on screen.



Virtual laboratory – flip-flops



Virtual laboratory – traffic lights



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A/D and D/A converters and their parameters, traffic light controllers, memories and microprocessors – architecture, bus systems and their arithmetic logic unit.

### **GALLERY**

A catalogue of commonly used IC schematics taken from the 74xx and 40xx series. Also includes photographs of common digital integrated circuits and circuit technology.

**NEW**

## **MODULAR CIRCUIT DESIGN** by Max Horsey and Philip Clayton

This CD-ROM has been developed from Max Horsey's *Teach-In* series *A Guide to Modular Circuit Design* (EPE Nov '95 to Aug '96). This highly acclaimed series presented a range of tried and tested analogue and digital circuit modules, together with the knowledge to use and interface them. Thus allowing anyone with a basic understanding of circuit symbols to design and build their own projects.

Essential information for anyone undertaking GCSE or "A" level electronics or technology and for hobbyists who want to get to grips with project design.

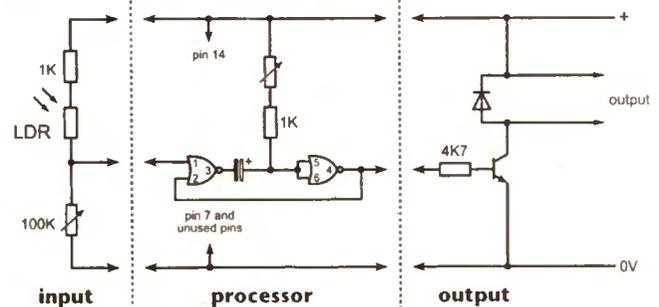
Over seventy different Input, Processor and Output modules are illustrated and fully described together with detailed information on construction, fault finding and components, including circuit symbols, pinouts, power supplies, decoupling etc. A full contents list and alphabetical index are provided and, at every stage, alternative modules are offered.

Written by a highly experienced author and teacher (Max is Head of Electronics at Radley College), this CD brings it all together for all students of electronics.

Single User Version £19.95 inc. VAT  
Multiple User Version £34 plus VAT

### **designing your circuit**

simply select your modules from the wide choice available, read how they work and join them up to make your circuit



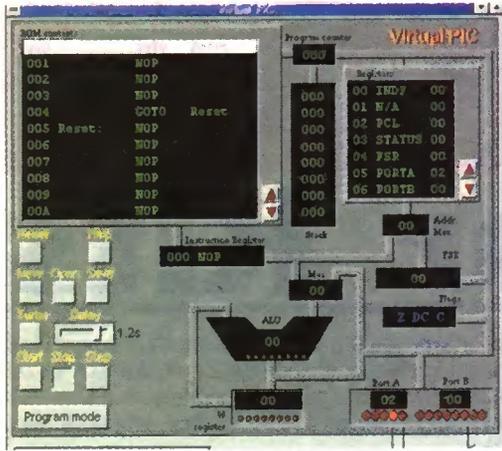
"I found that I could design a circuit without my teacher's help. And it worked! Everything was to hand - which chips to use - and which pins did what."

Andrew Preston (GCSE student)

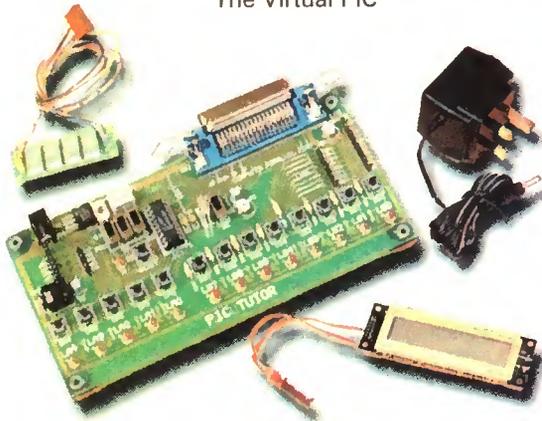
A Web Browser is required for Modular Circuit Design – one is provided on the *EPE CD-ROM No.1* (see opposite) but most modern computers are supplied with one.

Interested in programming PIC microcontrollers?

# PICtutor by John Becker



The Virtual PIC



Deluxe PICtutor Hardware

Developed from our famous and incredibly popular *EPE PIC Tutorial* series by John Becker (*EPE* March to May '98) this CD-ROM, together with the PICtutor experimental and development board, will teach you how to use PIC microcontrollers with special emphasis on the PICx84 devices. The board will also act as a development test bed and programmer for future projects as your programming skills develop.

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Whilst the CD-ROM can be used on its own, the physical demonstration provided by the PICtutor Development Kit, plus the ability to program and test your own PIC16x84s, really reinforces the lessons learned. The hardware will also be an invaluable development and programming tool for future work once you have mastered PIC software writing.

Two levels of PICtutor hardware are available – Standard and Deluxe. The Standard unit comes with a battery holder, a reduced number of switches and no displays. This version will allow users to complete 25 of the 39 Tutorials – it can be upgraded to Deluxe at a later date, by adding components, if required.

The Deluxe Development Kit is supplied with a plug-top power supply (the Export Version has a battery holder), all switches for both PIC ports plus l.c.d. and 4-digit 7-segment l.e.d. displays. It allows users to program and control all functions and both ports of the PIC and to follow the 39 tutorials on the CD-ROM.

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Demos (not Modular Circuit Design) available on the *EPE CD-ROM No.1* (Free with the November '98 issue) – send £2 for this CD-ROM if you require the demos. For Modular Circuit Design demo send £6.95 for cut down version (£5 refunded if you buy full version). **Minimum order** for credit card payment is £5.

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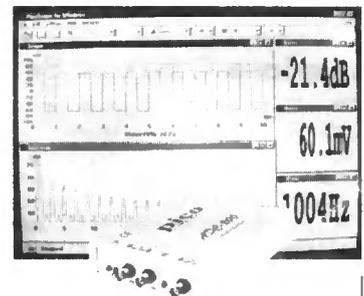
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Send your circuit ideas to: Alan Winstanley, *Ingenuity Unlimited*, Wimborne Publishing Ltd., Allen House, East Borough, Wimborne, Dorset BH21 1PF. They could earn you some real cash **and a prize!**

## Hot Wire Anemometer - *Ingenuity Unlimited*

**T**HE PRINCIPLE of the hot wire wind-speed indicator (anemometer) depends on an object, much hotter than its ambient surroundings, being cooled by an amount proportional to the wind speed. Here are two simple methods by which this principle can be utilised.

The circuit diagram shown in Fig.1a uses a self-compensating bridge circuit containing an op.amp IC1 and an NTC thermistor RTH1 (5k @ 25°C). On power-up, the op.amp output goes high, which drives transistor TR1 (an emitter follower) to feed more current into the bridge circuit comprising resistors R1, R3 and R4 and the thermistor.

With the values given, the thermistor self-heats until the value drops to 1 kilohm (at around 65°C) when it equals resistor R4 in value. Equilibrium is then established, so that the circuit supplies sufficient current to the thermistor to match heat losses through conduction or convection currents around the device.

If the thermistor (RTH1) is exposed to air flow, this results in a proportional increase in the op.amp output voltage which will try to maintain the state of equilibrium. In order to compensate for low ambient temperatures, a second thermistor (shielded from the wind), could be arranged to offer a small voltage output of appropriate polarity.

How an LM317 variable regulator, IC1, could be used in an alternative design is shown in Fig.1b. To self-heat the thermistor in still air so that its resistance is 1k requires

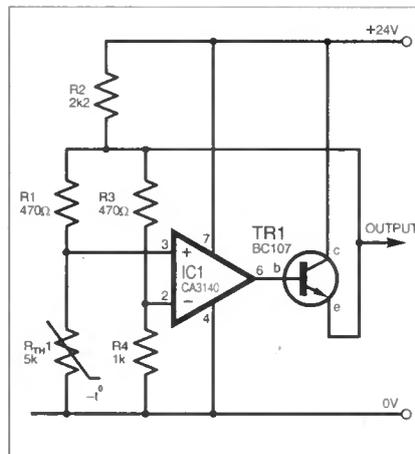


Fig.1a. "Hot-wire" principle Anemometer circuit.

a voltage across it of around 12V and a current of 12mA. Hence preset VR1 should be set to just under 100 ohms in value. The regulator output is 13V in still air and rises markedly when the thermistor is exposed to airflow.

A method of displaying the output on a microammeter is shown in Fig.1c, and it is also a good idea to decouple the "still air" quiescent voltage at the same time. This "still air voltage" could be nulled out by the current by using a -15V supply, so that

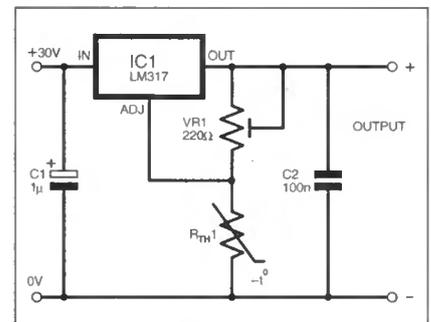


Fig.1b. Anemometer formed from a variable regulator.

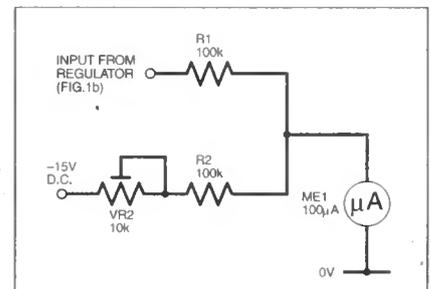


Fig.1c. Moving coil meter display for the Anemometer of Fig.1b.

the meter only registers the "excess" voltage developed by the airflow.

A.E. Whittaker, Stone, Staffs.

## Soldering Iron "Ready" Indicator - *Ingenuity Unlimited*

**T**HE SIMPLE circuit of Fig. 2 is suitable for indicating when your soldering iron has reached its operating temperature. It may be used in conjunction with any *thermostatic* iron such as the Weller TCP series, and it can even be used with thermostatic irons that use a low voltage power supply, and also electronically controlled irons.

The circuit is connected in series with the mains supply to the soldering iron. The l.e.d. D1 will illuminate when the iron is drawing enough current to drop a few volts across resistor R1. This means that when the thermostat in the iron switches off, the l.e.d. will extinguish to indicate that the iron is ready. The Zener diode D2 protects the l.e.d. against reverse voltages and limits the forward voltage to 5.6V.

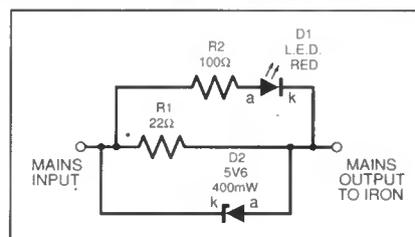


Fig.2. Circuit diagram for the Soldering Iron Ready Indicator. (See text for component ratings.)

With the values shown, load powers of between 45W and 60W are suitable. For other powers, resistor R1 is adjusted according to the

formula  $R1 = 1000/P$  ohms, where  $P$  is the power of the iron. This ensures about 15mA r.m.s. runs through the l.e.d. when the iron is warming up. For  $R1 = 22$  ohms and an iron of 45W, a normal 0.6W resistor is fine.

Resistor power dissipation is given by the formula:

$$P = \frac{1}{2} \left( \frac{P1}{Vs} \right)^2 R1$$

watts, where  $P1$  is the iron power and  $Vs$  is the mains r.m.s. voltage.

The circuit *must* be constructed within a fully *insulated plastic box* and care *must* be taken to ensure that no metal mounting screws etc. which are accessible to the user can become live. Use *nylon* mounting screws.

Jeremy Siddons,  
Buxton, Derbyshire.

## Lossless Current Sensing -

**C**ENTRE-TAPPED dual rectifiers instead of full-wave bridges are still used in some applications despite the poorer transformer utilisation and efficiency of the circuit. A simple way in which to sense the output current of this type of power supply, without the need to resort to "lossy" shunts or expensive Hall-effect devices, is shown in circuit diagram Fig.3.

A centre-tap rectifier draws d.c. current from each transformer secondary winding, whilst the primary current is alternating. This d.c. current corresponds to the average d.c. current and causes a voltage drop in the copper windings which can be measured. In Fig. 3, the winding resistance is actually used as a shunt resistor for the ammeter, so the apparent amp reading will increase with winding temperature by some 25 per cent.

Point "X" yields a negative d.c. voltage which is proportional to current taken from the d.c. output terminals. Resistors R1 and R2 should preferably be matched values to resolve low currents, though the test circuit used 5 per cent resistors and detected currents from 60mA up to 8A, which was the limit of the transformer.

Gerard la Rooy, New Zealand.

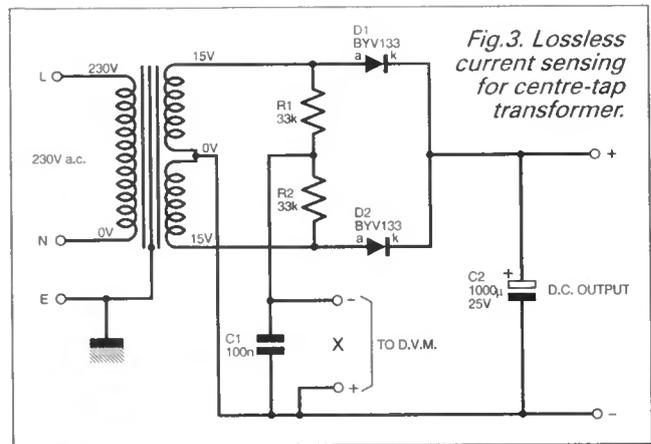


Fig.3. Lossless current sensing for centre-tap transformer.

## Foghorn Timing Switch -

**T**HE CIRCUIT illustrated in Fig. 4 was designed to sound a foghorn signal every two minutes as laid down in Rule 35 of the *International Regulations for Preventing Collisions at Sea, 1972*, and includes the following four signals:

1. Power vessel under way.
2. Power vessel stopped.
3. Sailing, fishing, towing, etc.
4. Vessel being towed.

Rule 35 does not apply to vessels less than 12 metres in length, although it does say, "if she does not, she shall make some other efficient sound signal at intervals of not more than two minutes."

The circuit idea consists of a 1-of-10 counter (IC1) clocked by a 555 (IC2). Steering diodes are used on appropriate outputs of the 4017 counter IC1 and are selected using a system of rotary switches to operate a transistor-driven relay. This in turn controls the foghorn, which sounds the corresponding number of blasts.

### Circuit Operation

Consider the circuit operation with the rotary 4-way 3-pole switch set at position "1". This generates a "dash" which is

common to all four patterns. It bypasses the switching system and is easily followed.

Operation revolves around the action of capacitor C2 and IC2. The potential across C2 alternates between 1/3 and 2/3 of the 12V supply. Pin 3 of the 555 switches high and low alternately, driving the boat's foghorn relay via transistor TR1, and also feeding back pulses to clock the 4017 chip.

