THE No.1 MAGAZINE FOR ELECTRONICS TECHNOLOGY & COMPUTER PROJECTS

EVERYDAY DECEMBER 2004

PRACTICAL ELECTRONICS

£3.10

VERSATILE PIC FLASHER
Sound, temperature, light and movement triggered

SUPER VIBRATION SWITCH
Ultra sensitive detector

BUY EPE ON THE WEB

SIMPLE WIND DIRECTION INDICATOR
Inexpensive, easy to build instrument

PLUS

SMART KARTS III
Extra sensory perception!

12
9 770262 361126

www.epemag.co.uk

Colour CCTV camera, 8mm lens, 12V d.c. 200mA 582x628 Resolution 380 lines Automatic aperture lens Mirror function PAL Back Light Compensation MLR, 100x40x40mm. Ref EE2 £75.90

Built-in Audio 15lux CCD camera 12V d.c. 200mA 480 lines s/n ratio >48db 1V P-P output 110mm x 60mm x 50mm. Ref EE1 £108.90

Metal CCTV camera housings for internal or external use. Made from aluminium and plastic they are suitable for mounting body cameras in. Available in two sizes 1 – 100 x 70 x 170mm and 2 – 100 x 70 x 280mm Ref EE6 £24.20 EE7 £28.60 multi-position brackets Ref EE8 £8.80

Excellent quality multi-purpose TV/TFT screen, works as just a LCD colour monitor with any of our CCTV cameras or as a conventional TV. Ideal for use in boats and caravans 49.7MHz-91.75MHz VHF channels 1-5,168.25MHz-222.75MHz VHF channels 6-12, 471.25MHz-869.75MHz, Cable channels 112.325MHz-166.75MHz Z1-Z7, Cable channels 224.25MHz-446.75MHz Z8-Z35 5" colour screen. Audio output 150mW. Connections, external aerial, earphone jack, audio/video input, 12V d.c. or mains. Accessories supplied Power supply, Remote control, Cigar lead power supply, Headphone Stand/bracket 5" model £152.90 Ref EE9, 6" model £163.90. Ref EE10

Self-cocking pistol plcr002 crossbow with metal body. Self-cocking for precise string alignment Aluminium alloy construction High tec fibre glass limbs Automatic safety catch Supplied with three bolts Track style for greater accuracy Adjustable rear sight 50lb drawweight 150ft sec velocity Break action 17" string 30m range £23.84 Ref PLCR002

Fully cased IR light source suitable for CCTV applications. The unit measures 10 x 10 x 150mm, is 12V d.c. operated and contains 54 infra red LEDs. Designed to mount on a standard CCTV camera bracket. The unit also contains a daylight sensor that will only activate the infra-red lamp when the light level drops below a preset level. The infra red lamp is suitable for indoor or exterior use, typical useage would be to provide additional IR illumination for CCTV cameras £53.90 Ref EE11

Mains operated and designed to be used with any CCTV camera causing it to scan. The clips can be moved to adjust the span angle, the motor reversing when it detects a clip. With the clips removed the scanner will rotate constantly at approx 2-3rpm. 75 x 75 x 80mm £25.30. Ref EE12

Colour CCTV Camera measures 60x45mm and has a built-in light level detector and 12 IR LEDs 0.2 lux 12 IR LEDs 12V d.c Bracket Easy connect leads £75.90 Ref EE15

A high quality external colour CCTV camera with built-in infra-red LEDs measuring 60 x 60 x 60mm Easy connect leads colour Waterproof PAL 1/4in. CCD 542 x 588 pixels 420 lines 0.05 lux 3.6mm F2 78 deg lens 12V d.c 400mA Built-in light level sensor. £108.90. Ref EE13

Colour pinhole CCTV camera module with audio. Compact, just 20x20x20mm, built-in audio and easy connect leads PAL CMOS sensor 6-9V d.c Effective Pixels 628x582 Illumination 2 lux Definition >240 Signal/noise ratio >40db Power consumption 200mW £38.50. Ref EE21

A small colour CCTV camera measuring just 35 x 28 x 30mm. Supplied complete with bracket, microphone and easy connect leads. Built-in audio. Colour 380 line resolution PAL 0.2 lux +18db sensitivity Effective pixels 628 x 582 Power source 6-12V d.c. Power consumption 200mW £39.60 Ref EE16

Complete wireless CCTV sytem with video. Kit comprises pinhole colour camera with simple battery connection and a receiver with video output. 380 lines colour 2.4GHz 3 lux 6-12V d.c. manual tuning Available in two versions, pinhole and standard. £86.90 (pinhole) Ref EE17 £86.90 (standard) Ref EE18

Small transmitter designed to transmit audio and video signals on 2.4GHz. Unit measures 45 x 35 x 10mm. Ideal for assembly into covert CCTV systems Easy connect leads Audio and video input 12V d.c. Complete with aerial Selectable channel switch £33. Ref EE19

2.4GHz wireless receiver Fully cased audio and video 2.4GHz wireless receiver 190x140x30mm, metal case, 4 channel, 12V d.c. Adjustable time delay, 4s, 8s, 12s, 16s. £49.50. Ref EE20

The smallest PMR446 radios currently available (54x87x37mm).These tiny handheld PMR radios not only look great, but they are user friendly & packed with features including VOX, Scan & Dual Watch. Priced at £64.90 PER PAIR they are excellent value for money. Our new favourite PMR radios! Standby: – 35 hours Includes: – 2 x Radios, 2 x Belt Clips & 2 x Carry Strap £64.90 Ref ALAN1 Or supplied with 2 sets of rechargeable batteries and two mains chargers £93.49. Ref Alan2

Beltronics BEL550 Euro radar and GATSO detector Claimed Detection Range: GATSO up to 400m, Radar & Laser guns up to 3 miles. Detects GATSO speed cameras at least 200 metres away, plenty of time to adjust your speed £350.90. Ref BEL550

TheTENS mini Microprocessors offer six types of automatic programme for shoulder pain, back/neck pain, aching joints, Rheumatic pain, migraines headaches, sports injuries, period pain. In fact all over body treatment. Will not interfere with existing medication. Not suitable for anyone with a heart pacemaker. Batteries supplied. £21.95 Ref TEN327 Spare pack of electrodes £6.59. Ref TEN327X

Dummy CCTV cameras These motorised cameras will work either on 2 AA batteries or with a standard DC adapter (not supplied) They have a built-in movement detector that will activate the camera if movement is detected causing the camera to 'pan' Good deterrent. Camera measures 20cm high, supplied with fixing screws. Camera also has a flashing red l.e.d. built in. £10.95. Ref CAMERAB

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 £16.50. Ref IRF2 or a 12" sq for £34.07 IRF2A

GASTON SEALED LEAD-ACID BATTERIES

1.3AH 12V @ £5.50 REF GT1213
3.4AH 12V @ £8.80 REF GT1234
7AH 12V @ £8.80 REF GT127
17AH 12V @ £19.80 REF GT1217

All new and boxed, bargain prices. Good quality sealed lead-acid batteries

SOLAR PANEL 10 watt silicon solar panel, at least 10 year life, 365 x 26mm, waterproof, ideal for fixing to caravans, boat, motorhomes etc. Nicely made unit with fixing holes for secure fittings. Complete with leads and connectors. Anodised frame. Supplied with two leads, one 3M lead is used for the o/p with two croc clips, the other lead is used to connect extra panels. Panels do NOT require a blocking diode, they can be left connected at all times without discharging the battery. £93.49. REF PAN

8A solar regulator 12V, 96 watt, 150mm x 100mm x 25mm. £30. REF SOLREG2

High-power modules (80W+) using 125mm square multi-crystal silicon solar cells with bypass diode. Anti-reflection coating and BSF structure to improve cell conversion efficiency: 14%. Using white tempered glass, EVA resin, and a weatherproof film along with an aluminium frame for extended outdoor use, system Lead wire with waterproof connector. Four sizes, 80W 12V dc, 1200 x 530 x 35mm, £315.17. REF NE80, 123W 12V d.c., 1499 x 662 x 46mm, £482.90. REF NDL3. 125W 24V, 1190 x 792 x 46mm, £482.90. REF NEL5 and 165W 24V, 157 x 826 x 46mm, £652.30.

BULL GROUP LTD

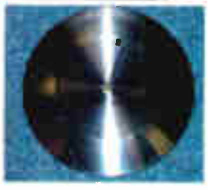
UNIT D, HENFIELD BUSINESS PARK, HENFIELD, SUSSEX BN5 9SL
TERMS: CASH, PO, CHEQUE PRICES + VAT WITH ORDER PLUS £5.50 P&P (UK) PLUS VAT.
24 HOUR SERVICE £7.50 (UK) PLUS VAT.
OVERSEAS ORDERS AT COST PLUS £3.50

Tel: 0870 7707520 Fax 01273 491813

Sales@bullnet.co.uk

www.bullnet.co.uk

THE TIDE CLOCK. These clocks indicate the state of the tide. Most areas in the world have two high tides and two low tides a day, so the tide clock has been specially designed to rotate twice each lunar day (every 12 hours and 25 minutes) giving you a quick and easy indication of high and low water. The Quartz tide clock will always stay calibrated to the moon. £23.10 REF TIDEC



LINEAR ACTUATORS 12-36V D.C. BUILT-IN ADJUSTABLE LIMIT SWITCHES. POWER COATED 18in. THROW UP TO 1,000lb. THRUST (400lb. RECOMMENDED LOAD). SUPPLIED WITH MOUNTING BRACKETS DESIGNED FOR OUTDOOR USE. These brackets originally made for moving very large satellite dishes are possibly more suitable for closing gates, mechanical machinery, robot wars etc. Our first sale was to a company building solar panels that track the sun! Two sizes available, 12in. and 18in. throw. £32.95. REF ACT12, £38.45 REF ACT18.

POWERSAFE DEEP CYCLE BATTERIES
12V 51AH. NOW ONLY £29.95 EACH
YUASA 6V 100AH NOW ONLY £25 + £5 POSTAGE EACH

BRAND NEW MILITARY ISSUE DOSE METERS (radiation detectors). Current NATO issue. Standard emergency services unit. Used by most of the world's military personnel. New and boxed. £75.90. REF SIEM69

NIGHT VISION SYSTEM. Superb hunting rifle sight to fit most rifles, grooved for a telescopic sight. Complete with infra-red illuminator. Magnification 2.7x. Complete with rubber eye shield and case. Opens up a whole new world! Russian made. Can be used as a hand-held or mounted on a rifle. £108.90. REF PN1

These Samarium magnets measure 57mm x 20mm and have a threaded hole (5/16th UNF) in the centre and magnetic strength of 2.2 gauss. We have tested these on a steel beam running through the offices and found that they will take more than 170lb. (77kg) in weight before being pulled off. With keeper. £21.95. REF MAG77

Peltier Effect heat pump. Semiconductor thermo-electric device which works on the Peltier effect. When supplied with a suitable electric current, can either cool or heat. Also when subject to an externally applied temperature gradient can produce an electric current. Ideal for cooling or controlling the temperature of sub assemblies. Each module is supplied with a comprehensive 18-page Peltier design manual featuring circuit designs, design information etc., etc. The Peltier manual is also available separately. Maximum watts 56.2 40 x 40mm Imax, 5.5A Vmax, 16.7 Tmax (c-dry N2), 72. £32.95 (inc. manual. REF PELT1. Just manual £4.40 REF PELT2.