The first four outputs Q0-Q3 of this decade counter (IC1) provide the "dashes and dots" and the remainder provide the delay of two minutes before IC1 is reset by the final count on pin 11, after which the cycle repeats. At switch-on, capacitor C2 is fully discharged, so pin 3 of the timer IC2 goes high and the horn sounds. Also at switch-on, a positive-pulse is applied through capacitor C1 to reset IC1 at pin 15, so pin 3 of IC1 is now high.

This "high" on Q0 (pin 3) starts to charge capacitor C2 via diode D1, potentiometer VR2, and diode D13 which allows the positive charging current to bypass VR7, whose function is to vary the spaces between the signal blasts. Eventually, in a time constant set by the combination of VR2 and C2, the timer output, IC2 pin 3, goes low, and C2 starts to discharge through VR7. Output Q0 of IC1 is still high but serving

no purpose. Eventually C2 discharges to 1/3 of the supply and IC2 output goes high. This clocks the 4017 and Q1 goes high.

Switch S1 is set to position "1", then Q1 output is diverted straight through via diode D2 and resistor R2, to turn on transistor TR2. Thus the output transistor TR1 is inhibited by shunting its base to 0V, and this principle is repeated for the rest of the outputs via the various switch contacts and diodes, although the 555 continues timing and resetting.

The rotary switch S1 can be moved to any of four positions to generate a sequence of foghorn blasts automatically. Switch S2 may be pressed to sound the horn manually.

Calibration is best carried out in position "4", with control VR3 set quite low. Set VR2 for a fairly long blast, followed by VR4 to VR6 for short blasts.

Next, select position "2" and adjust VR1 to lengthen the second dash, to match the first original long blast. Adjust VR7 for the interval between sounds, and finally VR3 to pad out the two minute interval. (So that you avoid incurring the wrath of fellow mariners, or at least alarming everyone, I suggest testing is performed using a 12V buzzer! A.R.W.)

Don Clark, Seaford, East Sussex.

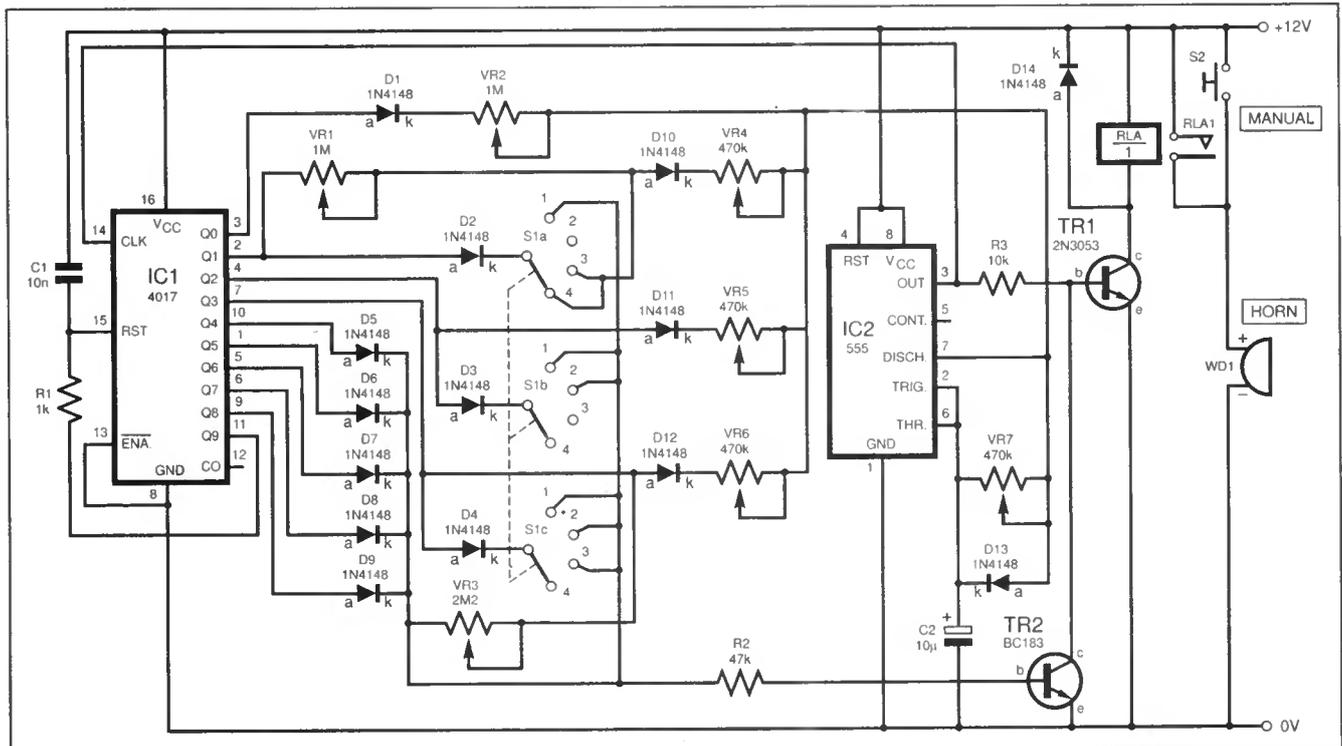


Fig.4. Circuit diagram for a Foghorn Timing Switch.

## TOROIDAL MAINS TRANSFORMERS

All with 220/240V primary winding

**24V + 24V** at 25VA would give 25V at 1A or 50V at 1/2A, price, £3. Order Ref: 3P245.

**30V + 30V** at 120VA would give 30V at 4A or 60V at 2A, price £8. Order Ref: 8PG2.

**110V + 110V**, at 120VA would give 110V at just over 8A or 220V at 1/2A, price £8. Order Ref: 8PG3.

**35V + 35V** at 150VA would give 35V at 6 1/2A or 70V at 2A, price £8. Order Ref: 8PG9.

**35V + 35V** at 220VA would give 35V at 6 1/2A or 70V at 3 1/4A, price £9. Order Ref: 9PG4.

**110V + 110V** at 220VA would give 110V at 2A or 220V at 1A, price £10. Order Ref: 10PG5.

**45V + 45V** at 500VA would give 45V at 11A or 90V at 5 1/2A, price £20. Order Ref: 20PG7.

**110V + 110V** at 500VA would give 110V at 5A or 220V at nearly 3A, price £25. Order Ref: 25PG8.



## SUPER WOOFERS.

A 10in. 4ohm with power rating of 250W music and normal 150W. Normal selling price for this is £55 + VAT, you can buy it £29 including VAT and carriage. Order Ref: 29P7. The second one is an 8in. 4ohm, 200W music, 200W normal, again by Challenger, price £18. Order Ref: 18P9. Deduct 10% from these prices if you order in pairs or can collect. These are all brand new in maker's packing.



## SMART HIGH QUALITY ELECTRONIC KITS

All kits are complete with p.c.b. and other components in a blister pack

CAT. NO.	DESCRIPTION	£
1003	5W electronic siren	2.53
1005	Touch switch	2.87
1008	SF function generator	6.90
1010	5-input stereo mixer with monitor output	19.31
1016	Loudspeaker protection unit	3.22
1017	30W linear CB	14.71
1020	0-50 minute timer	2.99
1023	Dynamic head preamp	2.50
1024	Microphone preamplifier	2.07
1025	7W hi-fi power amplifier	2.53
1026	Running lights	4.60
1027	NiCad battery charger	3.91
1030	Light dimmer	2.53
1032	Stereo tone control	4.14
1039	Stereo VU meter	4.60
1042	A.F. generator 350Hz-16kHz	1.70
1043	Loudness stereo unit	3.22
1047	Sound switch	5.29
1048	Electronic thermostat	3.68
1050	3-input hi-fi stereo preamplifier	12.42
1052	3-input mono mixer	6.21
1053	Electronic metronome	3.22
1054	4-input instrument mixer	2.76
1056	8V20V 8A stabilised power supply	12.42
1057	Cassette head preamplifier	3.22
1059	Telephone amplifier	4.60
1062	5V 0-5A stabilised supply for TTL	2.30
1063	12V 2A power supply	2.30
1064	+ 12V 0-5A stabilised supply	3.22
1067	Stereo VU meter with leads	9.20
1068	10V 0-5A stabilised power supply	2.53
1070	Hi-Fi preamplifier	7.47
1071	4-input selector	6.90
1082	Car voltmeter with i.e.d.s	7.36
1083	Video signal amplifier	2.76
1085	D.C. converter 12V to 6V or 7-5V to 9V	2.53
1086	Music to light for your car	4.60
1093	Windscreen wiper controller	3.68
1094	Home alarm system	12.42
1098	Digital thermometer, with i.c.d.	11.50
1100	2x18W interated amplifier	18.39
1101	Dollar tester	4.60
1106	Thermometer with i.e.d.s	6.90
1107	Electronics to help win the Pools	3.68
1112	Loudspeaker protection with delay	4.60
1113	2x18W power amplifier	5.98
1115	Courtesy light delay	2.07
1118	Time switch with triac 0-10 mins	4.14.
1122	Telephone call relay	3.68
1123	Morse code generator	1.84
1126	Microphone preamplifier	4.60
1127	Microphone tone control	4.60
1128a	Power flasher 12V d.c.	2.53
1133	Stereo Sound-to-Light	5.26

**BATTERY MOTOR WITH GEARBOX.** Will operate on any DC voltage between 6V and 24V, price £3. Order Ref: 3P108. A speed controller is available for this. £12 in kit form or £20 made up, but if you intend to operate it from the mains, then our power supply 2P3 will give you 3 speeds and will also reverse. Price of power supply is £2.

**ANOTHER PROJECT CASE.** Should be very suitable for a non-recognisable bug or similar hand-held device. It is 150mm long, 36mm wide and 15mm thick. Originally these were TV remote controls, price 2 for £1. Order Ref: 1068.

**A MUCH LARGER PROJECT BOX.** Size 216mm x 130mm x 85mm with lid and 4 screws. This is an ABS box which normally retails at around £6. All brand new, price £2.50. Order Ref: 2.5P28.

**BT TELEPHONE EXTENSION WIRE.** This is proper heavy duty cable for running around the skirting board when you want to make a permanent extension. Four cores properly colour coded, 25m length only £1. Order Ref: 1067.

**LARGE TYPE MICROSWITCH.** With 2in. lever, changeover contacts rated at 15A at 250V, 2 for £1. Order Ref: 1.21R7.

**MINI MICROSWITCH.** Only approximately 15mm long with a 20mm lever which could quite easily be removed, changeover contacts rated at 5A AC, 50p each. Order Ref: 1.21R8.

**FLEX PROTECTORS.** Rubber, 30mm long, 8mm diameter with a 12mm shoulder. Ideal for protecting flex passing through a metal panel, 5 for £1. Order Ref: 1.21R10.

**10K POT.** With double-pole mains on/off switch, good length of 1/2in. spindle and hex fixing nut, 50p each. Order Ref: 1.22R6.

**DITTO** but 5K. Order Ref: 1.11R24.

**AMSTRAD POWER SUPPLY/AMPLIFIER.** This is quite a big unit, measures approximately 8in. long and 3 1/2in. wide and has a heatsink approximately 3in. high. At one end is the mains transformer which looks to be about 40VA. Then there is an assortment of i.c.s., power transistors and the lead coming out terminates on a panel with twin speaker sockets and miscellaneous input sockets. Price £5. Order Ref: 1.1R2.

**BALANCE ASSEMBLY KITS.** Japanese made, when assembled ideal for chemical experiments, complete with tweezers and 6 weights 0.5 to 5 grams. Price £2. Order Ref: 2P444.

**SUPER CROMPTON PARKINSON MAINS MOTOR.** Really well made, totally enclosed by ventilated framework. Size approximately 4in. diameter, 4in. high and with 2in. of a 3/8in. spindle. Speed is 750rpm, hp is not quoted but we estimate this to be around 1/6hp. Price £10. Order Ref: 10P149.

**EQUIPMENT COOLING BLOWER.** Near enough 5in. square and 1 1/2in. thick but a really good air mover. Mains operated, price £4. Order Ref: 7.15L.

**OVEN THERMOSTAT** with knob calibrated so you can set it to cut out at any temperature up to 600°F. £3. Order Ref: 3P229.

**SPEAKER IN CABINET.** Just right if you want music in the garden. Cabinet size approximately 6in. x 5in. x 4in. thick, speaker is 6 1/2in. 8 ohm. These are ex-equipment but in tip condition, price £4 each or 2 for £7. Order Ref: 812L.

**PURE SINE WAVE GENERATOR.** All parts to make this, £3. Order Ref: 1.10R14.

**DOORBELL PSU.** This has A.C. voltage output so is ideal for operating most doorbells. The unit is totally enclosed so perfectly safe and it plugs into a 13A socket. Price only £1. Order Ref: 1.30R1.

**THIS MONTH'S TWO FOR ONE OFFER IS THE SWITCH MODE POWER SUPPLY** Made by Astec, outputs are 12V at 4A and 5V at 15A. This PSU can be modified with a few extra components and would then give 12V at 10A d.c. We give the details. The price is still £9.50 but you get two instead of one. Offer ends 31st December. Order Ref: 9.5P4.

**GEAR WHEELS.** Set of 5, quite small, should enable you to get a variety of speeds, mounted in a metal case but easy to remove and use separately. Price £1 the set. Order Ref: D409.

**WIND GENERATORS.** The ex-GPO alternator, our ref 5P249, has been used to generate from the wind. We understand it will light a 100W bulb or through rectifiers would charge batteries. These are ex-GPO equipment but fully guaranteed, price £5 each.

**CYCLE LAMP BARGAIN.** You can have 100 6V MES bulbs for just £2.50 or 1,000 for £20. They are beautifully made, slightly larger than the standard 6-3V pilot bulb so they would be ideal for making displays for night lights and similar applications. 50 joined in series can be connected to the mains and would make a very attractive window display. 100 for £2.50. Order Ref: 2.5P29.

**12Vx12V RELAY.** Miniature, clear plastic enclosed, has one set changeover contacts, one set that breaks contact and 3 sets that make contact. Price £1 each. Order Ref: GR30.

**COMPONENT MOUNTING PANEL.** Heavy Paxolin, size approximately 10in. x 2in. with 32 pairs of brass pillars for soldering or binding on components, £1. Order Ref: 1.7RC26.

**AIR-SPACED TUNING CAPACITOR.** Twin 100pF with trimmers, extra small. Fixed from the front by 3 screws, £2 each. Order Ref: 1.7RC29.

**PEA LAMPS.** Very tiny, only 4mm, but 14V at 0.04A, wire-ended, 25p each. Order Ref: 1.7RC28.

**HIGH AMP THYRISTOR.** Normal two contacts from the top and heavy threaded fixing underneath. We don't know the amperage of this but think it to be at least 25A. Price 50p each. Order Ref: 1.7RC43.