New transmitter, receiver and camera kit. £75.90. Kit contains four channel switchable camera with built-in audio, six IR l.e.d.s and transmitter, four channel switchable receiver, 2 power supplies, cables, connectors and mounting bracket. £75.90. Wireless Transmitter. Black and white camera (75 x 50 x 55mm). Built-in 4 channel transmitter (switchable). Audio built-in 6 IR l.e.d.s. Bracket/stand. Power supply 30m range Wireless Receiver 4 channel (switchable). Audio/video leads and scart adapter. Power supply and manual. £75.90. REF COP24.

This miniature Stirling Cycle Engine measures 7in. x 4¼in. and comes complete with built-in alcohol burner. Red flywheels and chassis mounted on a green base, these all-metal beauties silently running at speeds in excess of 1,000 r.p.m. attract attention and create awe wherever displayed. This model comes completely assembled and ready to run. £106.70. REF SOL1

SHOP ONLINE
WWW.BULLNET.CO.UK

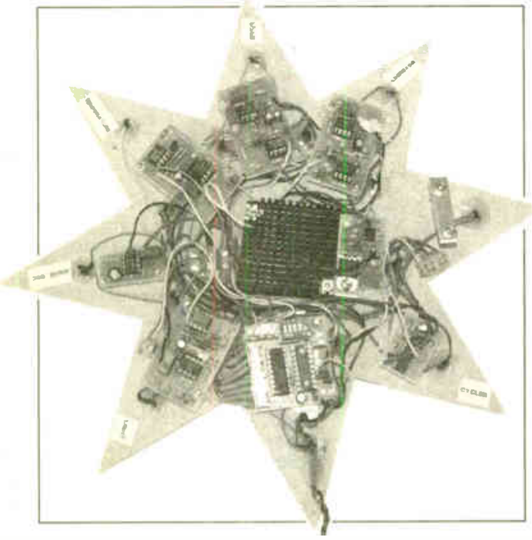
ISSN 0262 3617
PROJECTS ... THEORY ... NEWS ...
COMMENTS ... POPULAR FEATURES ...

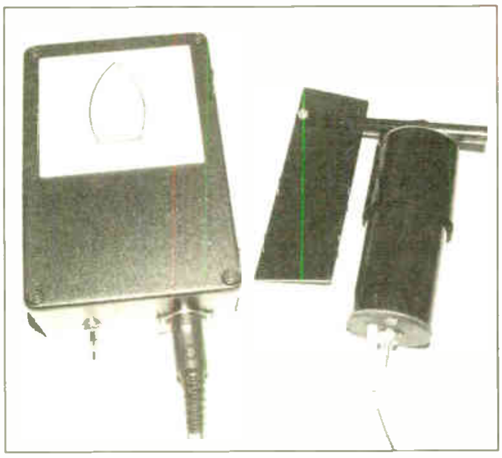
VOL. 33. No. 12 DECEMBER 2004
Cover illustration: Martin Bond/Science Photo Library

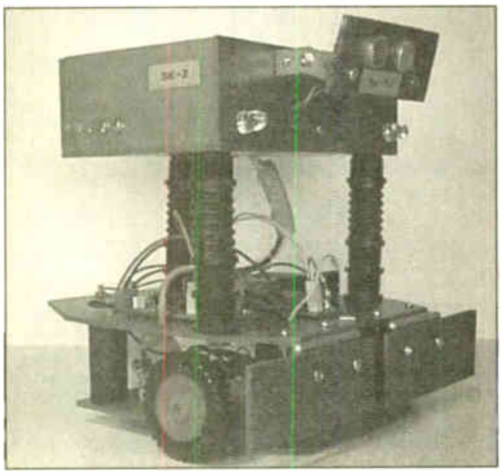
EVERYDAY PRACTICAL ELECTRONICS

INCORPORATING ELECTRONICS TODAY INTERNATIONAL

www.epemag.wimborne.co.uk
EPE Online: www.epemag.com







Projects and Circuits

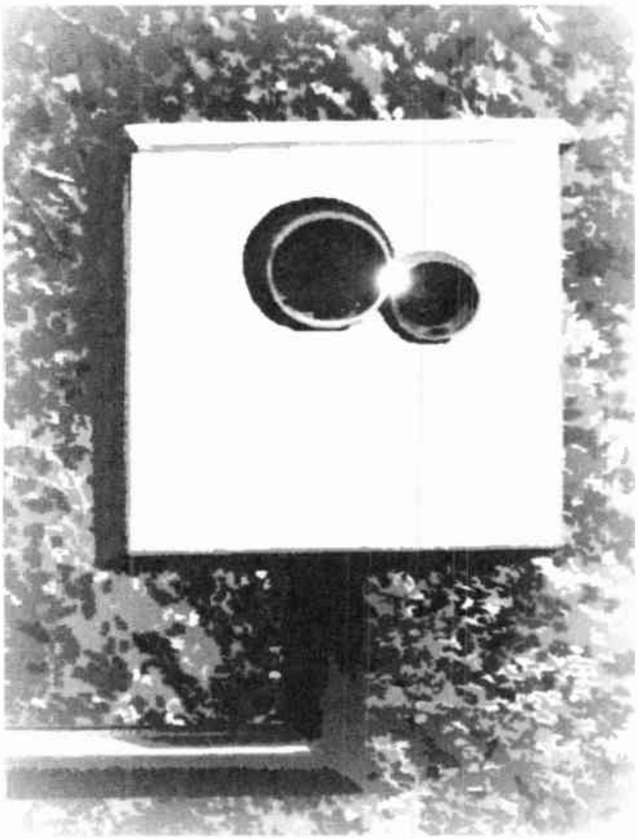
Series and Features

Regulars and Services

Our January 2005 issue will be published on Thursday, 9 December 2004. See page 831 for details

NEXT MONTH

CAMERA WATCH



How often have you found yourself surprised by the presence of a speed camera while driving, your attention distracted while you frantically check your speed? Or come across a sharp bend in the road and had to break sharply? Wouldn't it be great if you could have a simple device that could gently warn you of these oncoming "black spots?" Although speed cameras are controversial they are (in the main) located where speed control is important, so having a device that can remind you to take extra care has its merits. The purpose of this project is to produce a device that can advise of places that require attention to speed, not to help you avoid prosecution for speeding!

So what does the Camera Watch do? It monitors its precise location using an embedded GPS receiver, and alerts you to oncoming blackspots. The positions of the cameras or blackspots are stored in a non-volatile EEPROM. The EEPROM can store up to 1000 locations, and once every second a microcontroller scans all of the stored locations, comparing them to the current position.

When it has found the closest blackspot it displays your distance from it on an l.e.d. bargraph. When you get very close a low level beep is emitted. A second button can be used to cancel the beep, and it also functions as a delete key to remove unwanted locations from the EEPROM.

LIGHT DETECTOR

Unfortunately due to lack of space we were unable to include this project in this (December) issue but it will be published in the January issue.

The design makes use of an l.e.d. as a simple light sensor that generates a photovoltage that varies with light intensity. By comparing the photovoltage with a variable reference voltage, the circuit provides a digital output signal that changes state when the monitored light level crosses a preset threshold.

The detector also provides visual indication by illuminating the sensor l.e.d. when the light exceeds the preset level. In this way, the l.e.d. provides a dual function, acting as both the sensor and the indicator. An optional, optically-isolated output is also available.

GATE ALARM

This project is a deluxe version of an original simple circuit that proved very popular. The circuit has been kept simple but it operates in a sophisticated way. Its chief characteristic is that the tone it emits is set apart from the action of the gate. Thus the perception is that the alarm has not been triggered by the gate. In fact during testing, people tended to look around to see how they might have been detected – not suspecting that the alarm was connected to the gate. The design can, of course, be used in a variety of applications where a basic alarm is required.

PLUS 32-BIT MATHS FOR PICS

NO ONE DOES IT BETTER

EVERYDAY PRACTICAL ELECTRONICS

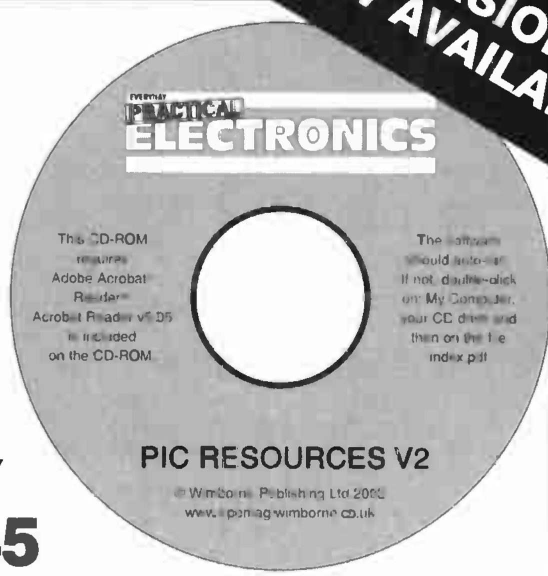
DON'T MISS AN ISSUE – PLACE YOUR ORDER NOW!

Demand is bound to be high

JANUARY 2005 ISSUE ON SALE THURSDAY, DECEMBER 9

VERSION 2 NOW AVAILABLE

EPE PIC RESOURCES CD-ROM V2



Version 2 includes the EPE PIC Tutorial V2 series of Supplements (EPE April, May, June 2003)

ONLY £14.45 INCLUDING VAT and P&P

The CD-ROM contains the following Tutorial-related software and texts:

- EPE PIC Tutorial V2 complete series of articles plus demonstration software, John Becker, April, May, June '03
- PIC Toolkit Mk3 (TK3 hardware construction details), John Becker, Oct '01
- PIC Toolkit TK3 for Windows (software details), John Becker, Nov '01

Plus these useful texts to help you get the most out of your PIC programming:

- How to Use Intelligent L.C.D.s, Julyan Ilett, Feb/Mar '97
- PIC16F87x Microcontrollers (Review), John Becker, April '99
- PIC16F87x Mini Tutorial, John Becker, Oct '99
- Using PICs and Keypads, John Becker, Jan '01
- How to Use Graphics L.C.D.s with PICs, John Becker, Feb '01
- PIC16F87x Extended Memory (how to use it), John Becker, June '01
- PIC to Printer Interfacing (dot-matrix), John Becker, July '01
- PIC Magick Musick (use of 40kHz transducers), John Becker, Jan '02
- Programming PIC Interrupts, Malcolm Wiles, Mar/Apr '02
- Using the PIC's PCLATH Command, John Waller, July '02
- EPE StyloPIC (precision tuning musical notes), John Becker, July '02
- Using Square Roots with PICs, Peter Hemsley, Aug '02
- Using TK3 with Windows XP and 2000, Mark Jones, Oct '02
- PIC Macros and Computed GOTOs, Malcolm Wiles, Jan '03
- Asynchronous Serial Communications (RS-232), John Waller, unpublished
- Using I²C Facilities in the PIC16F877, John Waller, unpublished
- Using Serial EEPROMs, Gary Moulton, unpublished
- Additional text for EPE PIC Tutorial V2, John Becker, unpublished

NOTE: The PDF files on this CD-ROM are suitable to use on any PC with a CD-ROM drive. They require Adobe Acrobat Reader – included on the CD-ROM

Order on-line from
www.epemag.wimborne.co.uk/shopdoor.htm
or www.epemag.com (USA $ prices)
or by Phone, Fax, Email or Post.