**THREE LEVEL PRESSURE SWITCH.** All 3 are low pressures and the switch could be blow-operated. With a suitable lubing these switches could control the level of liquid, etc., price £1. Order Ref: 67.

**BREAKDOWN UNIT,** Order Ref: BM41001. This is probably the most valuable breakdown unit that you have ever been offered. It contains the items specified below, just 2 of which are currently selling at £3.50 each. Other contents are:

Computer grade electrolytics, 330uF 250V DC, you get 4 of these, 4,700uF at 50V DC, you get 2 of these, 1,000uF at 16V DC, you get one of these, and 15A 250V double rocker switch, 115V to 250V selector switch. You also get a standard flat pin instrument socket, a 250V 5A bridge rectifier, 2 x 25A bridge rectifiers mounted on an aluminium heatsink but very easy to remove.

2 NPN powered transistors ref. BU447, currently listed by Maplins at £3.50 each, a power thyristor, Mullard ref. BTW69 or equivalent, listed at £3.

All the above parts are very easy to remove, 100s of other parts not so easy to remove, all this is yours for £5. Order Ref: 1.11R8.

**GLISTENING JEWEL CHRISTMAS LIGHTS.** This is a 40 light set which is twice the normal so you will have a tree to be really envied. If you put these around the door or window, it will please everybody. They are all ready with 2 spare bulbs, price £4.50. Order Ref: 4.5P2.

**35mm PANORAMIC CAMERA.** Has super wide lens, ideal for holiday viewing, is focus free and has an extra bright and clear viewfinder. Brand new and guaranteed, individually boxed, £6.50. Order Ref: 6.5P2.

**FLASHING BEACON.** Ideal for putting on a van, a tractor or any vehicle that should always be seen. Uses a Xenon tube and has an amber coloured dome. Separate fixing base is included so unit can be put away if desirable. Price £5. Order Ref: 5P267.

**MEDICINE CUPBOARD ALARM.** Or it could be used to warn when any cupboard door is opened. The light shining on the unit makes the bell ring. Completely built and neatly cased, requires only a battery, £3. Order Ref: 3P155.

**WATER LEVEL ALARM.** Be it bath, sink, cellar, sump or any other thing that could flood. This device will tell you when the water has risen to the preset level. Adjustable over quite a useful range. Neatly cased for wall mounting, ready to work when battery fitted, £3. Order Ref: 3P156.

**BIKE RADIO.** In fact, it's more than a radio, it's an alarm and a spotlight. The radio is battery operated, of course, and needs 3 AA cells. Only one band but this is the FM band so will receive Radio 1 and 2. Comes complete with handlebar fixing clips. Price £4. Order Ref: 4P72.

**PLAY THAT TUNE.** Hand-held 'Rainbow Piano'. Driven by 2 AA batteries. Has 22 playing keys and 2 others, one for rhythm and one for tempo. A beautifully made little unit, comes complete with the piano songcard which shows the user which buttons to press for 'London Bridge', 'Happy Birthday to You', 'Jingle Bells' and other tunes. An ideal stocking filler that any child will be delighted with. Price £3. Order Ref: 3P101B.

**BUMP 'N GO SPACESHIP.** A wonderful present for a budding young electrician. It responds to claps and shouts and should it strike an object, it will set off in another direction. Kit contains all the parts and a youngster should be able to assemble but you might have to help with the soldering of the components onto the p.c.b. The assembly instructions are very detailed and explicit and providing he follows the step by step illustrations then a successful spaceship will result, price £9. Order Ref: 9P9.

**PHILIPS 9in. MONITOR.** Not cased, but it is in a frame for rack mounting. It is high resolution and was made to work with the IBM 'One per disk' computer. Price £15. Order Ref: 15P1.

**METAL CASE FOR 9in. MONITOR.** Supplied as a flat pack, price £12. Order Ref: 12P3.

**TELEPHONE EXTENSION LEAD.** Nicely made and BT approved. Has the plug into BT socket one end and the telephone socket the other end, total length 12m, £2. Order Ref: 2P338.

**ORGAN MASTER KEYBOARD.** Three octave keyboard, extremely well made and with piano size keys. New and unused, only £5. Order Ref: 5P282.

**INSULATION TESTER WITH MULTIMETER.** Internally generates voltages which enable you to read insulation directly in megohms. The multimeter has four ranges, AC/DC volts, 3 ranges DC milliamps, 3 ranges resistance and 5 amp range. Ex-British Telecom but in very good condition, tested and guaranteed, probably cost at least £50 each, yours for only £7.50 with leads, carrying case £2 extra. Order Ref: 7.5P4.

**REPAIRABLE METERS.** We have some of the above testers but faulty, not working on all ranges, should be repairable, we supply diagram, £3. Order Ref: 3P176.

**LCD MULTIRANGE VOLTMETER/AMMETER.** A high quality 3 1/2 digit i.c.d. panel meter, incorporating an A-D converter chip (7106) to provide 5 voltage ranges and 5 current ranges within one unit. Ranges are selected by onboard connectors and expandable by resistors. Price £11.50. Order Ref: 11.5P2.

**PIANO ON KEY CHAIN.** Although it is quite small, only 20mm long, it will play any tune. Instructions with it tell you which keys to press for 'Happy Birthday', 'Twinkle Twinkle Little Star', 'Jingle Bells' and 'London Bridge'. It is also a light, it has a little lamp which can be operated by the end switch. Battery operated (not included), price £1.50. Order Ref: 1.5P39.

**12V RECHARGEABLE YUASA BATTERY.** Sealed so usable in any position - suit golf trolley, lawn mower, portable lights, etc., only £3.50. Order Ref: 3.5P1.

**CHARGER FOR YUASA BATTERY.** This battery charger plugs into a 13A socket, charges at approximately 1/2A so it would charge this battery overnight. Complete with croc clips, ready to go, £5. Order Ref: 5P269.

**QUARTZ CLOCK MOVEMENT.** A quality made movement with quartz crystal accuracy. Requires only one AA battery which will keep it going for 2 years or more. It is self-starting and maintenance-free. An extremely reliable unit. Universally applicable and easy to mount with centre fixing. Ideal if you want to give someone a special present of a picture with a clock. Complete with a set of hands. Price £3. Order Ref: 3P111.

**8mm PROJECTORS.** With zoom lens, brand new and perfect, complete with one reel and handbook. Regular price over £100, yours for £39. Order Ref: 39P1.

Ditto but with sound as well and a mike, £49. Order Ref: 49P1. The zoom lens alone is worth more.

**SOLDERING IRON.** Super mains powered with long life ceramic element, heavy duty 40W for the extra special job. Complete with plated wire stand and 245mm lead, £3. Order Ref: 3P221.

**DIGITAL THERMOMETER.** Suitable for outdoors or indoors, has an extra wide temperature range - 50°C to +70°C. Its sensor can be outside but with the readout inside, £4. Order Ref: 4P104.

**DYNAMIC MICROPHONE.** 500 ohm, plastic body with black mesh head, on/off switch, good length lead and terminated with audio plug, £2. Order Ref: 2P220.



**1/10th HORSEPOWER 12V MOTOR.** Made by Smiths, the body length of this is approximately 3in., the diameter 3in. and the spindle 1/2in. diameter. Quite a powerful little motor which revs at 2000rpm. Price £6. Order Ref: 6P47.

**MINI BLOW HEATER.** 1kW, ideal for under desk or airing cupboard, etc. Needs only a simple mounting frame, price £5. Order Ref: 5P23.

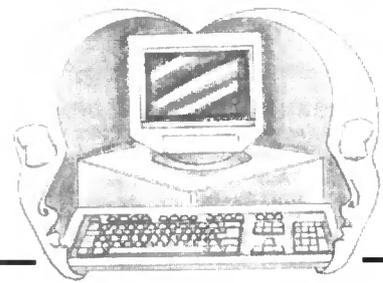
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# INTERFACE

Robert Penfold



## SERIAL L.C.D. REMOTE MONITOR FOR YOUR PC

IN THE previous *Interface* article (Sept '98) we considered the subject of using "intelligent" liquid crystal display (l.c.d.) modules as a simple form of monitor for a PC. Interfacing to the PC was via the "easy route" provided by a parallel printer port. Some readers prefer to use a PC serial port wherever possible because their PC has a spare serial port, but the parallel port or ports are occupied. Serial interfacing also has a potential advantage in that it can be used with long connecting cables, and in this application a simple two-wire link is all that is needed. This opens up the possibility of using an l.c.d. module as a remote monitor for a PC.

As explained in previous *Interface* articles, operating your PC add-ons via a serial port is inevitably more complex than using a parallel port. One reason for this is simply that the interface must include parallel-to-serial and (or) serial-to-parallel conversions in addition to the main circuit of your add-on device.

There can also be problems with a lack of handshake lines. A serial port does actually have handshake inputs and outputs, but these only provide basic on/off control of the data flow. Your add-on may require something more than this, and it is often necessary to improvise in order to obtain the desired result.

A serial interface is also relatively slow, but this does not matter in all applications, and is of no significance in the current context. An ordinary serial interface can transfer one or two kilobytes per second, which is sufficient to rewrite the display in a fraction of a second.

### Perfect Timing

The block diagram of Fig.1 helps to explain the way in which this serial interface for l.c.d. modules functions. As explained in the previous *Interface*

article, it is possible to read information from the modules, but in normal operation this is unnecessary. Accordingly, this l.c.d. interface can write data to the module but it cannot read any status information from it.

The serial to parallel conversion is provided by a 6402 UART (universal asynchronous receiver/transmitter), and in this case only the receiver device is utilized. No connections are

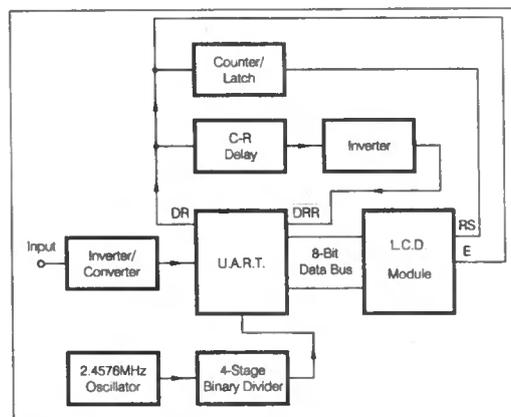


Fig.1. Block diagram for the Serial L.C.D. Monitor for your PC.

made to the transmitter section of the device.

Due to the lack of any clock or other timing signals the transmitting and receiving devices can only be accurately synchronized by using standard transmission rates. This interface is designed to operate at 9600 baud, which means that bits are sent at a rate of 9600 bits per second.

The UART's clock signal is at 16 times the required baud rate, which works out at 153.6kHz for a baud rate of 9600. This is provided by a 2.4576MHz crystal oscillator and a four stage (divide by 16) binary counter circuit.

### New Data

RS232C serial interfaces do not use normal 5V logic levels, but instead operate with nominal signal voltages of plus and minus 12V. The input signal must therefore be processed to produce an output at normal logic levels for the UART. Also, the raw input signal is of the wrong polarity and must be inverted before it is fed to the UART. A single transistor inverter stage is all that is required to provide this signal conditioning.

As soon as bytes of data have been decoded they are placed onto the 8-bit output of the UART. This is fine as far as it goes, but the l.c.d. module has no way of knowing when new data is present on the data bus. Each time new data is placed on the bus a strobe pulse must be applied to the enable (E) input of the l.c.d. module. The "data ready" output of the UART goes high each time new data is placed on the outputs, and this flag can be reset by taking the "data reset ready" input of the UART low.

In this interface the data "ready output" is automatically reset by feeding it from the "data ready reset" output via an inverter. A simple C-R circuit provides a delay that stretches the output pulse produced at the "data ready" output, and this ensures that it reliably latches data into the l.c.d. module.

### Short-Comings

This still leaves a major short-coming in that two types of data are written to the module. Initially two or three bytes of data are written to the module to set it to the correct operating mode, and the "register select" (RS) input of the module must be held low while these instructions are sent. Then the "register select" input is taken high, and further

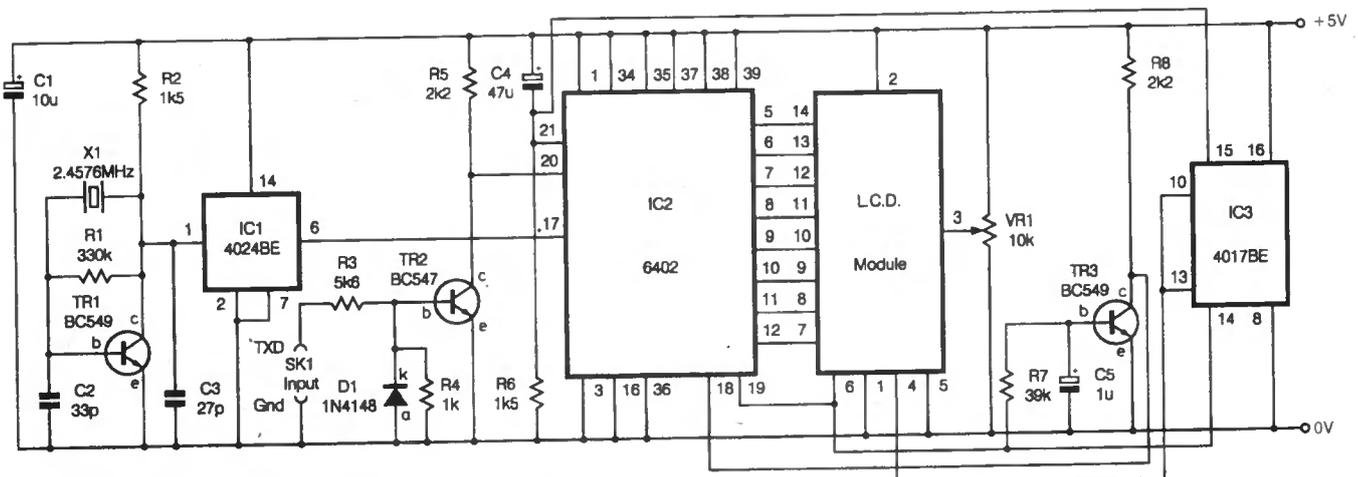


Fig.2. Full circuit diagram for the Serial L.C.D. Monitor for your PC.

bytes of data are interpreted as character information.

The simple system used in this interface has a counter that holds the "register select" input low for the first three bytes of data, and holds it high thereafter. This enables the module to be set up in the required manner, and it can then be fed with the relevant data information.

There is an obvious flaw in this arrangement, which does not permit the module to be set back to the command mode to permit cursor positioning. Despite this limitation the interface is perfectly usable, and it is just a matter of using the mode of operation that automatically scrolls the display each time it receives a new byte of data. The cursor remains stationary and the display scrolls to the right, rather than vice versa.

If necessary, with this mode of operation the screen can be cleared simply by writing a series of spaces to the module so that any existing characters are scrolled to the end of the display. Admittedly this scrolling method of operation is relatively crude, but it keeps the interface reasonably simple, and also avoids complications in the software.

### Circuit Details

The full circuit diagram for the Serial L.C.D. Remote Monitor for PC interface appears in Fig. 2. Transistor TR2 is used in the inverter stage at the serial input, and it operates as a simple common emitter switch. The clock oscillator uses TR1 in a conventional crystal oscillator circuit, and IC1 is the four stage binary divider. The 4024BE used for IC1 is actually a seven-stage divider, but in this circuit only the first four stages are used. As suggested by the "universal" part of its name, the UART (IC2) can handle any normal serial word format. Its control inputs are hard-wired for operation with one start bit, eight data bits, one stop bit, and no parity checking. A long positive reset pulse is required at switch on, and this is provided by capacitor C4 and resistor R6.

The eight data outputs of IC2 connect direct to the corresponding inputs of the l.c.d. module. Potentiometer VR1 is the contrast control for the display module, it is adjusted for the best display quality.

### Data Ready

The "data ready" output of IC2 (pin 19) drives inverter TR3 by way of a simple C-R timing circuit that is comprised of resistor R7 and capacitor C5. The inverted signal at the collector of TR3 drives the "data ready reset" input of IC2 (pin 18).

As explained previously, this produces a positive pulse each time fresh data is placed on the outputs of IC2. This pulse is fed to the "enable" input of the l.c.d. module (pin 6) to indicate that new data is available, and it is also fed to the clock input of IC3 (pin 14). The latter is a 4017BE decade counter and one-of-10 decoder.

The l.c.d. module's RS input (at pin 4) is driven from output 4 (pin 10) of IC3's decoder section, which goes low at switch-on when IC3 is reset by the same reset circuit that is used for the UART. After three bytes of control data have been written to the l.c.d. module, output 4 goes high, taking the module into the mode where it treats received data as character information.

It also takes the "inhibit" input of IC3 high so that further pulses at the clock input have no effect. After the initial three bytes of data the l.c.d. module therefore treats all further data as characters to be displayed.

### Power Point

Due to the use of CMOS integrated circuits and a liquid crystal display the total current consumption of the circuit is typically less than 10mA. There is no 5V output available from a PC serial port, but methods of obtaining a suitable supply from one of the other ports have been described in previous articles. If you have a fairly modern PC it might be worthwhile investigating its USB ports, as these can provide a 5V supply output.

The connections to the serial port are made via a 9-way or 25-way female D-connector, depending on the style of serial port used on your PC. Connection details for both types of port are provided in Fig. 3.

### Software

The interface will only work properly if the serial port is set for the correct baud rate and word format. From MS-DOS this is achieved using the Mode command. For serial ports one and two respectively, use the command "com1:96,n,8,1," or "com2:96,n,8,1,".

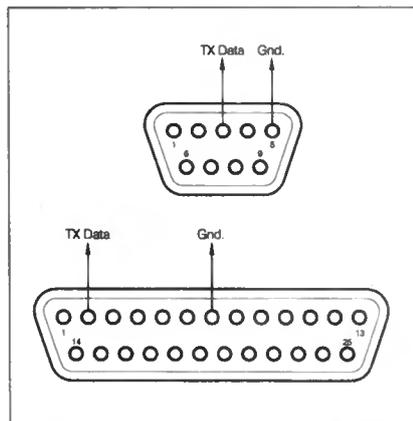


Fig.3. Connection details for both types of PC serial port.

The easiest way of sending serial data is to write information to the base address of the appropriate serial port. This is either &H3F8 for serial port one, or &H2F8 if you are using serial port two.

As the Serial L.C.D. Remote Monitor for PC interface does not use any form of handshaking it is necessary to provide a hold-off to prevent data from being written at an excessive rate. The speed of the system is limited by the rate at which the serial interface can transfer data, and with a baud rate of 9600 just over one millisecond is required per byte of data.

The accompanying GW-BASIC listing sets the display module to the correct mode of operation and then transfers single characters from the keyboard to the module. Note that the GW-BASIC INPUT function will not accept a space as a valid character for a text string, and that entering a space will terminate the program with an error message.

Line 20 assigns a value of &H2F8 to the variable SPORT (serial port), and this is the address of serial port 2. If you are

### Listing 1: L.C.D. Test Program

```

10 REM LCD TEST PROGRAM
20 SPORT=&H2F8
30 OUT SPORT,48
40 GOSUB 130
50 OUT SPORT,14
60 GOSUB 130
70 OUT SPORT,5
80 GOSUB 130
90 INPUT$
100 A=ASC(A$)
102 IF A=36 THEN GOTO 200
110 OUT SPORT,A
120 GOTO 90
130 FOR D=1 TO 2000
140 NEXT
150 RETURN
200 FOR C=1 TO 40
210 OUT SPORT,32
220 GOSUB 130
230 NEXT C
240 GOTO 90

```

using the interface on serial port 1, a value of &H3F8 must be used here instead.

The next six lines of the program output three bytes of data to the display, and these set it to the correct operating mode. First a value of 48 sets the display to single line operation, 8-bit data transfers, and the normal 7x5 font. Then a value of 14 switches on the display and selects a visible but non-blinking cursor.

Finally, a value of 5 sets the entry mode, and in this case the cursor is set to stay at the left of the display with the on-screen characters scrolling one place to the right each time a new character is received. A subroutine provides a delay that ensures the data is not written to the display too quickly.

### Character Loop

The next part of the program is a loop that waits for a character to be entered at the keyboard, and the RETURN key to be pressed. It then outputs the corresponding ASCII value to the display, which should produce the appropriate character immediately to the right of the cursor.

The program loops indefinitely so that you can enter as many characters as you like, but they must only be entered one at a time. The usual CONTROL-BREAK combination will terminate the program.

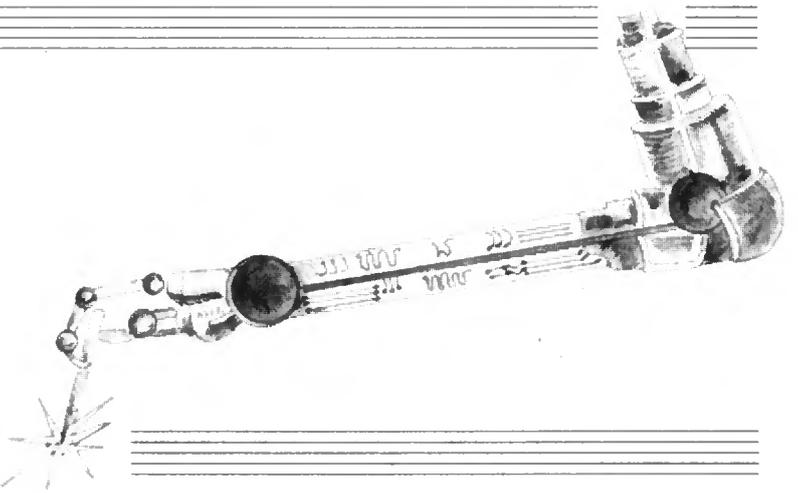
Entering a dollar (\$) sign causes the program to branch to the subprogram at line 200. This loops the program 40 times, writing a space (ASCII value 32) to the l.c.d. module on each loop, so that the screen is cleared.

There is a minor irritation when using the l.c.d. module in the right scrolling mode, which is that the text strings have to be written in reverse order! Thus, in order to display "Hello-World" it is actually "dlroW-olleH" that has to be written to the display.



# CIRCUIT SURGERY

ALAN WINSTANLEY



We take a quick look at null modem leads for PhizzyB followers, and we check out relay ratings and light-dependent resistors too, with a simple light-dependent switch circuit.

## Null Modems and D-connectors

If you're interested in learning about how computers work, and how to use your PC to program and control external circuitry, you need look no further than our new *PhizzyB Computers* series. This combines an interactive demonstration tool with a real hardware *PhizzyB* connected to your serial port.

You can then assemble a program on your PC using the *PhizzyB Simulator* editor, and download it using the *PBLink* utility to a real *PhizzyB*. You can then run the same program both on your PC as well as the real thing: the real hardware version will then interface to other add-on units including (next month) a Liquid Crystal Display and (later) an Infra-Red Communications System and more.

The *PhizzyB* requires a *null modem* serial cable to be used to connect to the "host" PC. Such cables are also used when connecting one PC to another, to enable games or file transfers between two PCs. The Tx/D and Rx/D signals cross over within the cable, to connect the transmit data of one port to the receive data of the other. (Magenta Electronics offer a full kit (or ready assembled) *PhizzyB* and they

can also supply the null modem cable, see their advert elsewhere in this issue).

Some bucket-part PCs have serial ports mounted on the chassis with a separate off-board bracket and ribbon cable, whilst many serial ports mount directly onto the motherboard. The latter type seem to be more common and use 9-pin D-connectors, but we have come across some examples where 25-pin serial ports are used.

The numbering scheme for 9-pin and 25-pin D-type *female* connectors, as used in the suggested null modem lead, seen from the rear (solder) view of the sockets is shown in Fig.1a. However, things can get very confusing, especially when comparing female and male D-connector numbering schemes, which are mirror images of one another.

Note the sequence of numbering on the D-connectors in Fig.1b, where this time they are compared with the *pin* view rather than the solder view. In a *female* connector, pin 1 is top-right, but is top-left in a *male* plug as shown. Obviously if you turn the plug around to insert it into the socket, then you will soon see that the pin numbers of both components all correspond.

This stands to reason and looks obvious, but it can be very confusing especially when confronted with D-connectors for the first time. Luckily, manufacturers often annotate the pins of their connectors in the plastic moulding just to be sure, but whenever you are interpreting any interwiring diagrams, you can save yourself some wasted effort and delicate soldering by double checking whether the diagram is the solder view or the pin view, and whether it's a female or male connector!

To round off this topic, Fig. 2 shows the interwiring diagrams for 9-pin and 25-pin null modem leads. All views are of the solder-sides of the connectors. Be sure to confirm the type of serial port used on your own PC before you purchase any parts, though.

## Pull-ups and Relays

*Mr. Harsh Mehta* had a variety of queries as follows:

*Can you provide me some guidance with the following queries? I would like to know*

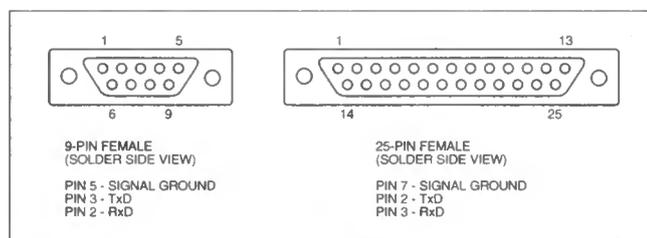


Fig.1a. Pin numbering schemes of 9-pin and 25-pin female D-type connectors, shown from "solder" view.

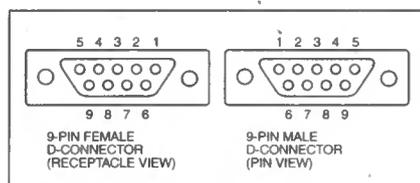


Fig.1b. Comparison of the schemes for 9-pin D-type male and female connectors, taken from the receptacle or pin view. The same principle applies to large connectors.

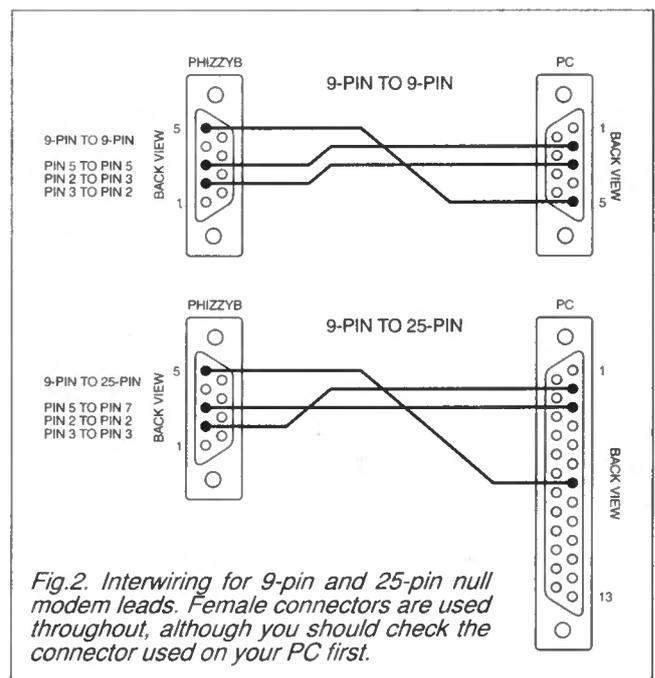


Fig.2. Interwiring for 9-pin and 25-pin null modem leads. Female connectors are used throughout, although you should check the connector used on your PC first.

what is the use of Pull-Up and Pull-Down resistors and how do they function?

Also, with mechanical relays I found the following specifications. 24V D.C./220V A.C. What does this mean? Are there A.C. and D.C. relays? How do they work? Last of all, what is a Photo Cell and how does it work? (By E-mail.)

There's quite a lot to deal with, so let's start with your question concerning pull-up resistors. These are used in logic circuits to ensure that a logic input is normally biased towards a logic '1', say +5V; then when a logic 0 signal comes along, the input is taken low by the signal.

Conversely, a pull-down resistor biases that point to logic 0 (the 0V rail) instead. This is necessary if you want to ensure that a particular point is firmly held at a logic high or low, in between data being received by that input.

In discrete logic circuits, ordinary resistors can be used whose values are not particularly critical (say 10k (kilohms) or so for bipolar, or 1M (megohms) for CMOS). A good example will be seen in the PhizzyB constructional article this month, in which a series of switches are hooked to a PhizzyB input port (see Fig. 3).

The inputs to the switches (S1 to S8) are all wired to +5V (logic high) and the outputs connect directly to the input data bus of the PhizzyB via a 20-way ribbon cable. If any of the switches are open (off) then the corresponding input data line could be left "floating" (unconnected) in an indeterminate logic state, which may affect the reliability of the data read by the PhizzyB from that port. Hence it was decided to force all unused inputs low by using 4k7 pull-down resistors.

Rather than use separate discrete resistors we utilised a single-in-line (s.i.l.) package, which contains nine resistors all commoned together (one is unused). This common is connected to 0V (logic low), to produce a convenient bank of pull-down resistors. (By wiring this terminal high to +5V, a series of pull-up resistors could be created instead.)

Obviously, the common pin must be correctly identified and wired low, hence the need to identify it as pin 1. In the case of the specified Bourns resistors, pin 1 is marked with a dot on the body.

## Relay Contacts

Your question on relays next. The two main aspects to check are the *contact ratings* and the *relay coil values*. A relay manufacturer such as Omron will quote the following values for the coil and the contacts.