EPE PIC RESOURCES V2 CD-ROM ORDER FORM

Please send me .... (quantity) EPE PIC RESOURCES V2 CD-ROM

Price £14.45 each – includes postage to anywhere in the world.

Name ....

Address ....

....

....

.... Post Code ....

☐ I enclose cheque/P.O./bank draft to the value of £ ....

☐ Please charge my Visa/Mastercard/Amex/Diners Club/ Switch/Maestro

£ ....

Card No. ....

Card Security Code .... (The last 3 digits on or just under the signature strip)

Valid From .... Expiry Date ....

Switch Issue No. ....

SEND TO: **Everyday Practical Electronics, Wimborne Publishing Ltd., 408 Wimborne Road East, Ferndown, Dorset BH22 9ND.**
Tel: 01202 873872. Fax: 01202 874562.
Email: orders@epemag.wimborne.co.uk

Payments must be by card or in £ Sterling – cheque or bank draft drawn on a UK bank.

Normally supplied within seven days of receipt of order.

Send a copy of this form, or order by letter if you do not wish to cut your issue.

BECOME A PIC WIZARD WITH THE HELP OF *EPE!*

122004

ESR ELECTRONIC COMPONENTS

Station Road, Cullercoats, Tyne & Wear, NE30 4PQ

Prices Exclude Vat @17½%.
UK Carriage £2.50 (less than 1kg)
£5.50 greater than 1kg
Cheques / Postal orders payable to
ESR Electronic Components.
PLEASE ADD CARRIAGE & VAT TO ALL ORDERS

See Next / Last Months Ad. for ELECTRONIC COMPONENTS

PCB Production - Processing Equipment

We carry a large range of the photographic & chemical processing equipment for PCB production, a full list with full technical specifications is available in our catalogue or vist our web site.

UV Exposure units
2 x 8W Tubes, 6 min timer
229 x 159mm working area
Model 332-002 £88.78
4 x 15W Tubes, 7 min timer
330 x 260mm working area
Model 332-004 £194.51

Chemical Processing
Low cost plastic tray £1.80
Process tanks feature electrically operated pumps and/or heaters with thermostat control, suitable for boards upto 320 x 260mm.
Universal Tank with heater
Model 333-007 £161.60
Bubble etch Tank with heater & bubble pump.
Model 333-004 £198.50

PCB Production - Laminates

Copper clad - paper
Single sided low cost paper composite board

100 × 160mm Board	£0.44
100 × 220mm Board	£0.62
160 x 233mm Board	£1.02
220 x 233mm Board	£1.40
8" x 12" Board	£1.70

Copper clad - glass fibre
Single & Double 1.6mm 305g/m²

100 × 160mm Single	£0.85
100 × 220mm Single	£1.25
160 x 233mm Single	£2.29
220 x 233mm Single	£2.88
8" x 12" Single	£3.44
100 × 160mm Double	£0.88
100 × 220mm Double	£1.25
160 x 233mm Double	£2.30
220 x 233mm Double	£2.90
8" x 12" Double	£3.50

Photoresist Coated
1.6mm 35 micron Pre-coated with a high quality photo-resist layer. Available in low cost paper composite or Glass fibre, Single & Double sided. Other sizes also available.

	Paper		Glass Fibre	
Size	Single	Double	Single	Double
4 × 6"	£1.47	£1.82	£1.89	£2.17
6 x 12"	£4.20	£5.04	£5.60	£6.23
9 x 12"	£6.30	£7.70	£8.40	£9.38
10 x 12"	£8.19	£10.01	£10.78	£11.83
12 x 12"	£8.26	£10.08	£10.99	£12.25
100 x 160mm			£2.38	£2.66
203 x 114mm			£3.01	£3.43
220 x 100mm			£3.08	£3.71
233 x 160mm			£4.83	£5.32
233 x 220mm			£6.83	£7.70

PCB Production - Development

0.1" Copper Stripboard

Size	Tracks/Holes	
25 x 64mm	9T / 25H	£0.24
64 x 95mm	24T / 37H	£0.87
95 × 127mm	36T / 50H	£1.41
95 × 432mm	36T / 170H	£4.39
100 × 100mm	39T / 38H	£1.40
100 × 500mm	39T / 199H	£6.20
119 × 455mm	46T / 179H	£5.40
Stripboard track cutter		£1.99

Solderless Breadboard

Tie Points & Size		Power Rails	
390	81 x 60mm	2	£2.75
840	175 x 67mm	2	£4.86
740	175 x 55mm	1	£4.03
640	175 x 42mm	0	£3.08

Many other sizes available, also jump wires & matrix board.

PCB Production - Tools

Drill Bits
HSS parallel shank bits available in sizes from 0.3mm to 2.0mm
0.3-0.95mm in 0.05mm steps £0.60ea £4.00/10
1.0-2.0mm in 0.1mm steps £0.40ea £3.60/10
HSS Reduced shank (2.35mm) bit available in sizes from 0.6mm to 1.7mm in 0.1mm steps £0.84ea £7.60/10
Reground Tngsten carbide reduced shank (3.2mm) available in sizes from 0.6 to 1.6mm in 0.1mm steps £1.90

Drilling Machines
Expo reliant 12V drill, 3.8mm capacity, 8400rpm £12.78

Minicroft MX1 230V, 8000 - 21000rpm with chuck & collet.
Model EPE270-390
Normal price £48.51

" SPECIAL OFFER PRICE £31.02 "

PCB Production - Chemicals

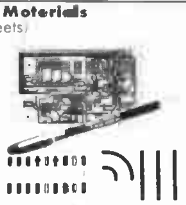
100ml	Aerosol Photoresist spray, covers 2m²	£4.25
50g	Powder developer, makes 1lt	£1.09
500g	Powder developer, makes 10lt	£7.08
250g	Ferric Chloride Pellets, makes 500ml	£1.68
500g	Ferric Chloride Pellets, makes 1lt	£3.04
2.5kg	Ferric Chloride Pellets, makes 5lt	£9.84
1.1kg	Clear Fine etch crystals, makes 5lt	£17.58
90g	Tin Plating Powder, makes 1lt	£11.58
200ml	Aerosol Flux spray	£3.41
110ml	Aerosol PCB Laquer spray	£3.63

PCB Production - Drafting Materials

A4 Artwork Film (per 10 sheets)
Clear Manual Film £1.25
Clear Laser Film £1.75
White HQ Laser Film £4.62

Etch Resist Pens
"Dolo" Pen £2.98
"Staedtler" Fine Pen £0.88

Etch Resist Transfers
Seno mixed DIL pads £2.24
Seno mixed Rnd pads £2.24
Alfac mixed pads £1.84
Transfer Spatular £1.25



We carry the full range of Seno & Alfac PCB transfers, see our catalogue for full details.

Servisol Products

Aerosols

200ml	Switch Cleaner	£1.96
200ml	Freezer	£3.97
400ml	Foam Cleanser	£2.13
400ml	Cleaner / lubricant	£2.79
75ml	Vide Head Cleaner	£1.94
200ml	Aero Klene	£2.85
200ml	Aero Duster	£4.66
250ml	Cold Clean	£3.14
200ml	Label remover	£3.52
400ml	Isopropyl alcohol	£3.36

Tubes

25g	Heatsink Compound	£2.60
50g	Silicone grease	£2.50

Magnifying Desk Lamp

A high quality scratch resistant magnifying glass fitted to a balanced swivel arm and desk mount. An integral flourescent tube provides illumination.
Magnification: 3x Lens: 120mmØ
Tube: 22W Daylight simulation.

Model: 028-205 £28.80

Soldering Irons

We carry in stock a wide range of soldering iron and soldering accessories. Irons from 12 to 100 Watts.
20W 240V Basic £3.74
25W 240V Ceramic £14.05
30W 240V Basic £4.68

Desolder Pumps
Basic 165 x 18mmØ £2.85
Antistatic 195mm £3.92
Antex Mini 198mm £6.02
Antex Pro 210mm £10.26

NEW CATALOGUE OUT NOW

available from **www.esr.co.uk**

Tools - Cutters & Strippers

We carry a wide range of specialist tools for the electronics industry including:

Side Cutters
130mm Low cost £1.99
115mm Draper £2.38
115mm Box Jointed £4.26
145mm Long reach £3.40

Wire Strippers
130mm Low cost £2.30
150mm Draper 5mmØ £5.86

Digital Multimeter

Model: 121-120
Price: £11.47

A highly featured digital multitester for professional use. Offers 30 ranges and 8 functions including temperature, capacitance, diode, continuity and hFE measurement. Large 3.5 digit LCD display with automatic polarity indicator. Supplied with shrouded test leads, K type temperature probe and shock proof rubber holster

Technical Specifications
DC voltage 200mV - 1000V (±0.5%)
AC volts 2V - 700V (±0.8%)
DC current 2mA - 20A (±1.2%)
AC current 200mA - 20A (±1.8%)
Resistance 200 Ohms - 20M Ohms (±0.8%)
Capacitance 2000pF - 20 F (±2.5%)
Temperature 0 C - 1000 C (±1.5%)
Frequency 20kHz (±1%)
Max display 1999
Power supply 9V (PP3 battery)
Dimensions 88 x 173 x 40 mm

Educational Kits

These kits are an ideal way to start you interset in electronics. They freature re-useable components which are attached via springs & wires and easy step by step guides to make a range of exciting projects. The 300-in-1 featurs a breadboard for more complex circuits.

30-in-1	£13.18
50-in-1	£16.80
130-in-1	£32.29
300-in-1	£55.20

Tools - Ratchet Crimping Pliers

High quality ratchet crimping pliers for various terminals including Automotive, Data, Power and Data connections.
Red / Blue / Yellow £15.80
BNC /TNC RF series £15.19
RJ11/12 Data Series £22.32
RJ45 Data Series £20.43
RJ11/12 & 45 Series £12.64

CK® Tools Crimp Pliers
Green/Red/Blue £24.38
Red/Blue/Yellow £21.83
0.24-2.5mm² crimps £24.35
0.5-6.0mm² crimps £24.77
Non insulated crimps £24.38

Cable - Ribbon

7/0.127mm Grey ribbon cable on a 0.05" 1.27mm pitch with a red identifying stripe. Supplied by 305mm (1ft) or on full 30.5m (100ft) reels.

Size	per 305mm	per Reel
10 Way	£0.10	£5.36
14 Way	£0.14	£7.50
16 Way	£0.16	£8.58
20 Way	£0.20	£10.72
26 Way	£0.26	£13.94
34 Way	£0.34	£18.22
40 Way	£0.40	£21.44
50 Way	£0.50	£26.80
60 Way	£0.64	£33.92
IDC Crimp tool		£11.80

CCTV - Complete Systems

We carry the full range of *Micromark* Black & White and Colour CCTV systems for the home or office.
These complete easy install systems are supplied complete with power supply, cables and all fixings. Simple plug-in connections, for use with any TV or Video with a scart socket.

Black & White Systems from £22.97

Panel Meters

High quality analogue panel meters, class 2, zero point correction, mirror scale and prewired for panel illumination. Meter size 46 x 60mm, Cutout size: 38mmØ.

All meters £5.89 each
6V Lamps £1.23 /pair

Range	Int Ω
0-50 A	6k5
0-100 A	1k0
0-500 A	430Ω
0-1mA	200Ω
0-10mA	2Ω6
0-50mA	1Ω2
0-100mA	0Ω65
0-500mA	0Ω12
0-1A	60mΩ
0-3A	20mΩ
0-5A	12mΩ
0-15A	4mΩ
0-10V	10k
0-15V	15k
0-30V	30k
±50 A	1k9

CAT5e Networking

UTP Cable
305m Box, conforms to CAT5E 100MHz standard, ETA verified TIA/EIA 568-B.2

Only £23.99 per box exc carriage.

RJ45 Outlet Kit
Backing Box
2 Gang Plate
RJ45 Module
Blank Module
Colour coded id inserts.
special price £3.14

Tools
Plastic punch down tool & cable stripper £1.42
Professional punch down IDC & trim tool £7.38

NOW In Stock
Patch & Cross-over leads from £0.50, Full range of outlet modules/keystone outlets, switches & accessories.

CCTV - Black & White Module

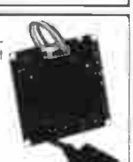
A miniature CMOS camera module with a 3.6mm F2 Lens, video output & power via connectors provided.

Specs (660-800)
Power: 12Vdc 50mA
Video System: CCIR
Pixels: 352 x 288
Min Illumination: 0.5Lux
Video Output: 1 Vpp, 75Ω
Dims: 35 x 35 x 28mm 20g **£17.93**

CCTV - Colour Module

A miniature colour CMOS camera module with a 3.6mm F1.2 Lens, video output & power via connectors provided.

Specs (660-842)
Power: 12Vdc 150mA
Video System: PAL
Pixels: 628 x 582
Min Illumination: 3Lux
Video Output: 1 Vpp, 75Ω
Dims: 28 x 28 x 28mm 20g **£36.33**



Tel: 0191 2514363 Fax: 0191 2522296 Email: sales@esr.co.uk http: //www.esr.co.uk

EVERYDAY PRACTICAL ELECTRONICS

THE No.1 MAGAZINE FOR ELECTRONICS TECHNOLOGY & COMPUTER PROJECTS

VOL. 33 No. 12 DECEMBER 2004

Editorial Offices:
EVERYDAY PRACTICAL ELECTRONICS EDITORIAL
WIMBORNE PUBLISHING LTD., 408 WIMBORNE ROAD EAST, FERNDOWN, DORSET BH22 9ND
Phone: (01202) 873872. Fax: (01202) 874562.
Email: enquiries@epemag.wimborne.co.uk
Web Site: www.epemag.wimborne.co.uk
EPE Online (downloadable version of *EPE*): www.epemag.com
EPE Online Shop: www.epemag.wimborne.co.uk/shopdoor.htm
See notes on **Readers' Technical Enquiries** below – we regret lengthy technical enquiries cannot be answered over the telephone.
Advertisement Offices:
EVERYDAY PRACTICAL ELECTRONICS ADVERTISEMENTS
MILL LODGE, MILL LANE,
THORPE-LE-SOKEN, ESSEX CO16 0ED
Phone/Fax: (01255) 861161 Email: epeads@aol.com

Repeats

At one time we used to baulk at publishing similar projects to those in past issues. Nowadays, however, we are in a situation where technology is moving so fast that it is not only worthwhile but often necessary to publish revamped projects. This is because new devices can make construction more simple, but also because they can often add effectively to the abilities of the original designs. Sometimes we also have the situation where the basic project is still valid but additions have been developed that enhance its performance.

Over the next few months we have the results of such developments. This month it's the *Versatile PIC Flasher MK2* with various extra boards and a simplification of the original design, all of which result in a better basic unit, plus a host of add-ons to enhance its abilities; it can now be made sensitive to sound, temperature, light and movement.

Electric

In the February issue we will feature another enhanced project the *PIC Electric MK2*. With the development of more sophisticated PICs this project will again have enhanced features from the original published in the February and March 1996 issues. As a point of interest the first ever such project was the *Telectric* published in *PE* in March 1982, it used an 8035 microprocessor plus eight other i.c.s to perform the task of measuring, calculating and displaying power consumption. It cost around £55 to build at the time, taking inflation into account that is the equivalent of around £130 now.

At that time Watford Electronics were advertising a wide range of electronic components, plus a few computer items and the VIC20 Microcomputer with 5K of RAM (expandable to 32K) for £165, you could also have a VIC20 cassette deck to record your data on for an extra £34 – how things have changed!

In line with developments John is also working on a revised version of the TK3 software to incorporate the various new PIC chips, so watch out for that in a future issue. This month's *Pic N' Mix* will also be of interest to TK3 users as it shows how to programme some of the 8-pin PICs using TK3.

Never ending progress!

Mike Kenward

READERS' TECHNICAL ENQUIRIES

E-mail: techdept@epemag.wimborne.co.uk

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.**

PROJECTS AND CIRCUITS

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.

A number of projects and circuits published in *EPE* employ voltages than can be lethal. **You should not build, test, modify or renovate any item of mains powered equipment unless you fully understand the safety aspects involved and you use an RCD adaptor.**

COMPONENT SUPPLIES

We do not supply electronic components or kits for building the projects featured, these can be supplied by advertisers (see *Shoptalk*). **We advise readers to check that all parts are still available before commencing any project in a back-dated issue.**

ADVERTISEMENTS

Although the proprietors and staff of EVERYDAY PRACTICAL ELECTRONICS take reasonable precautions to protect the interests of readers by ensuring as far as practicable that advertisements are *bona fide*, the magazine and its Publishers cannot give any undertakings in respect of statements or claims made by advertisers, whether these advertisements are printed as part of the magazine, or in inserts.

The Publishers regret that under no circumstances will the magazine accept liability for non-receipt of goods ordered, or for late delivery, or for faults in manufacture.

TRANSMITTERS/BUGS/TELEPHONE EQUIPMENT

We advise readers that certain items of radio transmitting and telephone equipment which may be advertised in our pages cannot be legally used in the UK. Readers should check the law before buying any transmitting or telephone equipment as a fine, confiscation of equipment and/or imprisonment can result from illegal use or ownership. The laws vary from country to country; readers should check local laws.

AVAILABILITY

Copies of *EPE* are available on subscription anywhere in the world (see opposite), from all UK newsagents (distributed by COMAG) and from the following electronic component retailers: Omni Electronics and Yebo Electronics (S. Africa). *EPE* can also be purchased from retail magazine outlets around the world. An Internet on-line version can be purchased and downloaded for just $10.99US (approx £7) per year available from **www.epemag.com**

SUBSCRIPTIONS

Subscriptions for delivery direct to any address in the UK: 6 months £16.50, 12 months £31, two years £57; Overseas: 6 months £19.50 standard air service or £28.50 express airmail, 12 months £37 standard air service or £55 express airmail, 24 months £69 standard air service or £105 express airmail. To subscribe from the **USA** or **Canada** see the last magazine page.

Online subscriptions, for downloading the magazine via the Internet, $10.99US (approx £7) for one year available from **www.epemag.com.**

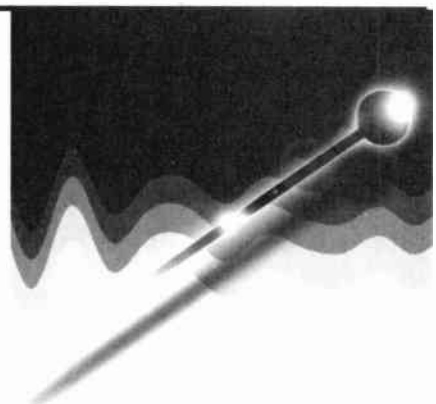
Cheques or bank drafts (in **£ sterling only**) payable to *Everyday Practical Electronics* and sent to EPE Subs. Dept., Wimborne Publishing Ltd. 408 Wimborne Road East, Ferndown, Dorset BH22 9ND. Tel: 01202 873872. Fax: 01202 874562. **Email:** subs@epemag.wimborne.co.uk. Also via the **Web** at: **http://www.epemag.wimborne.co.uk.** Subscriptions start with the next available issue. We accept MasterCard, Amex, Diners Club, Maestro or Visa. (For past issues see the *Back Issues* page.)

BINDERS

Binders to hold one volume (12 issues) are available from the above address. These are finished in blue p.v.c., printed with the magazine logo in gold on the spine. Price £6.95 plus £3.50 p&p (for overseas readers the postage is £6.00 to everywhere except Australia and Papua New Guinea which cost £10.50). *Normally sent within seven days but please allow 28 days for delivery – more for overseas.*

Payment in £ sterling only please. Visa, Amex, Diners Club, Maestro and MasterCard accepted. Send, fax or phone your card number, card expiry date and card security code (the last 3 digits on or just under the signature strip), with your name, address etc. Or order on our secure server via our UK web site. Overseas customers – your credit card will be charged by the card provider in your local currency at the existing exchange rate.

Constructional Project



Super Vibration Switch

Thomas Scarborough

A super sensitive modern-day update of the old-fashioned vibration switch

THE old-fashioned vibration switch is well-known. This consists of a flexible lever, fixed at one end, with a small weight attached to the other. When there is vibration, the weight "bobs" slightly, knocking a terminal beneath it. Electrical contact is made, and an alarm is triggered. This type of switch usually has an adjustment screw, to adjust the gap between the weight and the terminal, thus adjusting its sensitivity.

The "super switch" project presented here simulates this old-fashioned vibration switch. As with the old switch, it too has an adjustment screw.

There are just two superficial differences. First, an indicator light indicates that vibration has been detected. Second, it has three terminals instead of two – namely +VE, 0V, and OUT. The OUT terminal goes logic "high" when vibration is detected, and by means of these terminals the Super Vibration Switch may be plugged into circuits with widely varying supply voltages, from 2V to 18V.

Super Sensitive

The real difference, however, lies in its sensitivity. As simple as it is, it may justifiably be described as being "super-sensitive". While the old-fashioned vibration switch is best suited to detecting noticeable motion, such as a bike being disturbed, or valuables being lifted, the Super Vibration Switch is capable of picking up very subtle vibrations indeed.