The **maximum switching voltage** is the maximum *open circuit* load voltage that can be switched by the relay contacts. You will often see both d.c. and a.c. values quoted.

The **maximum switching current** is not surprisingly the maximum current (a.c. or d.c.) which the contacts are able to interrupt without damage. This may sometimes be lower than the *carry current*, which is the (higher) value the contacts

can handle providing they don't have to interrupt the circuit as well.

Bear in mind that a certain amount of relay contact arcing and switch bounce will occur when the load is switched, which eventually causes the contacts to pit and "soot up": the makers will obviously restrict the maximum values which the contacts can be expected to switch reliably. Somewhat higher currents can often be carried by the contacts if they are not expected to switch at those levels.

Another specification is the **maximum switching capacity**, which is the maximum permissible contact load in Watts or VA. This is not necessarily the same as the value obtained by multiplying the maximum contact ratings (in Volts and Amps) together, as it depends on the load being switched.

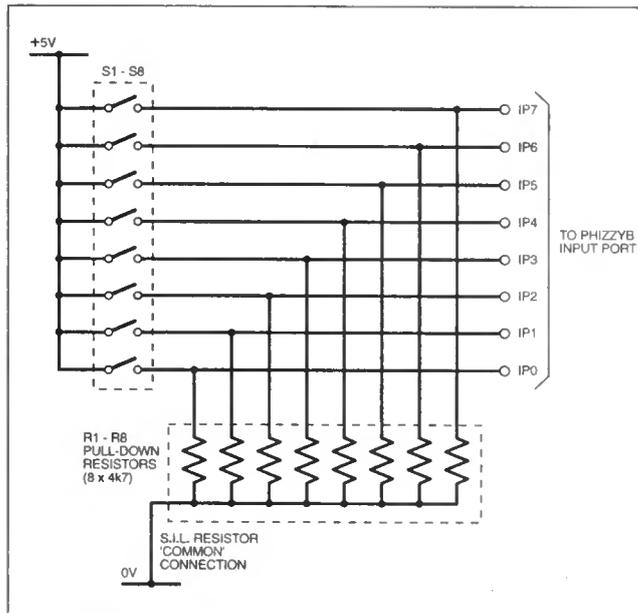


Fig.3. PhizzyB input port experiment, using 8-way d.i.p. switch and a s.i.l. resistor network for pull-down resistors.

A simple resistive load (such as a large heating element) is "kindest" to relay contacts but if complex electrical loads are used (including inductors, motors or fluorescent lighting, which include a power factor correction capacitor) the relay contacts must be de-rated substantially as per the load's VA rating. I'm not too sure why a **minimum switching capacity** is sometimes quoted, I guess it relates to the minimum load required to overcome contact resistance and electrical noise.

Other parameters for the contacts are usually less critical, and include the *operate time* and *release time*, in milliseconds. Whether one period is greater than the other depends on the mechanical design of the relay.

A figure of 10ms to 15ms is typical for a large power relay, but a small telecommunications type relay used in a modem could switch in 3ms. (Figures for contact bounce times of say 0.3ms to 0.5ms can sometimes be quoted which can be critical to the work of telecoms or logic designers.)

## Coil Ratings

Looking next at the coil ratings, two values will be specified, the **coil voltage** and its **resistance**. As you spotted for

yourself, you can buy both a.c. and d.c. voltage coils. Flicking through a relay manufacturer's catalogue, one popular range of plug-in relays includes both a 110V d.c. coil (resistance 9,300 ohms, current 12mA - as calculated by Ohm's Law), and a 110V a.c. coil (1,800 ohms 20mA).

The current drawn by that a.c. coil depends on its a.c. resistance or *inductive reactance* (which is why Ohm's Law doesn't work!), so a.c. and d.c. coils should not be considered as interchangeable merely because their voltage rating is the same. Some a.c. coils may be specified at 50Hz or 60Hz operation or "dual frequency", remembering that frequency has a bearing on the reactance of a coil and the current drawn.

The d.c. coil's resistance is of interest to hobbyists because using Ohm's Law, we can calculate the direct current needed by the coil, and then the additional circuitry can be designed (e.g. using a transistor buffer - see *Circuit Surgery* last month). Don't forget to use a reverse diode across a d.c. coil, to shunt out the enormous *back-e.m.f.* that a relay coil generates when it switches off.

This is created when the magnetic field which surrounds the coil suddenly implodes back into the windings and induces a voltage in the coil. A 12V coil can produce as much as **300V reverse e.m.f.** which is clearly a potential source of trouble for any components in the same circuit.

If much larger loads are to be controlled (such as giant pumps or process machinery), industrial engineers will employ what is effectively a huge version of a power relay - a clunky device called a *contactor*, which has separate coil and contacts mounted together in a control box, along with stop/start push-button controls. Check any of the larger catalogues for details.

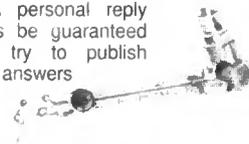
## Light-dependent switch

Looking at your final question, a "photo cell" is just the popular name coined for a photo-conductive cell, which is nothing more than a light-dependent resistor (l.d.r.) based on cadmium sulphide (CdS). They respond to light in the visible and infra red spectrums.

An l.d.r. should not be confused with a "photo-voltaic cell" which actually

### 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](mailto: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.



creates a small voltage relative to incidental light levels. In the golden days of *Everyday Electronics*, using an l.d.r. in a project (e.g. my world-beating *Auto Nightlight* of July 1978 vintage) always implied using the ORP12, as manufactured at the time by Mullard. There are several alternatives readily available today.

As a final wrap this month, Fig. 4 shows a suggested circuit based on a transistor Schmitt trigger, which combines an l.d.r. with a transistor-driven relay to produce a light-dependent switch suitable for dusk-to-dawn switching. Just the thing for these winter months!

Component values are not critical, and you should not be afraid to substitute for other parts to hand. See you next month!

• Apologies to regular readers for any delay in responding to your growing mountain of letters and E-mail. Every item is read and I will attempt to reply as soon as possible. — Alan

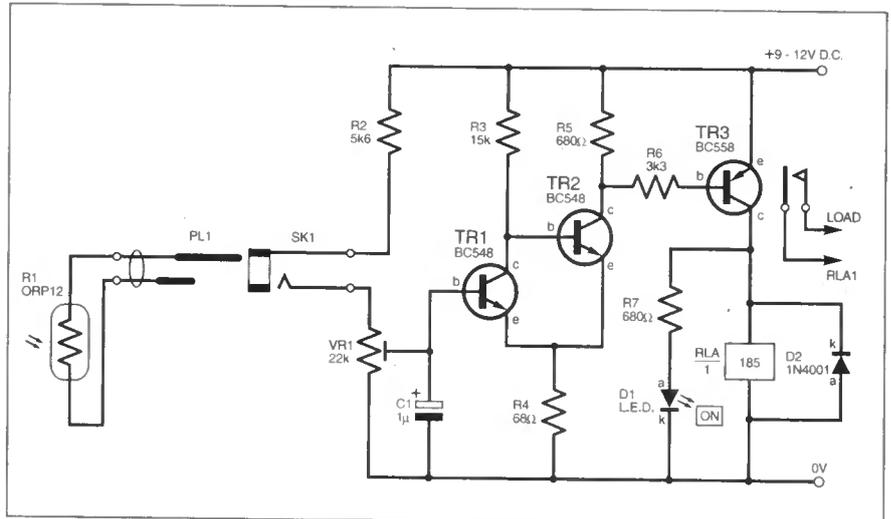


Fig. 4. A light-operated, "snap action" circuit using an l.d.r. (light-dependent resistor R1) as a sensor to control a transistor-driven relay. Components are not critical and preset VR1 sets the switching level.

## SHOP TALK

with David Barrington

### Handheld Function Generator

With such a small-sized project, obviously the choice of components for the *Handheld Function Generator* is crucial if they are to fit in the specified neat case. Also, the type and placing of the switches and controls on the printed circuit board is important — so take care.

Starting with the small sloping front case, it can be used either way up, the only source we have found is from **Maplin** (☎ 01702 554000) code KC96E. This case has a cable "knock-out" disc for lead entry and is just made for the probe. The recommended probe comes in two sections, metal tip and insulating cover. This was purchased from **Farnell** (☎ 0113 263 6311) code 497-204 (black) or 497-198 (red), these come in packs of five.

The sub-min. p.c.b. mounting slide switches used in the model also came from Farnell: 3-way double-pole, code 733-672; 2-way single-pole, code 733-647. The switch mounting socket-pins come as 32-way strips and are cut to size with an art knife or side-cutters. These should be generally available and usually sold as "modular connectors" intended for mother-daughter boards. Try Maplin, code DC17T. Do not forget to remove the plastic shroud from the switch centre pin sockets.

Turning our attention to the capacitors. These were ordered from the above two companies, although most of our components advertisers should be able to come up with suitable caps; but check out sizes before purchase. The polyester capacitors came from Maplin's layer range and the sub-min. electrolytic from Farnell's MS7 series, code 490-684.

Only use the specified 7621 CMOS op.amp in this circuit. Although some alternative op.amps are quoted as capable of working at a 3V supply, they either work poorly or not at all below 3V. The data for the 7621 claims a minimum supply of around 1V. The TDA7052 low-voltage power amp should not be too hard to find. The same comment applies to the screened stereo chassis jack socket.

Moving on to the modular potentiometer package, with several accessory options. You need to order a "vertical" and a "horizontal" type here, as a 100 kilohm type is not available in the vertical version. Unusually, horizontal and vertical in this case refer to the *control shaft* and not the mounting of the presets. These controls were ordered through Maplin, codes DT46A (H) and DT35Q (V).

There are a number of alternative control shafts listed and the larger dual-shaft was ordered (Maplin DT49D) as it has serrated control ends. As it is longer than needed, you will have to cut off the excess flush with the underside of the p.c.b.

The small printed circuit board, including the N-cell board, is available from the *EPE PCB Service*, code 213.

### EPE Mind PICKler

Although construction of the *EPE Mind PICKler* project is not covered until next month, we have included the components list, and made available the p.c.b., this month so that constructors can buy in parts now. Having said that, not too many items stand out as special, hard to find, components.

So, let us start with the ready-programmed PIC. A 7-program PIC16F84 microcontroller is being made available to readers (*mail order only*) by the author for the sum of just £10 inclusive UK. Overseas readers must add an extra £1 for postage and packing (overseas orders must be in pounds sterling).

Orders should be sent to the following and all payments made out

to Mr A. Flind at 22 Holway Hill, Taunton, Somerset, TA1 2HB. No callers.

If you wish to do your own programming, the software is supplied as TASM source and object files on a 3.5in. PC-compatible disk from the Editorial Offices, see *EPE PCB Service* page 913. There is an admin charge of £2.75 each (UK). For overseas readers, the charge is £3.35 (surface mail) and £4.35 (airmail). If you are an Internet user, it can be downloaded *Free* from our FTP site: <ftp://ftp.epemag.wimborne.co.uk/pub/PICS/MindPICKler>. It was also on last month's *Free* CD-ROM.

Regarding the semiconductors: op.amps type OP296 (code NP22Y) and OP279 (code NP18U), 5V voltage reg. (AV35Q) and quad Schmitt NAND gate 74HC132 (AE72P) all came from Maplin. You must purchase transistors with the L suffix as other types have different pinouts.

The case used for the model is a Vero Patina type (Maplin NC90X) that has been introduced to succeed their 200 series. This is a fairly expensive case and readers may care to choose their own style.

The printed circuit board is available from the *EPE PCB Service*, code 214. Finally, please heed the warning notice about PICKler's use!

### Fading Christmas Lights

You must use high quality capacitors in the *Fading Christmas Lights* project where they are required to operate in association with the mains supply. They *must* be Class-X types rated for *direct* connection across the mains, and no doubt advertisers will be able to supply the required item.

The chokes L1 to L3 may prove a problem. The type used in the prototype are known as "open toroidal" suppression types and were ordered from **Farnell** (☎ 0113 263 6311), 581-239. The plastic bodied pushswitches also only seem to be stocked by the above, code 140-690.

A pre-programmed microcontroller type PIC16C54N can be obtained from the author at £9.50 (including postage). Please send cheques/postal orders to: **B. Trepak, 20 The Avenue, London W13 8PH**. Mail order only — no callers. Overseas orders must include payment in pounds sterling with a banker's draft drawn on a bank with a UK address.

If you do intend to do your own programming, the software listing is available from the Editorial Offices on a 3.5in. PC-compatible disk, see *EPE PCB Service* page 913. There is a nominal admin charge of £2.75 each (UK), the actual software is *Free*. For overseas readers, the charge is £3.35 surface mail and £4.35 airmail. If you are an Internet user, it can be downloaded *Free* from our FTP site: <ftp://ftp.epemag.wimborne.co.uk/pub/PICS/xmastlights>.

The printed circuit board is available from the *EPE PCB Service*, code 215. You *MUST* use a tamperproof plastic box for this project.

### PhizzyB I/O Board

Talking to Alan W, we found that, although he purchased his components for the *PhizzyB I/O Board* from Farnell, most items are standard and it's a matter of shopping around for "best price". Alternative, cheaper connectors, all from **Maplin**, would be: 20-way IDC non-latch box header, FJ14Q; 20-way 0.05in. IDC con., FG84F; 20-way flat IDC cable, XR74R.

The 4-section printed circuit board is available from the *EPE PCB Service*, code 216 (see page 913).

### Damp Stat

Not much to report on the parts needed for the *Damp Stat* project as nearly all seem to be "off-the-shelf" types. You will probably be offered 18-turn or 22-turn square cermet presets, either will do. See *PICKler* entry regarding semiconductors. The printed circuit board is obtainable from the *EPE PCB Service*, code 209 (see page 913).

# KITS WANT MORE FOR YOUR MONEY?

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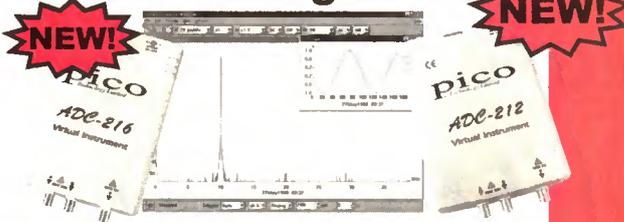
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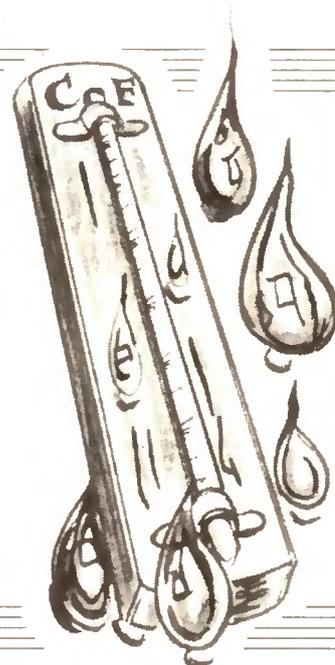
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# DAMP STAT ELECTRONIC THERMOSTAT

ANDY FLIND Part Two



*Control the environment inside your workshop/garage, or anywhere dampness is likely to invade!*

**T**HIS project is an extension to last month's T-Stat Electronic Thermostat controller system. Damp is often a problem for anyone using a garage or outhouse of any kind as a workshop, and for the electronic hobbyist it can be particularly serious.