It will easily pick up a person walking across a wooden floor at virtually any distance (e.g. at the far side of a hall). The author's prototype was capable of picking up a pin striking a wooden floor at two metres distance. It reliably picked up a telephone receiver being put down in the next room, and the vibration of the neighbours car doors closing at twenty metres distance.

If it were any more sensitive, it would be rendered useless by unnamed vibrations from every direction. Having said this, the circuit does have an adjustment screw, to adjust the switch to whatever level of sensitivity would best suit one's purposes.

In Concept

The switch's principle of operation is already well known. It uses a cheap, standard piezo element which flexes slightly in response to vibrations, thus creating a minute electrical output. In short, it converts mechanical or acoustic energy to electrical energy. The circuit responds to both mechanical and acoustic energy, but heavily favours mechanical energy – that is, vibration.

Dedicated bi-morph elements are also available for this purpose – however, these are more costly, and are not as robust as the piezo element used here. Such bi-morph elements may also be tried in this circuit.

A piezo sensor is, of course, only as good as the circuit which is used to detect its electrical output. The Super Vibration Switch uses a particularly sensitive and stable circuit based on an inexpensive 7556 dual timer i.c. (see block diagram Fig.1).

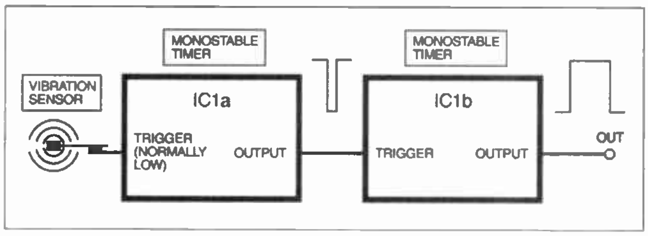
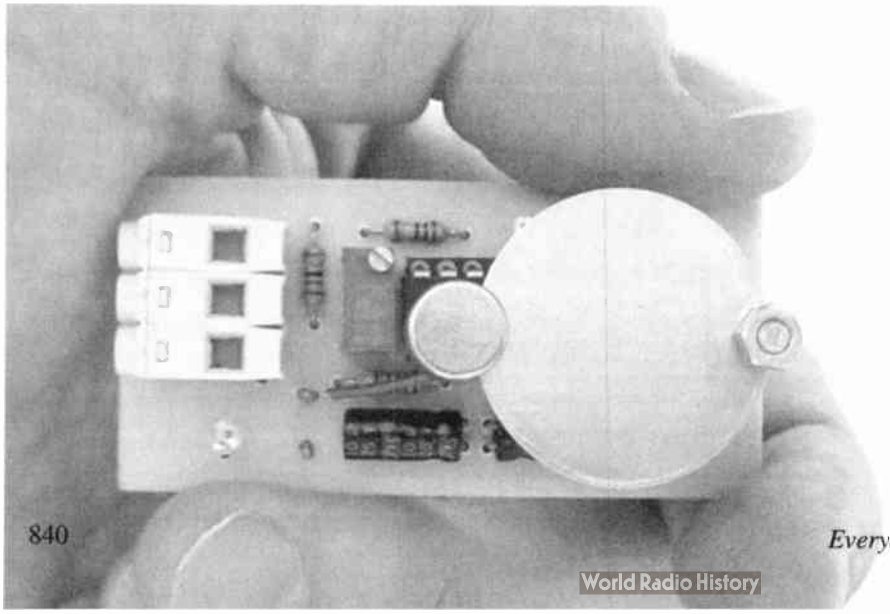


Fig.1. Block diagram for the Super Vibration Switch

Note that a dual 7556 i.c. is used rather than a single 7555. This is because the sensitivity at a 7555's trigger input drops slightly as its timing period increases. Therefore, to maximise sensitivity, the timing period of IC1a is kept very short (about 6μs), while that of IC1b provides a longer output pulse (about 1s). This makes the difference between a sensitive vibration switch, and a "super-sensitive" one.

Notice that IC1a gives a brief negative-going output pulse rather than the usual positive-going pulse, which is a "back-to-front" way of employing IC1a, described in more detail below.



No Frills

It was decided not to add any special features to the Super Vibration Switch, but to leave it conceptually as simple as the original on which it is modelled. Any additional tricks would be the domain of a suitable control circuit. However, for good measure, a simple add-on 12V relay driver circuit is included (see Fig.2) – to provide a "breathing space" after switch-on (the act of switching on the circuit might cause vibration), a delay before triggering, and a timed relay output.

No constructional details are given for this circuit as readers will have their own ideas about the form of control/alarm set-up they require.

Circuit Details

The full circuit diagram, including the optional relay driver stage, is shown in Fig.2. The section to the right of the three-way terminal block (TB1) connections make up the suggested relay driver circuit.

A piezo element or piezo sounder typically has a capacitance of a few tens of nanofarads (nF), although this may vary greatly. Sensor X1 therefore acts as a small capacitor, which is kept charged at a steady voltage through a potential divider network made up of resistors R1, R2 and preset potentiometer VR1. The voltage across X1 further biases IC1a's trigger input, so that this is normally held "low" – but only just.

Note that R1, VR1, and R2 should all have precisely the same temperature coefficient. This is crucial to the stability of the circuit. If, for instance, resistors R1 and R2 would have a temperature coefficient of 200 parts per million per degree C (200ppm/°C), and preset VR1 a temperature coefficient of 100ppm/°C, this could cause a drift of the potential at IC1a trigger input pin 6 of as much as one-tenth of one percent over a 24-hour period.

With a circuit as sensitive as this one, this could significantly affect performance. If you are not certain that you can match the temperature coefficients, substitute link wires for resistors R1 and R2, and increase the value of preset VR1 to 1M, to 2M or 5M if you can obtain such values.

Timer IC1a is shown in a standard monostable configuration. However, it is not used in an orthodox way. Normally, IC1a's trigger input (pin 6) would be held "high", so that the monostable timer would be triggered by negative-going pulses. In this case, however, the input is held "low", so that IC1a's output (pin 5) is normally held "high". As soon as the piezo element is disturbed, IC1a's trigger input momentarily goes "high", and output pin 5 briefly goes "low".

The main advantage of using IC1a in this way is that a number of components may be dispensed with at output pin 5, where an inverting circuit would otherwise be required. Since we are seeking a very short pulse, and since this would be provided both through orthodox and unorthodox means, it is convenient to wire IC1a in this way.

COMPONENTS

Approx. Cost Guidance Only **£10** *excl. Relay Driver*

Resistors

R1	2M2
R2,R4	1M (2off)
R3,R5	100k (2off)
R6	1k

All 0·25W 5% carbon film

See **SHOP TALK** page

Potentiometers

VR1	500k 25-turn cermet, top or side adjust

Capacitors

C1,C3,C4	10µ min.radial elect. 25V (3 off)
C2	1n polyester

Semiconductors

D1	3mm ultrabright l.e.d.
IC1	ICM7556IPD CMOS dual timer i.c. (no equiv alents – see text)

Miscellaneous

X1	3V to 30V piezoelectric element approx. 30mm diameter
TB1	3-way p.c.b. mounting screw terminal block, 5mm pin pitch

Printed circuit board available from the *EPE PCB Service*, code 474; 14-pin d.i.l. socket; multistrand connecting wire; link wire; 9V PP3 type battery (optional); battery clips (optional); neodymium magnets (3off-optional, see text); 20mm x 3mm bolt; 3mm nuts (4off); 3mm washer; solder pins (2off); solder etc.

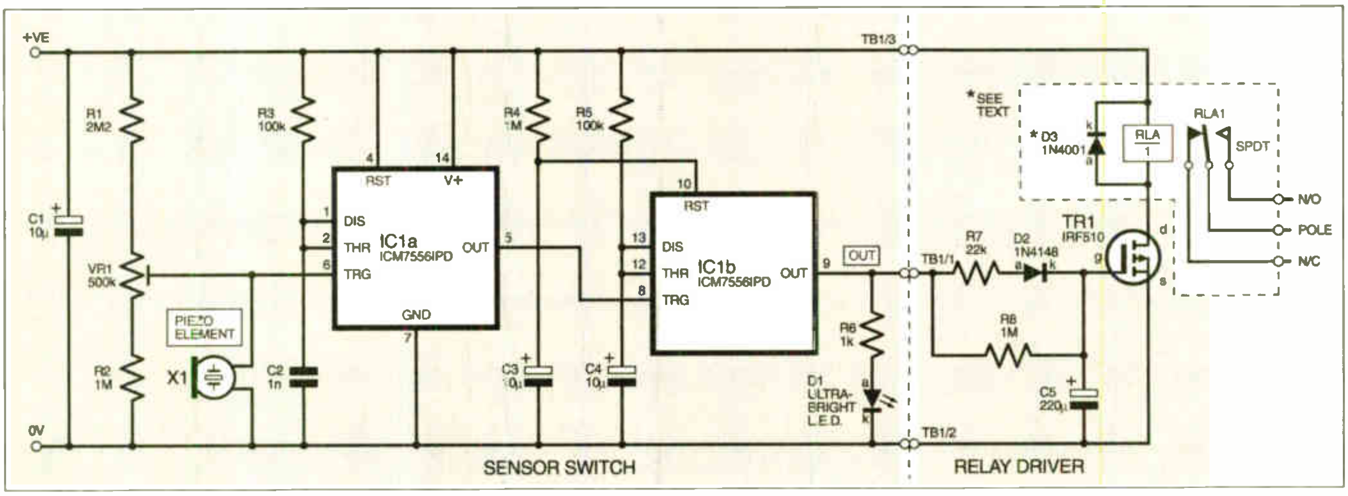


Fig.2. Complete circuit diagram for the Super Vibration Switch. This includes the optional relay driver circuit – see text.

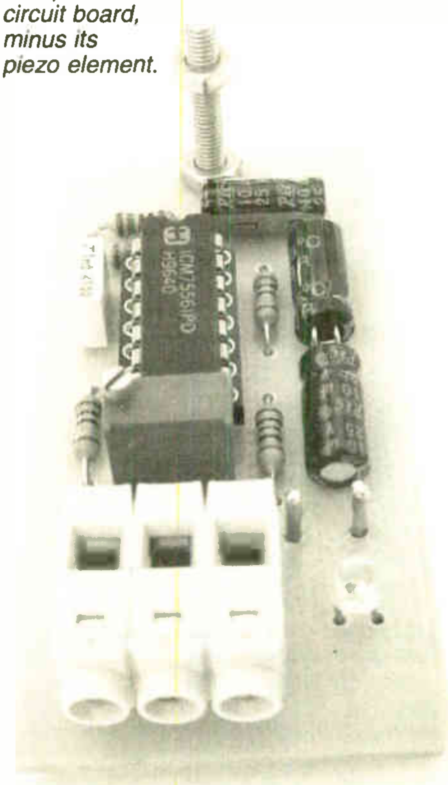
The input impedance of IC1a trigger pin 6 is very high (about one thousand five hundred megohms), and the values of bias components R1, VR1, and R2 are also high, thus maximising the sensitivity of piezo sensor X1. Further, the 7556 i.c. is a very stable device, so that, with the matched temperature coefficients mentioned earlier, the author experienced no drift or spurious triggering at all during trials.