The author uses part of a garage, partitioned off and lined with sheets of thick expanded polystyrene for thermal insulation. Although not an ideal solution this was cheap to construct and is satisfactory so long as the damp is effectively controlled.

## DAMP STAT

To achieve this a special thermostat was designed and built. Whilst the workshop is in use the thermostat's Run setting is selected and it operates in the usual way, heating the room to an adjustable preset temperature for comfort. At other times a Standby setting causes the inside temperature to "track" 10°F above the outside temperature.

This low temperature differential coupled with good thermal insulation means the system is not too costly to run but there is always a tendency for dampness to migrate towards the outside. The system has been in operation for about twelve years now and works very well so readers seeking a solution to their own problems of damp may like to try it.

The original circuit recently developed a minor fault. Whilst this proved to be only a faulty preset resistor in the indicator circuit it was difficult to repair since this older mains-powered design can at best be described as lethal! It was this occurrence that led to the design of a new version using the much safer separate mains Power Controller unit described in the Nov '98 issue.

## CIRCUIT DESCRIPTION

The full circuit diagram for the Damp Stat is shown in Fig.1. It uses two LM335Z temperature sensors, one for inside and one for the outside temperature. In this circuit they are fitted with calibration trimming resistors so that their outputs can be adjusted to correspond correctly.

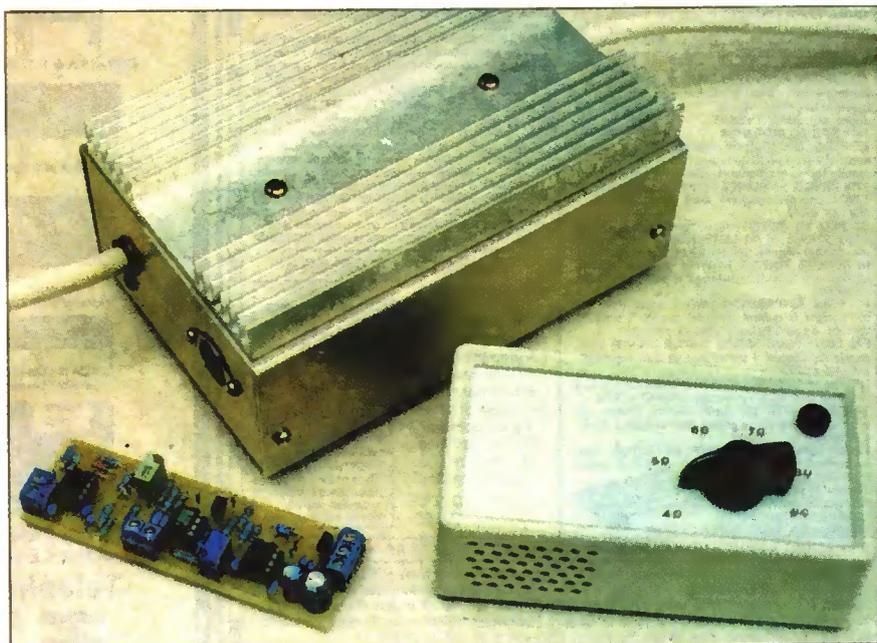
The outside sensor IC1 is supplied with a current of about 1mA by resistor R1. This current also flows through R2 so the voltage at the top of this resistor is about 51mV higher than the output from IC1,

corresponding to a temperature increase of about 10°F.

The network of resistors and potentiometers, comprising VR2, R4, R5, R6 and R7 with VR3, set up reference voltages corresponding to 40°F and 80°F for the upper and lower limits of the inside thermostat control's range. Resistors R4 and R5 "swamp" variations in the total value of VR3 and also provide a voltage equivalent to 60°F.

There is little point in allowing the heating in Standby mode to operate above 60°F. It is also undesirable to let the internal temperature fall to freezing, if only to prevent ice forming in the p.c.b. etching fluid!

Therefore, a dual clamping circuit prevents the signal from the top of resistor R2 from rising above the equivalent of 60°F or dropping below 40°F. This is accomplished by the two op.amps in IC2 which act as comparators and clamp the voltage from R2 through diodes D1 and D2 as appropriate.



Damp Stat p.c.b. together with last month's Power Controller and Room Temperature Thermostat.

## RAIL-TO-RAIL

The output part of the circuit is built around dual op.amp IC4. IC4a simply buffers the input voltage selected by switch S2. This will correspond to either the Outside temperature plus 10°F or the current Interior setting from control VR3.

The buffered voltage from IC4a is fed to comparator IC4b, which compares it with the input from the inside temperature sensor IC3 and turns the output to the Power Controller unit on or off accordingly through transistor TR1. Resistors R11 and R12 provide positive feedback equivalent to about one degree F for a positive switching action. L.E.D. D3 indicates when the output is On whilst R13 provides a low impedance path to negative for the control connection when it is Off.

A special feature of IC4 is that its outputs are "rail-to-rail". The circuit was originally designed with the 7621 device which also has this feature, as used by the simple *Room Temperature Thermostat* featured last month. However, a difference of several degrees between indicated and operating temperatures soon became apparent due to the high input offset voltages

of the 7621. The simple solution to this problem was to replace the 7621 with an OP296GP device which has a much better offset specification.

## TEMPERATURE METERING

Accurate voltage signals corresponding to both input and output temperatures are available in this circuit so it is worth providing an indicator. IC5 forms a meter amplifier providing indication through a 100µA moving-coil meter.

Preset control VR5, together with resistors R15 and R14, allow adjustment of the zero setting. Span adjustment is not required since the combination of resistors R16 and R17 provide an accuracy within 1% for a span of 0°F to 100°F.

Although an indication is unlikely to be needed below about 20°F, the indicated value is still easy to read and this scale does avoid the need for recalibrating the meter scale, which will almost certainly be marked 0 to 100. Resistor R18 limits the meter current to a safe value if the input is overdriven. Switch S1 selects the signal from the outside sensor or the inside one,

or shows the current setting of the thermostat control VR3.

Power for the Damp Stat will normally be taken from the low-voltage supply in the Power Controller unit (last month), which is regulated to 12V by IC6 with decoupling capacitors C11 to C14. Readers may have noticed that this circuit has plenty of low-pass filtering and bypass capacitors.

The reason for this is that about a year or so after the author's original design was built new neighbours moved into an adjoining property. They turned out to be CB enthusiasts, and each time the "rig" was keyed the workshop heating sprang into life! Extensive h.f. suppression and bypassing was required to cure the problem, so this new version has this included from the outset.

## CONSTRUCTION

Most of the components for this project are mounted on a small printed circuit board (p.c.b.), as shown in Fig.2. This board is available from the *EPE PCB Service*, code 209.

Construction should be straightforward if resistors, diodes and small capacitors are

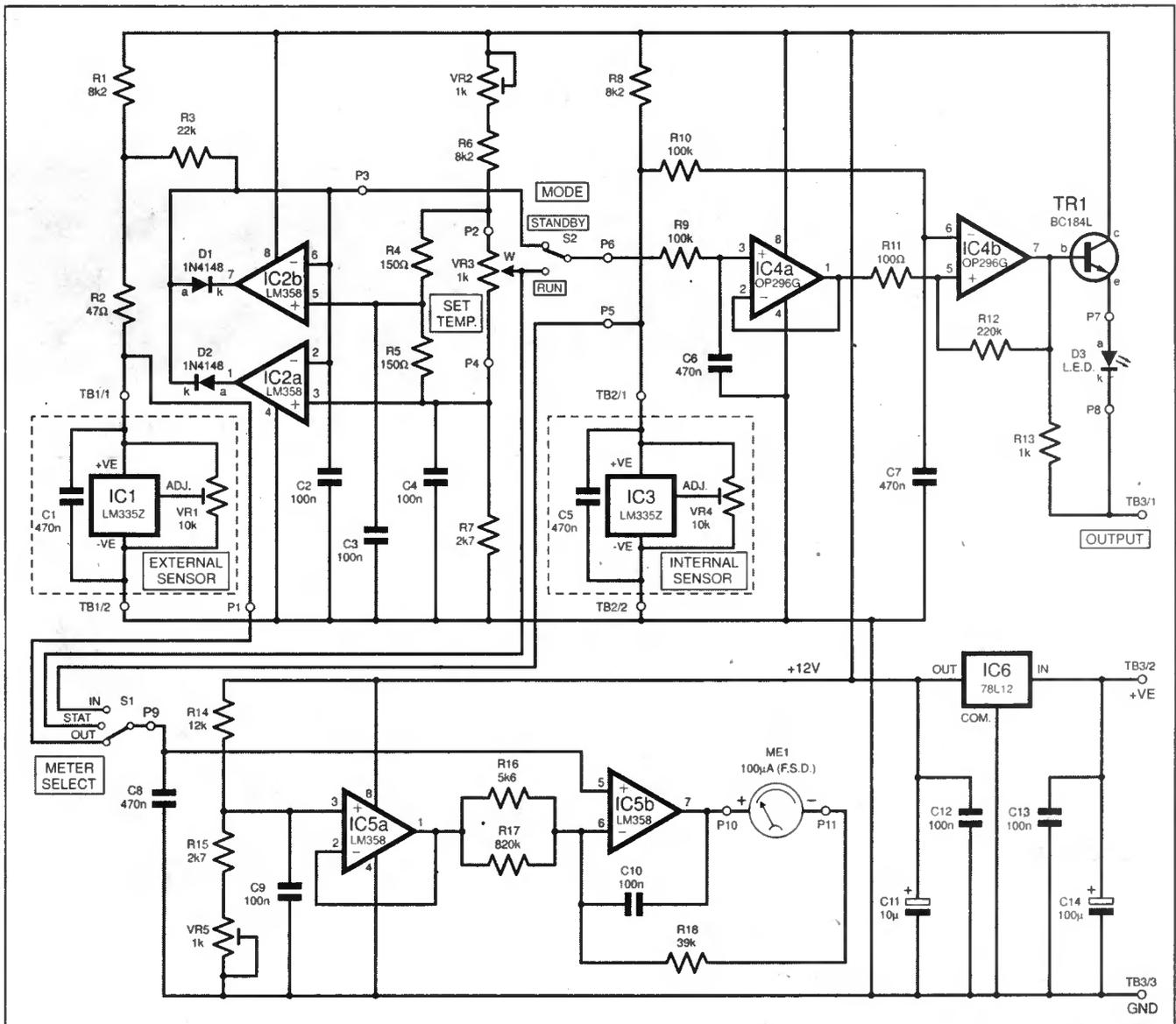


Fig. 1. Complete circuit diagram for the Damp Stat. The circuit is powered from one of last month's two Power Controllers.

fitted first, followed by larger or vertically taller components such as IC6, TR1, terminal blocks and electrolytic capacitors.

Finally, d.i.l. sockets should be used for IC2, IC4 and IC5, the i.c.s should *not* be inserted at this stage.

## TESTING

Testing begins with the provision of a supply voltage, either from one of the

mains Power Controller units (last month) or from a bench supply in which case it should be set to give about 15V. The presence of the 12V regulated supply from IC6 should be checked.

The meter circuit should be calibrated first as this can be used for checking and setting up the rest of the circuit. IC5

should be inserted, the meter should be connected to points J(+) and K(-) and a flying lead can be fitted to the meter circuit input point I.

A test input is needed for checking the sensor inputs, the easy way to provide one is to connect a 1 kilohm potentiometer with two resistors across the outside sensor

# COMPONENTS

## Resistors

R1, R6, R8	8k2 (3 off)
R2	47Ω
R3	22k
R4, R5	150Ω (2 off)
R7, R15	2k7 (2 off)
R9, R10	100k (2 off)
R11	100Ω
R12	220k
R13	1k
R14	12k
R16	5k6
R17	820k
R18	39k

All 0.6W 1% metal film

See  
**SHOP  
TALK**  
Page

## Potentiometers

VR1, VR4	10k 22-turn square cermet preset (2 off)
VR2, VR5	1k 22-turn square cermet preset (2 off)
VR3	1k rotary carbon, lin.

## Capacitors

C1, C5, C6,	470n resin-dipped ceramic (5 off)
C7, C8	
C2, C3, C4,	100n resin-dipped ceramic (7 off)
C9, C10,	
C12, C13	
C11	10μ radial elect. 63V
C14	100μ radial elect. 35V

## Semiconductors

D1, D2	1N4148 signal diode (2 off)
D3	5mm red l.e.d., 10mA type
TR1	BC184L npn silicon transistor
IC1, IC3	LM335Z temperature sensor (2 off)
IC2, IC5	LM358 dual op.amp (2 off)
IC4	OP296GP dual CMOS op.amp, rail-to-rail output
IC6	78L12 12V 100mA positive voltage regulator

## Miscellaneous

S1	3-way single-pole rotary switch
S2	s.p.d.t. toggle switch
ME1	100μA moving-coil meter
TB1, TB2	2-way p.c.b. mounting terminal block, low profile (2 off)
TB3	3-way p.c.b. mounting block, low profile

Printed circuit board available from the *EPE PCB Service*, code 209; plastic or metal case, size and type to choice; 8-pin d.i.l. socket (3 off); plastic knob; multistrand connecting wire; solder pins; solder etc.

**Approx Cost**  
Guidance Only **£23**  
excluding meter

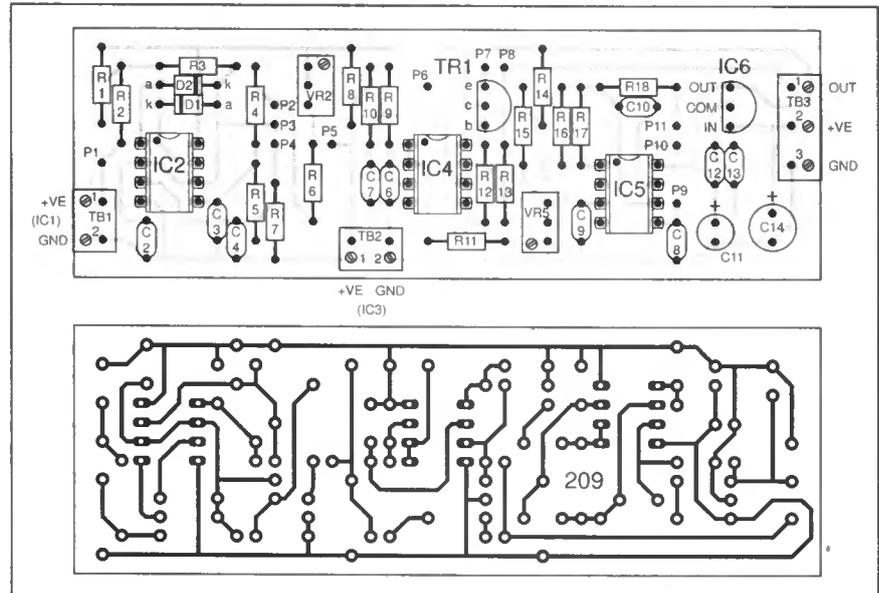
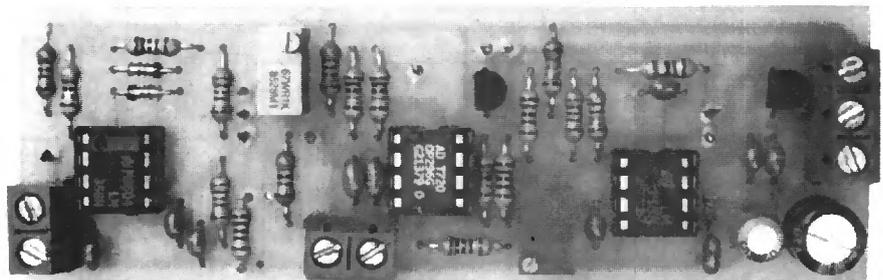


Fig.2. Printed circuit board component layout and full size underside copper foil master pattern for the Damp Stat.



Layout of components on completed printed circuit board.

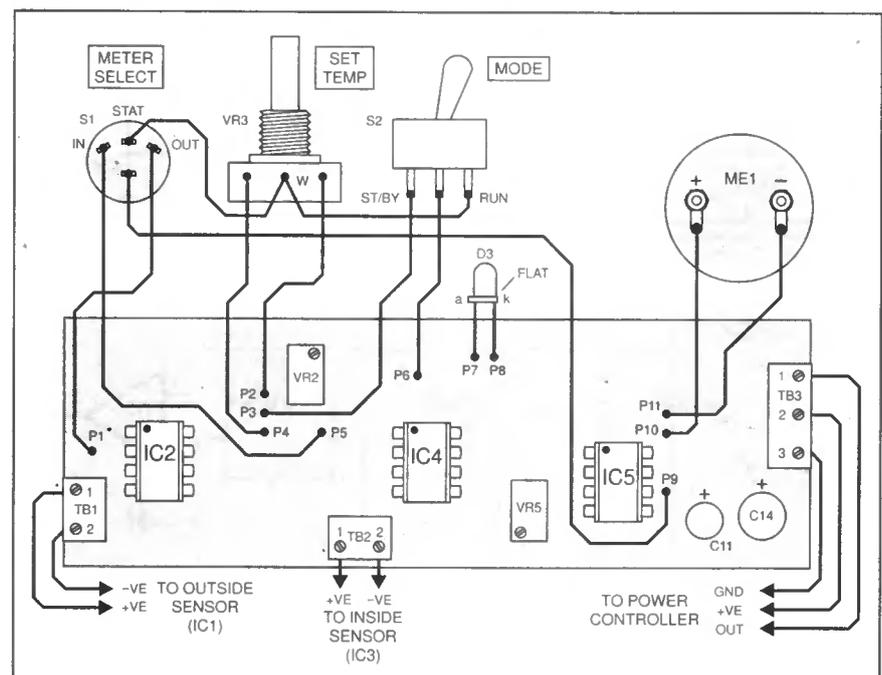


Fig.4. Interwiring details from p.c.b. to off-board components.

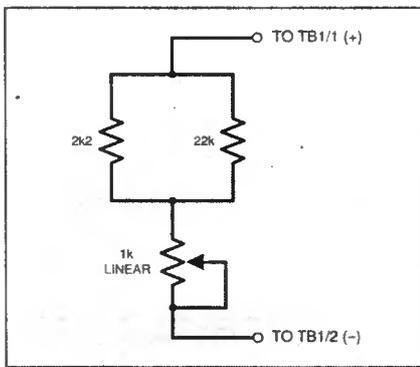


Fig. 3. Test input circuit diagram.

input TB1/1 and TB1/2 as shown in Fig. 3. This will provide input voltages equivalent to about  $-35^{\circ}\text{F}$  to  $120^{\circ}\text{F}$ . Using a DVM (digital voltmeter), the voltage across this can be adjusted to 2.832V which is equivalent to  $50^{\circ}\text{F}$  or half-scale on the meter.

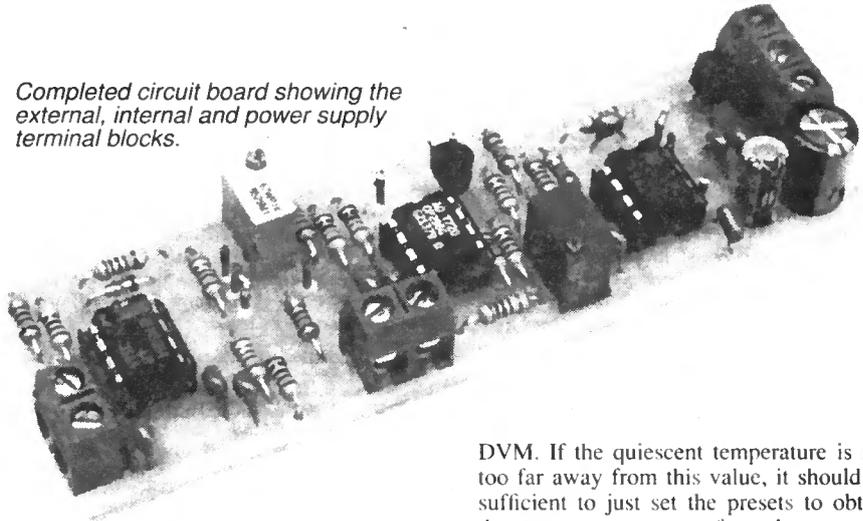
The meter input from point I should now be connected to TB1/1 and the multi-turn preset VR5 adjusted for a half-scale reading. Control VR3 should now be temporarily connected, and the meter can be used to monitor its bottom connection to point D whilst this is adjusted with preset VR2 for a reading of  $40^{\circ}\text{F}$ .

Next, IC2 should be inserted and the Standby voltage from point C should be monitored with the meter whilst the test input is raised and lowered. It should be found that this input will not go above  $60^{\circ}\text{F}$  or below  $40^{\circ}\text{F}$ , indicating correct operation of the clamp circuit.

We can now fit IC4 and the input to resistor R9, point F, connected to the wiper of VR3. L.E.D. D3 should be temporarily connected and a 1 kilohm resistor should be connected between the output and 0V connections of TB3 so that D3 will light when the output is On.

The test input should now be moved to the terminal block for the interior sensor IC3, TB2. The meter can be used to set the thermostat control VR3 to, say  $60^{\circ}\text{F}$ , then

Completed circuit board showing the external, internal and power supply terminal blocks.



used to monitor the applied test input. As this is raised and lowered past the set point D3 should turn on and off, indicating correct operation.

Following this, it only remains to fit the circuit into a suitable case and make the necessary external connections to the p.c.b. as shown in Fig. 4 to complete the main part of the project.

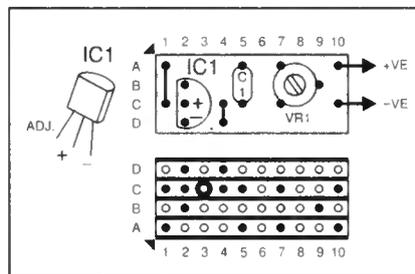


Fig. 5. Stripboard details for Sensors.

## SENSORS

The two sensors should now be built and calibrated. Both are assembled on small pieces of 0.1in. matrix stripboard as shown in Fig. 5.

The official way to calibrate an LM335Z sensor i.e. is to raise it to a temperature of  $25^{\circ}\text{C}$ , then adjust the preset to obtain an output of 2.982V using a

DVM. If the quiescent temperature is not too far away from this value, it should be sufficient to just set the presets to obtain the correct output for the current temperature, using the circuit's own meter as an indicator for this adjustment.

In the author's installation the interior sensor is fitted into a plastic 35mm film container mounted some distance from the control box. This was partly because the older circuit generated some heat and with this new version it could be fitted into the same case as the p.c.b. The choice is up to the constructor, but whichever is used, holes should be provided in the case to allow air to flow around it.

The external sensor will not need to have such a rapid response but it will probably have to be weatherproof. The prototype was fitted into a small plastic box and potted with some silicone rubber compound. This obviously makes it impossible to repair, but in twelve years it has yet to fail. It should, of course, be positioned where it is sheltered from sunlight, rain, strong winds and other sources of heat or cold which might interfere with its correct operation.

The economy of operation of this circuit obviously depends upon good insulation and draughtproofing of the premises to which it is fitted. Provided this is reasonably efficient it should help to minimise damp with surprising efficiency, giving long-term protection to vital equipment and paperwork.

## LM335Z Precision Temperature Sensor

The LM335Z is a temperature sensing i.c. It acts a bit like a Zener diode, in that when fed with a fairly constant current of between  $400\mu\text{A}$  and  $5\text{mA}$ , usually with a single resistor from the positive supply, a voltage develops across it. This voltage is linearly proportional to temperature at the rate of  $10\text{mV}$  per degree C.

The starting point for this voltage, however, is "absolute zero", which most readers will recall from their schooldays as being the equivalent of  $-273.15$  degrees C. This means that at 0 degrees C as we know it, "freezing point", the output from the LM335Z will be about 2.7315 volts.

The accuracy of the device isn't spot-on as supplied, it is quoted as being within two degrees over its operating range of  $-10^{\circ}\text{C}$  to  $+100^{\circ}\text{C}$ . However, this can be improved to within  $1^{\circ}\text{C}$  with a simple preset adjustment which is shown in the *Damp Stat* project.

### Calculations

Calculation procedures to convert temperature to voltage and vice-versa are as follows:

#### Temperature to Voltage:

Degrees F . . .  
Subtract 32  
Multiply by 5  
Divide by 9  
Degrees C . . .

Divide by 100  
Add 2.7315  
= Output Voltage . . .

#### Voltage to Temperature:

Volts . . .  
Subtract 2.7315  
Multiply by 100  
= Degrees C . . .  
Multiply by 9  
Divide by 5  
Add 32  
= Degrees F . . .

#### In Comparison

The LM35CZ and LM35DZ are similar devices with built-in current sources, already trimmed to within one degree C. They have internal offset compensation so that output starts at 0 degrees C.

However, use of a separate output terminal means that three connections are required to a remote sensor instead of just two, and they are also more expensive. Where measurements are to be made below 0 degrees C a circuit capable of working below the negative supply to the i.c. is required. These limitations make the cheaper LM335Z the preferred choice for this project.

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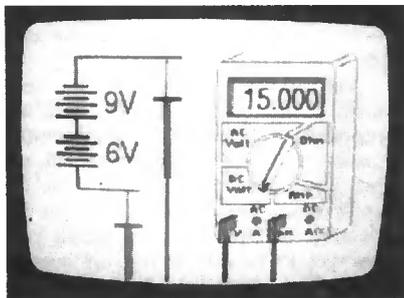
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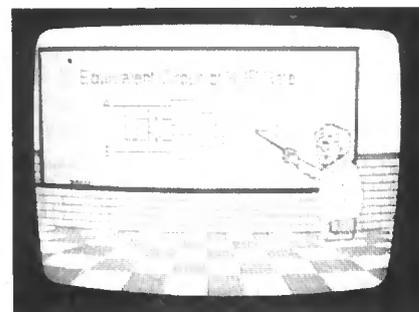
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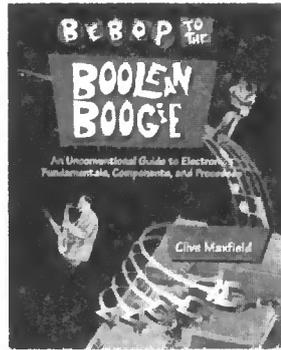
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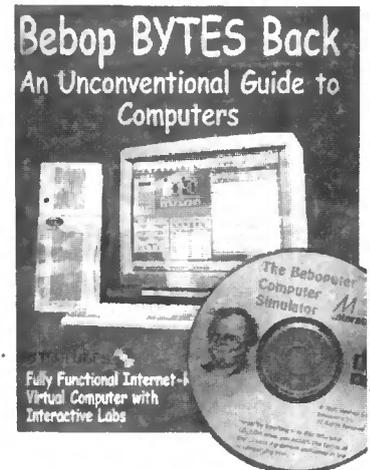
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Software programs for EPE projects are available on 3.5 inch PC-compatible disks or via our Internet site. Those marked with a single asterisk \* are all on one disk, order code PIC-DISK1, this disk also contains the *Simple PIC16C84 Programmer* (Feb '96). The *EPE PIC Tutorial* (\*\*) files are on their own disk, order code PIC-TUTOR. The disks are obtainable from the *EPE PCB Service* at £2.75 each (UK) to cover our admin costs (the software itself is free). Overseas (each): £3.35 surface mail, £4.35 airmail. All files can be downloaded free from our Internet FTP site: <ftp://ftp.epemag.wimborne.co.uk>.

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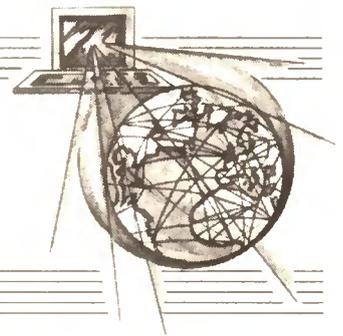
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# SURFING THE INTERNET

# NET WORK



ALAN WINSTANLEY

WELCOME to this month's *Net Work*, our column specially written for Internet users. One or two changes are taking place on the *EPE* web site, including a new link to our Internet-only edition of *EPE Online* hosted in the USA ([www.epemag.com](http://www.epemag.com)). We are also improving the "Recent Issues" section of our web site ([www.epemag.wimborne.co.uk](http://www.epemag.wimborne.co.uk)) in order to devote one web page per issue. They are accessed at pages which are named after their month and issue, so July 98's issue (the earliest currently available in this format) is at the page [0798.htm](#). The pages should be available from our web site for about a year.

The files for this month's projects are available on the FTP site at <ftp://ftp.epemag.wimborne.co.uk/pub/PICS/MindPICkler> and [pub/PICS/xmaslights](ftp://ftp.epemag.wimborne.co.uk/pub/PICS/xmaslights).

## Plight of the Navigator

Microsoft Internet Explorer 4 recently arrived in my office as an unwelcome guest preinstalled on a new Dell computer. After delivery, Step One was to disable the Active Desktop which I found gimmicky, pointless and irritating. Step Two was to attempt to configure all my Dial-Up Networking connections, and my E-mail software. Unfortunately things rapidly went downhill, with recurrent modem nightmares, crashes and re-boots galore and other anomalies. And no I haven't got Windows 98 (thanks).