IC1b is likewise wired as a monostable timer. With the values shown for resistor R5 and capacitor C4, this delivers a positive-going output pulse of about one second, illuminating l.e.d. D1. An ultrabright l.e.d. was chosen for D1, since this was easier to see at a distance. This makes sense with a vibration switch that is capable of responding at many metres' distance.

A timed delay of a few seconds at IC1b's Reset pin 10 is included to prevent any spurious triggering at switch-on. Since the Super Vibration Switch is merely intended to be wired to a suitable control circuit, the control circuit would normally add any further delays at switch-on or before triggering.

Optional Drive Circuit

The simple add-on relay driver circuit based on TR1, an *n*-channel power MOS-



Completed circuit board, minus its piezo element.

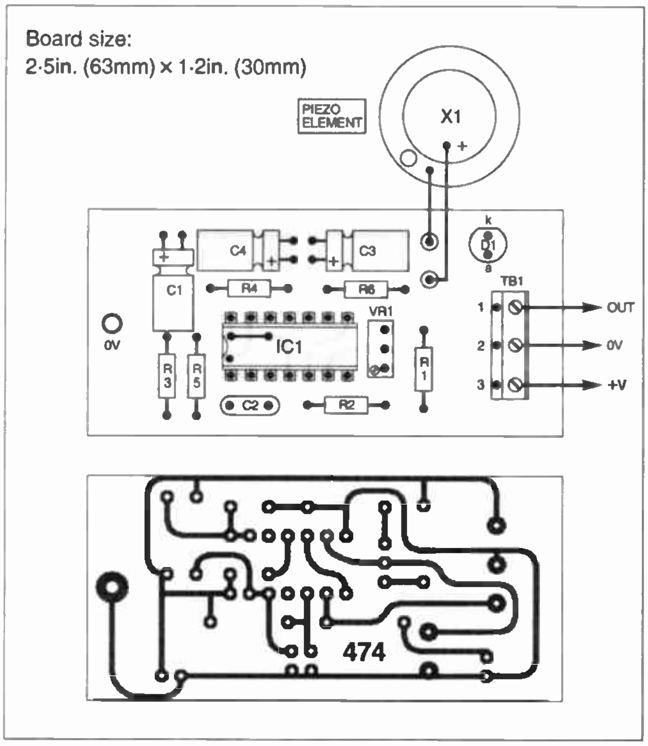
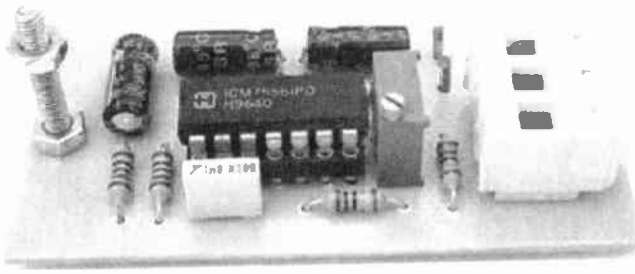


Fig.3. Printed circuit board component layout, underside copper foil master pattern and wiring to the piezo element.



Layout of components on the finished board.

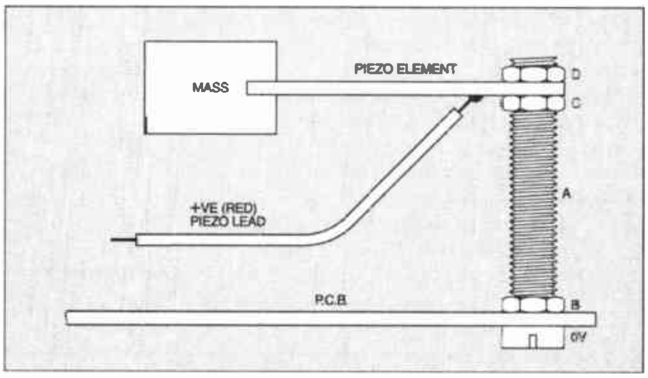


Fig.4. Piezoelectric element mounting details. In this set-up the negative (0V) supply connection to the p.c.b. is made via the mounting bolt.

FET, is provided for those who would like to obtain immediate results from the vibration switch. When vibration is detected, resistor R7 provides a short delay before closing relay RLA contacts.

If the value of R7 is small (e.g. 1k), the relay's response will be very snappy. If a higher value is chosen (e.g. 22k), this will provide a few seconds "breathing space" after switch-on, and a few seconds delay before triggering. Resistor R8 together with capacitor C5 provides a timed relay output of about a minute. These features could be useful, for example, for a bicycle alarm, where you would not want the alarm to trigger immediately at switch-on, or immediately on returning to the bicycle.

The values of R7, R8, and C5 may be experimented with freely, on condition that the values of R7 and R8 are not reduced below about 1kΩ.

The Super Vibration Switch uses a mere 1.5mA at 9V on standby, with the result that it could be powered continuously off a 9V PP3 type battery for about a month. A battery supply is recommended, to eliminate mains transients, and for more sensitive applications it would make sense to use a regulator.

Construction

The Super Vibration Switch is built on a small single-sided printed circuit board (p.c.b.) measuring 64mm x 32mm (2½in. x 1¼in.). This board is available from the *EPE PCB Service*, code 474. The topside component layout and full-size underside copper track master are shown in Fig.3.

If desired, this board may be enlarged to allow room for drilling mounting holes. Since dual timer IC1 is a CMOS device, anti-static precautions are advised (in particular, discharge your body to earth before handling).

Begin construction by soldering in position the single link wire (underneath the i.c. socket), the two solder pins, the 14-pin dual-in-line (d.i.l.) socket, and the 3-way terminal block. Continue with the capacitors, the resistors, preset VR1, and l.e.d. Double-check the polarities of capacitors C1, C3, C4 and l.e.d. D1 on the p.c.b.

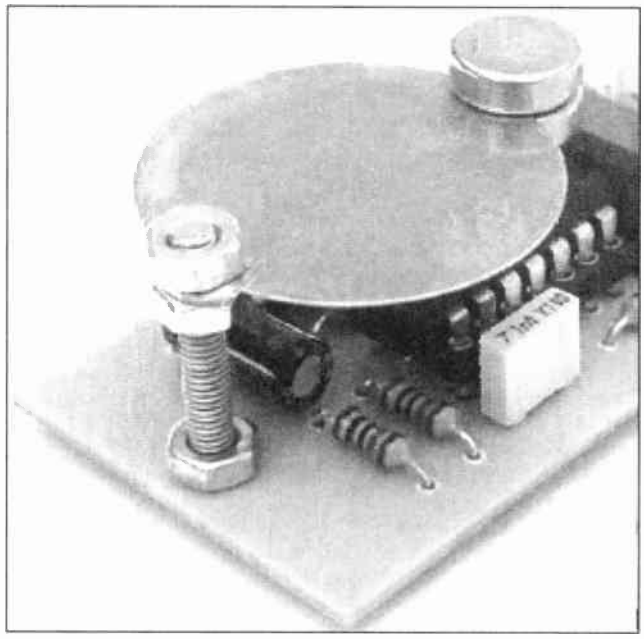
Finally, insert IC1 in the d.i.l. socket, ensuring that it is inserted the right way round. A side-adjust variable potentiometer may be used for VR1, depending on what would be most convenient. This may be required in particular if a larger piezo element and/or weight is used.

Sensor Assembly

To mount the piezo sensor X1 on the p.c.b. (see Fig.4), a 20mm long 3mm diameter bolt (A) is inserted through the hole provided on the p.c.b. from underneath, and fastened to the p.c.b. with a nut (B). Then a 3mm hole is drilled at one edge of the piezo element disc, near the base of its connecting wires. A washer is soldered to the edges of this hole to ensure a solid mounting surface for the bolt.

A nut (C) is now screwed onto the top of the bolt, with about 3mm of the bolt protruding over the top of it. The piezo element is slipped over the top of the bolt, with its flat (uniform) side up, and fastened tight with a final nut (D) on top.

The "far end" of the piezo element, suspended in the air, ideally needs to be weighted in such a way that most of the element will be free to flex. A weight of a few grams would be suitable, and this may be glued, clipped, or screwed to the edge of the piezo element. A greater weight is likely to increase sensitivity a little.



The piezo element mounted above the printed circuit board. Note the "vibration" weight/magnets.

The piezo element is then wired to the two solder pins provided, observing the correct polarity. Note that its negative (black wire) terminal may also be connected to the p.c.b. directly through the piezo mounting bolt, so that a wired connection to the solder pin may not be necessary.

Supply Leads

Make sure that the battery leads are inserted correctly in the terminal block as shown – the vibration switch has no reversed polarity protection, and could be destroyed if a mistake is made here. If the Vibration Switch is likely to be swapped in and out of circuits, it might be an idea to cut the copper track under the +VE connection of the terminal block, and to reconnect it via a 1N4001 rectifier diode, with the anode (the non-banded side) being soldered to +VE terminal. This will prevent reversed polarity damage.

In Use

Attach a battery (2V to 18V, and ideally around the middle of these two extremes). If l.e.d. D1 illuminates all the time, then preset VR1 needs to be turned back (anti-clockwise). If l.e.d. D1 does not illuminate at all, then VR1 needs to be turned up.

It should be found that without any special effort, the switch may be adjusted very sensitively. With a little care, the sensitivity described above should be achieved. For maximum sensitivity, you will need to stand back from the switch from time to time (and be careful not to move when you have) to assess the adjustment you have made.

The Super Vibration Switch is best placed on a surface which is most directly affected by the vibration you want to pick up. If it is the vibration of a floor you are seeking to detect, mount the switch directly on the floor. If it is the vibration of a tabletop, mount the switch on (or under) the tabletop – and so on.

Super Hall Effect Switch

A Hall effect switch is activated by a magnet, and is frequently used to monitor moving machinery. Such a switch will usually have a range of around 10mm.

A small modification to the Super Vibration Switch will enable it to simulate such a switch. Note, however, that it is not strictly a Hall effect switch, since it does not exploit the Hall effect.

In practice, it differs in two ways from a standard Hall effect switch. First, it only switches when the activating magnet is in motion, while a standard Hall effect switch will detect a stationary magnetic field. Second, the greater the sensitivity of the Super Hall Effect Switch, the more it will be susceptible to vibration.

The switch described here has a reliable range of up to 80mm, if it is set sensitively. That is, it potentially has about eight times the range of a typical Hall effect switch. This may be extended to about 200mm if a large activating magnet is used.

The Super Vibration Switch is turned into a "Hall effect" switch simply by attaching neodymium magnets to the piezo element (see photographs) in place of a weight used with the Super Vibration Switch. These magnets may be snapped onto the edge of the piezo element as shown, being held in place by their own magnetism and a little glue to assist.

Sensitivity

The Super Hall Effect Switch will further mimic a Hall effect sensor. Such sensors are used to sense the movement of ferrous objects (as opposed to magnets) in close proximity. In this case the switch will have a range of up to 30mm, if it is set sensitively.