A dozen phone calls to Dell and Microsoft, a new motherboard, a new memory, three modems and several on-site visits later, two technical support reps. suggested that one way of curing problems might be to type "ieremove" at the Run line, and thereby de-install Microsoft Internet Explorer 4. In the event, we decided to give it up as a bad job and my shiny new PC had to be shipped back to Ireland anyway, and – credit to Dell Computer Corporation – it was collected within five hours of my complaining.

Upon its return I wasn't surprised to see that Explorer 3 had been installed as the default web browser: I would have done the same myself. When I queried this, though, it was suggested that if I proceeded to re-install Explorer 4, I ought not to use the Active Desktop which has been known to "cause problems." As at today, not having the Active Desktop installed may now cause a problem as well, because my very latest version of Hot Metal Pro 5 requires – you guessed – the Active Desktop to be enabled if I am to access all of Hot Metal's features. The only alternative, says Softquad, is to use Windows 98.

I guess this will be the pattern of events for the next year or two. Anyway, just for the record, I am delighted to report that the PC hasn't missed a beat, and as an anonymous customer I found Dell's Customer Service highly commendable.

## Black Spot

I was soon to find that using version 3 of Explorer created a few problems of its own, when accessing the web sites of Microsoft and Dell in search of patches and drivers. Both sites use Active Server technology. My attempts at navigating around their web sites repeatedly came to a dead end, because of an error message "The object has moved and may be found here". Trying to jump "here" caused my session to grind to a frustrating halt; funnily enough the only way forward was to return fully armed with Netscape Navigator 4.0. Exactly the same happened with my CompuServe browser which I resurrected on the new PC. (The latest release of Netscape Navigator is V4.5, by the way: more at [www.browsers.com](http://www.browsers.com).)

For many experienced PC users, Microsoft Internet Explorer 4 is still one upgrade too many which they can probably quarantine alongside Windows 98. Unfortunately the dependency of some web sites on displaying properly (if at all) only if a certain browser is used, is as frustrating for users as ever. Let us also not forget the myriad of browser plug-ins extolled by some web sites: checking the BT Home Highway web site ([www.highway.bt.com](http://www.highway.bt.com)), for

example, I found that the use of Macromedia Shockwave did little to present the data behind BT's sales pitch more effectively than a web site full of static HTML would have done, only the Shockwave-enabled site took far longer to visit and therefore told me less in the time available. Some users may find the images of spinning motorway signposts captivating, though.

## Software Selection

Although I covered it last month, it's still going on – some readers are still confusing the addresses of our FTP (File Transfer Protocol) and World Wide Web sites by typing in FTP addresses whilst browsing our web site. They need to ensure they type the complete FTP address, which is (again) <ftp://ftp.epemag.wimborne.co.uk>. From there, navigate to [/pub](#) (the public directory, and the only one of interest) before drilling deeper down to the desired location (for example, our PIC files are stored in [/pub/PICS](#)). There is also a Mirror (copy) of our PIC-related files maintained by Thomas Stratford on <http://homepages.nildram.co.uk/~starbug/epopic.htm> if you prefer a web style.

Several popular FTP programs are available via the Internet and the rule is to fetch a shareware version and then buy the one which works for you. Features to look out for include an automatic "reget" of transfers, which means that if interrupted, the transfer can be restored from where it left off, rather than having to fetch the entire file again. Also, the ability to store sessions (the configuration, URL, passwords and other set-up data) related to particular FTP sites is useful. This month I've provided a list of some Internet software tools worth checking.

*Absolute FTP* is shareware and is said to boast an Explorer-type interface, drag-and-drop file transfers, reget plus the ability to run simultaneous transfers from multiple FTP sites, bandwidth permitting. Try [www.vandyke.com](http://www.vandyke.com). For Macintosh users, *Anarchie Pro* (v3.0) is now available from [www.shareware.com](http://www.shareware.com) with enhanced web support, offline browsing and an improved graphical front end.

*Terrapin FTP* and *Terrapin Postbox* (E-mail client) are at [www.terra-net.com](http://www.terra-net.com) and *Cute FTP* is available from [www.cuteftp.com](http://www.cuteftp.com). I like the looks of Crystal Art Software's *Crystal FTP* ([www.casdk.com](http://www.casdk.com)) which installed and worked instantly. It has a handy-looking "Quick" button and could be just the thing for struggling Windows users. Web site maintainers might also enjoy *Crystal SiteUpdater* [sic] from the same site. It helps with the publishing, synchronisation and validation of web sites but hasn't been tested by me. *FTPPro98* is an Explorer-style FTP client from [www.ftppro.com](http://www.ftppro.com), and *Bullet Pro FTP* looks particularly attractive at [www.bpftp.com](http://www.bpftp.com).

*FTP Explorer* from [www.ftpx.com](http://www.ftpx.com) has similar controls to Microsoft Windows Explorer which beginners might appreciate, and Anawave (noted for its "Websnake" software) offers a W95 FTP client interface called *FTP Icon Connection* at [www.anawave.com](http://www.anawave.com). Another popular Macintosh FTP application is *Fetch* from [www.dartmouth.edu](http://www.dartmouth.edu).

*WinZIP* (now in version 7) is the totally indispensable Windows Zip utility for compressing or decompressing files. A handy browser add-on means that you can view the contents of zipped files in your browser, without having to unzip them separately. Buy it! More from [www.winzip.com](http://www.winzip.com). "Zip up the Web" is a W95/NT freeware utility which (it says here) enables you to zip up and E-mail a collection of web pages without facing the chore of downloading the text and graphics. It creates a self-executable file of the web pages, which you can E-mail onwards. It's at [www.shareware.com](http://www.shareware.com).

The above URL's are ready-made for you on the Net Work page of our web site as usual. I welcome your suggestions for links to share with fellow readers and you'll receive a credit. E-mail ideas to [alan@epemag.demon.co.uk](mailto:alan@epemag.demon.co.uk).

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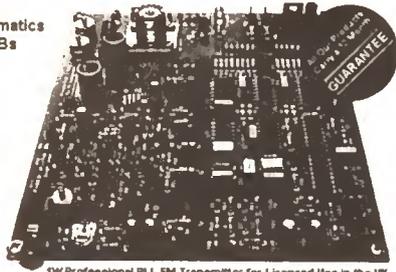
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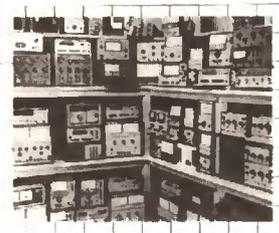
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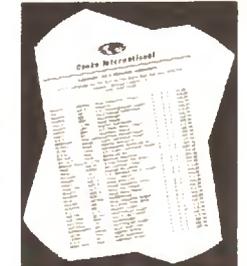
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**WATCH SLIDES ON TV** "Liesgang diav" automatic slide viewer with built in high quality colour tv camera, composite video output with a BNC plug. In very good condition with few signs of use. £108.00

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MP size 39x36x23mm spy camera with a fixed focus pin hole lens for hiding behind a very small hole. £57+vat = £66.98

40MC size 39x36x23mm camera for C mount lens this gives a much clearer picture than with the small lenses. £68.79

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Waterproof camera with stylish tilt & swivel case 75 x 75 x 75mm £109.00 or 10 x £89.32 + vat = £104.95

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DCA50 component analyser with lcd readout identifies transistors mosfets diodes & LEDs lead connections. £69.95

Speaker cabinets 2 way speaker systems with motorola tweeters

speaker dia	15"	12"	8"
power rating	250WRMS	175WRMS	100 WRMS
impedance	8ohm	8ohm	8ohm
freq range	40hz-20khz	45hz-20khz	60hz-20khz
sensitivity(1W/1M)	97db	94db	92db
size in mm	500x220x340	450x400x345	315x460x230
weight	21.1kg	16.8kg	7.4kg

price each for black vinyl coating £139.95 £99.99 £54.94  
grey felt coating £159.97\* £119.97\* £54.99  
\* not normally in stock allow 1 week for delivery)

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STA150 2x160Wrms (4ohm load)	14kg	£202.11
STA300 2x190Wrms (4ohm load)	11kg	£339.00
STA900 2x490Wrms (4ohm load)	15kg	£585.00

LEDs 3mm or 5mm red or green .7p each yellow 11p each cable ties 1p each £5.95 per 1000 £49.50 per 10,000

**Rechargeable Batteries**

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AAA (HP16) 180mAh	£1.75	1/3 AA with tags (philips)CTV1	£1.95

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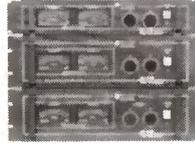
FEATURES: ★ Independent power supplies with two toroidal transformers ★ Twin L.F.D. Vu Meters  
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PRICES:- MXF200 £175.00 MXF400 £233.85  
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BASS/MID/TOP BASS/MID/TOP BASS/MID/TOP  
CONFIGURED 3 WAY 2 WAY BASS/MID COMBINED 2 WAY MID/TOP COMBINED

**FEATURES:**

Advanced 3-Way Stereo Active Cross-Over (switchable two way), housed in a 19" x 1U case. Each channel has three level controls: Bass, Mid & Top. The removable front fascia allows access to the programmable DIL switches to adjust the cross-over frequency: Bass-Mid 125/250/500Hz, Mid-Top 1.8/3/5Hz, all at 24dB per octave. The 2/3 way selector switches are also accessed by removing the front fascia. Each stereo channel can be configured separately. Bass Invert Switches are incorporated on each channel. Nominal 775mV input/output. Fully compatible with OMP Rack Amplifier and Modules.

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**VARIABLE SPEED**



The new CDJ1700 now offers a tough build quality boasting an all new shockproof transport mechanism, frame accurate cueing and wide range pitch control. The CDJ1700 looks after the CD's while the operator looks after the sound.

**FEATURES:**

★19"X2U RACK MOUNTING ★FULLY VARIABLE PITCH CONTROL PLUS/MINUS 16% ★PITCH BLEND ★3 BEAM LASER PICKUP ★1 BIT 8 X OVERSAMPLING DAC ★CUE AND LOOP FACILITY ★TRACK SKIP WITH FF/REV ★DIGITAL AND ANALOGUE OUTPUTS ★CONTINUOUS/SINGLE TRACK PLAY ★CLEAR BACKLIT MULTIFUNCTION DISPLAY ★10 TRACK PROGRAM PLAY ★TRACK ELAPSED, TRACK REMAINING AND DISC REMAINING TIME DISPLAYS.

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**ECHO & SOUND EFFECTS**



- ★ 4 STEREO INPUT CHANNELS
- ★ 2 DJ MIC INPUT CHANNELS
- ★ 2X7 BAND GRAPHIC EQUALISERS
- ★ HEADPHONE MONITOR WITH PFL
- ★ ASSIGNABLE CROSSFADE
- ★ DIGITAL ECHO

STEREO DISCO MIXER WITH:- ★2X7 GRAPHIC EQUALISERS ★2 MONO MIC INPUTS ★DJ MIC WITH FADER, TALKOVER AND VOICE CHANGER ★4 STEREO CHANNELS WITH INDIVIDUAL FADERS AND ASSIGNABLE CROSSFADE ★CHANNELS SWITCHABLE, TURNTABLE (MAG CARTRIDGE), CD, LINE, TAPE, ETC. ★ECHO WITH BALANCE, REPEAT AND DELAY ★HEADPHONE MONITOR WITH PREFADE LISTEN ★CHOICE OF 6 SOUND EFFECTS ★STEREO MONO SWITCH ★2 X LED VU METERS ★MASTER FADER ★OUTPUT 775mV ★SIZE:- 482X240X115mm ★POWER:- 230V AC 50/60Hz. PRICE:- £169.00 + £5.00 P&P

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- ★ EDUCATIONAL EXPERIMENTS ETC.

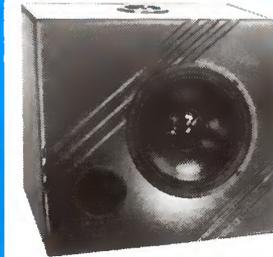
A top quality mini strobe with high light intensity for its size and variable flash rate adjustment. Housed in a silver/black steel case with adjustable mounting bracket. ★ Flash Rate:- Adjustable from zero to ten flashes per second ★ Mains Powered complete with plugged lead ★ 230V AC 50/60Hz

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PRICE:- £42.85 + £4.00 P&P



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PRICE:- £66.35 + £4.00 P&P



OMP/MF 300 Mos-Fet Output power 300 watts R.M.S. into 4 ohms, frequency response 1Hz - 100KHz - 3dB, Damping Factor >300, Slew Rate 60V/uS, T.H.D. typical 0.001%, Input Sensitivity 500mV, S.N.R. - 110dB. Size 330 x 175 x 100mm.  
PRICE:- £83.75 + £5.00 P&P



OMP/MF 450 Mos-Fet Output power 450 watts R.M.S. into 4 ohms, frequency response 1Hz - 100KHz - 3dB, Damping Factor >300, Slew Rate 75V/uS, T.H.D. typical 0.001%, Input Sensitivity 500mV, S.N.R. - 110dB, Fan Cooled, D.C. Loudspeaker Protection, 2 Second Anti-Thump Delay. Size 385 x 210 x 105mm.  
PRICE:- £135.85 + £6.00 P&P



OMP/MF 1000 Mos-Fet Output power 1000 watts R.M.S. into 2 ohms, 725 watts R.M.S. into 4 ohms, frequency response 1Hz - 100KHz - 3dB, Damping Factor >300, Slew Rate 75V/uS, T.H.D. typical 0.002%, Input Sensitivity 500mV, S.N.R. - 110dB, Fan Cooled, D.C. Loudspeaker Protection, 2 Second Anti-Thump Delay. Size 422 x 300 x 125mm.  
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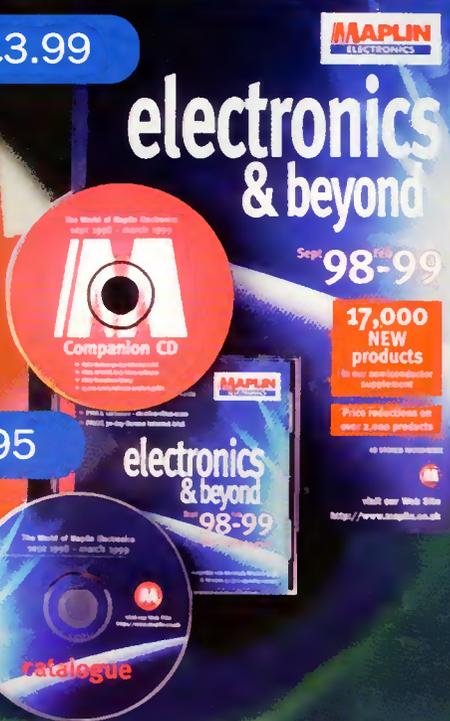
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