Note, however, that the switch will have a slower response than a true Hall effect sensor. While a Hall effect sensor has a fast response, being capable of measuring, for example, thousands of r.p.m. with machinery, the switch described here would be limited to a few hundred r.p.m – assuming, that is, that timing capacitor C4 were reduced sufficiently to match the pulses at IC1b's trigger input pin 8.

The circuit's response may also be improved by reducing the values of R1, VR1, and R2 of the potential divider, so that "capacitor" X1 would discharge more rapidly each time it were "activated". While this would likely reduce sensitivity the switch should still match the sensitivity of most Hall effect sensors, at far lesser cost.

In Secret

A further possibility exists. This is to replace the piezo element with a coil, e.g. a solenoid, wired in series with a 100nF capacitor. This would cause the circuit to pick up any fluctuations of current in the coil – which, needless to say, could be created by the movement of a magnet near to the coil. Among other things, this could be used as a secret switch which is activated by a magnet – e.g. to open a door.

The author wishes to thank his teenage son Matthew for conceiving the idea of the Super Hall Effect Switch.

TECHNO-TALK ANDY EMMERSON

Talking In Code

The way your words and data are carried across the telephone network has been transformed, aided by VoIP, as Andy Emmerson explains.

EVEN though the incident passed without any loud trumpeting at the time, six years ago there was a watershed in telecomms. British Telecom recorded in November 1998 that, for the first time, the volume of its data traffic had exceeded voice traffic. Hardly the stuff of "Hold the Front Page!" headlines, it was nevertheless widely noted by all telecomms operators at the time, largely on account of the implications it might have for their expanding networks.

Six years later the notion that network operators would need or desire to separate the volumes of speech and data carried seems almost ridiculous, or at least of academic interest only, simply because there is no effective difference. All speech is carried as data, meaning that we are all talking in code now.

Local Links

That code is Internet Protocol, IP for short, and virtually all of the world's new-build networks are based exclusively on IP. The local links connecting the telephone in your home or place of work may still be analogue and dedicated to speech alone, but the vast majority of the links between the (digital) exchanges operate in the universal information format of IP, in which speech, video, fax messages and computer data are all converted to the uniform flavour of alphanumeric soup known as IP.

The word "Internet" in Internet Protocol might lead you to assume that all this data is transmitted across the Internet, which is not the case regardless of what you might read elsewhere. The public Internet is unregulated, at times unreliable and unsuitable as a network for messages that may well be mission-critical for their senders and in emergency could actually mean the difference between life and death. The public telephone network delivers at least "five nines" reliability (99.999 per cent availability), which is something the Internet cannot possibly guarantee.

What's in a Name?

So why is IP called Internet Protocol? Although this data format was designed originally for use over the Internet, it is now used on many other networks as well and is effectively a universal standard. In the form of VoIP, short for Voice over Internet Protocol, we have a technique that enables speech to be sent along with all other kinds of data (also encoded in IP format) over circuits designed exclusively for data transmission.

Another expression you will encounter is Internet Telephony, which is the practice of transmitting speech across the Internet, which is not the same thing. Internet telephony frequently uses VoIP technology but not all VoIP uses the Internet (far more VoIP traffic is transmitted on entirely separate networks that are not connected to the Internet). Confused? I hope not...

Sounds Familiar

If the acronym VoIP sounds familiar, that's because it's widely used in advertisements from companies urging people on broadband to ditch their landline phones and use the Internet instead. It's not always as smart a move as it looks but let's look first at the proposition.

There are several ways of using VoN (Voice over Net) but most of them involve plugging a cheap handset (or an adapter to which you connect your existing phone) into the USB port of your PC or else into your broadband router (if you have one). After you have registered with a service provider (there are many of these) you can call other VoN users for nothing, connecting directly across the Internet.

Generally there is no charge for this facility and several of the service providers have interlinked their "virtual networks", enabling you to call people on other "networks" if you know their VoN address or number. For an additional charge you can also make calls to the public telephone network and you are issued a "real" telephone number (usually starting 0870) so that people can ring you.

Sound of Silence

Call charges are below BT rates in most cases and speech quality is about as good as you get on a mobile call. Occasionally there are echoes or short periods of silence, whilst calls are seldom as clear as a normal landline call. But you are saving money!

If the anonymity of an 0870 number is not to your taste you may be interested that some Internet telephony services in Britain offer real "geographical" numbers. A company called Sipgate is offering service in ten UK cities – Belfast, Birmingham, Cardiff, Edinburgh, Glasgow, Leeds, London, Liverpool, Manchester and Newcastle – with users given local numbers that use the existing area codes of those locations.

Sipgate intends to extend its service offering to other parts of the country in due course, with calls to landline phone numbers costing 1.19 pence a minute coupled with no line rental, no monthly charges, no monthly minimum and no set-up charge. You will, however, need to pay around £69 for the adapter box if you don't already have one.

Despite these and other advantages of VoN telephony there are significant downsides beyond the variable speech quality mentioned already. Basic reliability is a serious concern; I have been using the service for more than six months and there have been occasions when it has been inexplicably "off the air" for an hour or more. Imagine the consequence if you needed to dial the emergency services when this happened. Mains failure is another problem. Landline phones are powered over the wires but your VoN phone is only as reliable as the mains electricity supply.

Phantom Callers

Internet telephony is also innately unregulated and if you're sick of receiving spam on your computer, imagine the "pleasure" you'd have receiving the same kind of rubbish by telephone, enduring dozens of pre-recorded phone calls offering Viagra and Sexy Susan chatlines. The scenario is entirely plausible because VoN is software-driven and behind whatever telephone-type number you are allocated is your real identity (which is just a string of numbers such as 123456@skyppe.net).

A phone spamming operation merely needs to generate numbers sequentially to blast thousands of phone users with unwanted telemarketing. In a widely reported statement, Tom Kershaw, a vice president at security specialist VeriSign, stated: "The fear with VoIP spam is you will have an Internet address for your phone number, which means you can use the same tools you use for email to generate traffic. That raises automation to scary degrees."

Another shock is that hackers can fake the data that shows who's calling before you answer the phone. According to Kevin Poulsen of SecurityFocus newsletter, they can make their phone calls appear to be from any number they want, and even pierce the veil of Caller I.D. blocking to unmask an anonymous subscriber's ex-directory number.

Losers and Winners

Despite these shortcomings, VoN will take a share of the market for phone calls and customers are bound to be winners, even if service providers come and go, with some disappearing in the inevitable shakeout. The biggest losers will be established phone companies that don't cut prices to meet the new competition, and over the months to come you can look forward to some fascinating price wars over your phone bill.

News . . .

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

UPLOADING LITIGATION LOOMS

"We want damages and an injunction to stop", warns the BPI over illegal music uploading. Barry Fox reports

THE UK's BPI (British Phonographic Industry) has set its lawyers on 28 of the country's worst music file sharers. A hundred cases are also being launched in Austria, adding to 174 in Denmark, 50 in France, 100 in Germany, 7 in Italy and over 5700 actions brought in the US over the last six months. The actions are against people who are uploading, not downloading, and they are under civil not criminal law. The UK targets have been using KaZaA, Imesh, Grokster, Bearshare and WinMX.

"UK offenders will not get a criminal record" says BPI lawyer Geoff Taylor. "We want damages and an injunction to stop. We have not ruled out going after downloaders later."

Taylor refuses to give any figures for the damages sought but the IFPI expects an average of several thousand Euros per person. Actions brought in March against 80 people in Germany and Denmark have netted damages of up to Eu 13,000 per offender.

The BPI estimates that 15% of file-sharers account for 75% of downloads, so it makes sense to start with the worst offenders. One of the BPI's 28 targets has been offering 7000 music files.

BPI Chairman Peter Jamieson calls the action a "velvet fist – we gave a final warning in March and have sent out 350,000 IMs" (Instant Messages).

"When the first actions started in the USA in March people asked, *how can the record companies sue their customers?* Well the people we are suing are not our customers. Unless a drinks customer is someone who drives a truckload of stolen beer round the country giving it away, and occasionally buys a pint in a pub."

Last Resort

Says Jay Berman, Chairman and CEO of the IFPI: "This is a strategy of last resort. We do not live in an ideal world. Since actions began in the US there has been massive public awakening. Our message is that if you steal our music we will find you. There is nowhere to hide. No-one can say they weren't warned. We have sent out 39 million Instant Messages round the world to people who are downloading. And there is an alternative – there are over 150 legal sites round the world, 100 in Europe, with over 25 in the UK."

Geoff Taylor admits that no-one has actually yet been sued. The BPI has simply got the IP addresses of 28 people, and must now seek court orders to try and find the owners' names and addresses. The BPI will then try to settle before suing.

Writs and Wrongs

Jay Berman defends the case of the 12 year old girl sued in the USA. "We don't screen for political correctness. We only look for the level of activity. We don't know who we are dealing with until we get the name and address for the IP address. The mother of the 12 year old settled as soon as she found out what her daughter had been doing."

Record producers reacted angrily to the suggestion that some of the people being sued might have no assets, and thus not be worth suing. "Are you suggesting that because you have no money it is alright to steal?", he insisted. "And they can afford a broadband account", added Jamieson.

Jay Berman admits that the plan for an amnesty did not work in the USA, so will not be tried in Europe. "It didn't get off the ground. The record companies could only grant their own rights. They do not have control over the publishers' rights". Berman also admits that there is still no firm plan for a single pan-European scheme for legal downloading, because of territorial copyrights. Says Pete Waterman "It's very hard to know who owns what right to do what. It's a very complex issue."

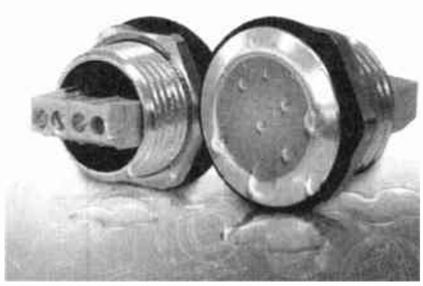
No Single Platform

Berman also confirms that there is still no plan for a single technology platform for all downloading, comparable to a CD bought anywhere that plays anywhere. "We are music companies, not technology companies. We sell music, we don't develop technology. We have to talk to the CE industry and the computer industry. They have proprietary systems and are proud of them. We are now talking with Microsoft and Apple about Digital Rights Management. We want a common platform and interoperability. But a single platform doesn't exist."

He says it is too early to be sure what impact the US actions have had. "But there has been an explosion in legal sites. I compare it to Giuliani's time as mayor of New York. Whether you liked him or not, he deserved credit because on his watch things got better."

Barman was asked whether the IFPI would recommend an end to copy protected CDs, now that legal action should remove the need to stop people copying to computers, and copy protection creates the side effect problem of compromising legitimate play on some CD players. "That is a decision for individual companies. It always was and it will remain so", he says. And asked if any of the panel had ever downloaded an MP3 file instead of buying a CD, Pete Waterman quipped. "We are in the record industry. If we want something we just call EMI and they send it over".

SUB-AQUA LIGHTING



A new range of waterproof 2-colour voltage level indicators has been announced by Lascar Electronics. The EM20-FPSI 1010 devices are designed to be easily panel mounted in most applications. The modules compare an input voltage against a user-defined voltage window, and the display colour shows whether the input voltage is below, within or above this window, with a red-green-red indication.

The user can readily set the switching thresholds, and hysteresis is built in. The voltage supply range is 7V to 24V d.c., with all connections made via screw terminals. For more information contact Lascar Electronics Ltd, Dept EPE, Module House, Whiteparish, Salisbury, Wilts SP5 2SJ. Tel: 01794 884567. Fax: 01794 884616. Web: **www.lascarelectronics.com.**

WEST LONDON RADIO & ELECTRONICS FAIR

Sunday 14 November 2004. Kempton Park Racecourse, Sunbury, Middx, opens its doors to The Radio & Electronics Fair, from 10.00am to 16.15pm. Amongst the many attractions, the Fair will feature: an extremely well-equipped and operated demonstration station; "byte-sized" lectures sponsored by the RSGB; the usual large-coverage talk-in station; RSGB bookstall and membership desk; free entrance to under-16s; display of the RAYNET emergency comms vehicle; bring and buy sale. Browse **www.radiofairs.co.uk**.

Ultralight Robo-Copters

Discovered too late for the Robotics Supplement in the October issue, the site at **www.didel.com** will no doubt fascinate you. Its emphasis is on what can best be described as sub-miniature robotics. What particularly takes our eye is the 6.9 grams Pixelite helicopter, built by Alexander van de Rostyne, using a Didel motor, gears, PicoBird and IR control.

Didel's site also provides access to obtaining really small robotics parts, including motors as small as 4mm diameter. Didel say that they offer a complete set of components to fly at down to 8gms. Some of their designs use PICs and Basic Stamp products. The site is partly in French, but there's more than enough in English to be understandable to most readers.

Thank you to reader Nick Tile for pointing out this site to us.

ATOMIC CLOCKS

We were intrigued to see on the *BBC News* website (**http://news.bbc.co.uk**) on 15 September that physicists have "shrunk atomic clocks". The reporter stated that:

"Atomic clock technology has been made so small it may soon be possible to incorporate super-accurate timekeeping into mobile devices such as cellphones. Computer chip fabrication techniques were used to make a clock mechanism that will neither lose nor gain a second in 300 years.

Researchers believe final development should see a battery-operated system that is about the size of a sugar lump. The US National Institute of Standards and Technology is behind the work." Browse **www.nist.gov**.

CREATIVE ROBOTICS NETWORK

The Creative Robotics Research Network is a new network for academic researchers, industry representatives, and visual and performance arts practitioners working in the areas of robotics, mechatronics and animatronics. It will be administered by members of the Open University Robotics Outreach Group.

The OU group has been running hands-on robotics activities across the UK since 2001, when their Blue Peter/RoboFesta Robot "Design a Really Useful Robot" competition attracted 32,000 entries.

Useful sites to browse:
www.creativerobotics.org.uk
www.robofesta-uk.org
http://crrn.open.ac.uk/aisb

GREENWELD ROBOTICS

Greenweld have sent us their latest catalogue showing the variety of components which they can supply in connection with robot building. The ranges include: low voltage motors and gearboxes; gears, wheels, pulleys and caterpillar tracks; miniature RC on-board camera system; sound recording modules; speech chip and p.c.b.

As many of you already know, Greenweld also have a complete range of components, switches, magnets, read switches, solenoids, and a host of surplus electrical and electronic equipment.

For more information contact Greenweld, Dept EPE, Unit 14, Horndon Business Park, West Horndon, Brentwood CM13 3XD. Tel: 01277 811042. Web: **www.greenweld.co.uk.**

ESR'S CAT

Recently received, two copies in fact, is ESR's latest catalogue, dated September '04. ESR are broadline distributors of audio-visual, CCTV, ICT, electrical and electronic components and accessories. Their catalogue contains over 80 A4 pages, yellow tinted, with informative line drawings, and tabulated data and prices. ESR categorise their range as being cables and hardware, components, connectors, p.c.b. production and switches.

For more information contact ESR Electronic Components, Dept EPE, Station Road, Cullercoats, Tyne & Wear NE30 4PQ. Tel: 0191 251 4363. Fax: 0191 252 2296. Email: **sales@esr.co.uk**. Web: **www.esr.co.uk**.

RAPID'S CAT

Celebrating their 25 years of trading, Rapid Electronics have send in their latest catalogue. "Defining the standard", is a caption of the front cover, a sentiment with which many of you will know to be true. In the news editor's opinion, Rapid have taken over the market where many hitherto well-respected names have left off, becoming the de-facto source of good quality electronic and hardware components from a vast range of categories.

With over 900 pages to browse through, this catalogue is not just a *must* for your workshop, but an *essential.*

For more information contact Rapid Electronics Ltd, Dept. EPE, Severalls Lane, Colchester, Essex CO4 5SJ. Tel: 01206 751188. Fax: 01206 751188. Email: **sales@rapidelec.co.uk**. Web: **www.rapidelectronics.co.uk**.

Free Information Site

Adrio Communication Ltd has re-launched its **radio-electronics.com** website as a resource of free information, data and tutorials for those interested in radio and electronics.

The site covers a variety of topics, which currently include: antennas, cellular telecommunications, private mobile radio, wireless connectivity, radio receivers, radio propagation, test and measurement techniques, electronic components, and technology news. The aim of the site is to provide information about the various technologies in an easy to understand and interesting style.

Adrio Communications is a provider of consultancy and training services to the electronics industry, with a main website at **www.adrio-communications.com**. This news item was sent to us by Ian Poole, who for many years authored our *New Technology* page.

QUASAR'S CAT

Quasar Electronics have sent us their latest catalogue, which on its front cover invites you to "Get plugged in with the UK's number one electronic kits specialist"! The catalogue certainly provides excellent evidence of the right to claim this descriptive title. It is remarkable how many kits are offered, and the amount of variety in them.

To pick at random from the list, there are kits for amplifiers, computer projects, games, motor controllers, radio receivers, security, test equipment, and many more besides. In addition they have software, tools, transformers and publications as well.

As usual, we recommend that this is a catalogue that should be on your workbench. To get a copy contact

Quasar Electronics Ltd, Dept EPE, PO Box 6935, Bishop's Stortford, CM23 4WP. Tel: 0870 246 1826. Fax: 0870 460 1045. Email: **sales@quasarelectronics.com**. Web: **www.quasarelectronics.com**.

DrDAQ Data Logger

- Low cost - under £60
- Built in sensors for light, temperature and sound (level and waveforms)
- Use DrDAQ to capture fast signals
- Outputs for control experiments
- Supplied with both PicoScope (oscilloscope) and PicoLog (data logging) software

For more information on DrDAQ, please visit:

www.picotech.com/drdaq109

PC Oscilloscopes

- Scope and spectrum analyser functions
- A fraction of the cost of benchtop scope
- Save multiple setups, for ease of use
- Save, print and e-mail your traces
- FREE technical support for life
- FREE software and upgrades
- Automated measurements

For more information on our scopes, please visit:

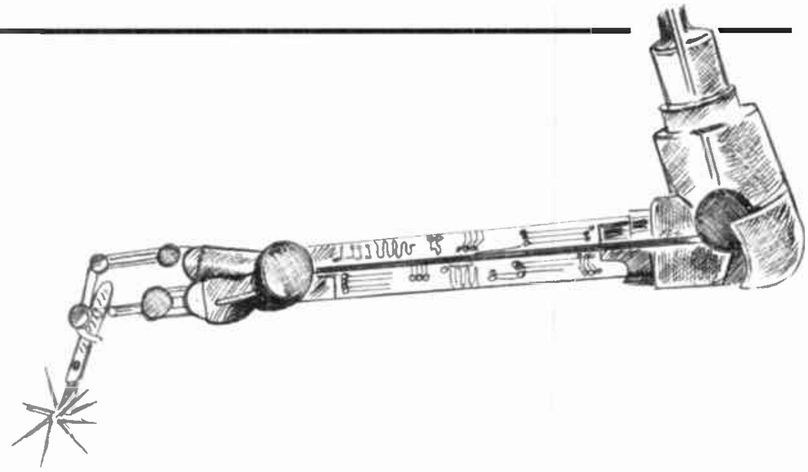
www.picotech.com/scope229

pico Technology Limited

Tel: 01480 396395 Fax: 01480 396296 E-mail: sales@picotech.com

Regular Clinic

Circuit Surgery



Alan Winstanley and Ian Bell

Our surgeons put the Universal Serial Bus (USB) under the microscope in a short series describing the ubiquitous PC serial connection in depth.

USB Background

For the next month or two we will be taking a detailed look at the Universal Serial Bus or USB, starting with a look at the basics of USB connections and the issues relating to USB power.

Electronics projects that connect to PCs have been popular with hobbyists since the earliest days of home computers. These projects have usually used either the serial (RS232) port or parallel printer port to connect the home-brewed circuit to the PC. The other option – designing a circuit board to plug into the ISA bus directly on the motherboard, and more recently the PCI bus inside the PC – was too complex for most amateurs to contemplate and it did not allow convenient plugging and unplugging of the circuit.

This situation had remained almost constant since the 1980s with many hobbyists becoming familiar with using the serial and parallel ports. The hardware was quite straightforward and software written in Visual Basic and other languages could readily use the ports.

However, recently PCs without either of these traditional ports have started to appear: instead they have Universal Serial Bus (USB) ports. By now, PCs without USB seem very dated and old serial and parallel connections are regarded as "legacy" ports and will eventually disappear – as will the 3.5in. floppy drive – from PCs. There are alternatives to USB, such as FireWire (also known as IEEE 1394), but USB has the largest market share.

Plug and Play

The Universal Serial Bus dates from 1996 when the USB 1.0 specification was published by Compaq, Intel, Microsoft and NEC, but it really arrived when Microsoft produced Windows 98, which started to include USB support. The technology was developed to allow true "Plug-and-Play" hot swappable connection of peripheral devices from mice and keyboards to cameras, scanners and printers via the same small sized USB connector, and at far higher data rates than were supported by the previous standards. Two versions of USB are currently in use: the older USB1.1 and now USB2.0, with the main difference being that the latter provides higher data rates.

The older USB1.1 supports two speeds 1.5Mbps and 12Mbps. USB2.0 (also known as High Speed USB) supports both these speeds plus 480Mbps, and it is fully backward compatible with USB1.1. In order to experience the highest speeds of USB2, a USB2 peripheral (scanner, camera, printer etc.), and a USB2 connecting cable must both be used in conjunction with a USB2 port. You can mix USB1.1 and USB2 devices together, but to operate at the fastest speeds, USB2 standard components are required throughout. And if that isn't fast enough for your needs, watch out in the future for Firewire 800, which is about twice as fast again as USB2.

A variant called "USB on the Go" would be used by peripherals that have no host PC but still rely on USB connectivity. For example, a digital camera might communicate with a photo printer and download images directly through USB on the Go, without the need to use a host PC, or a mobile phone might link to a PDA the same way.

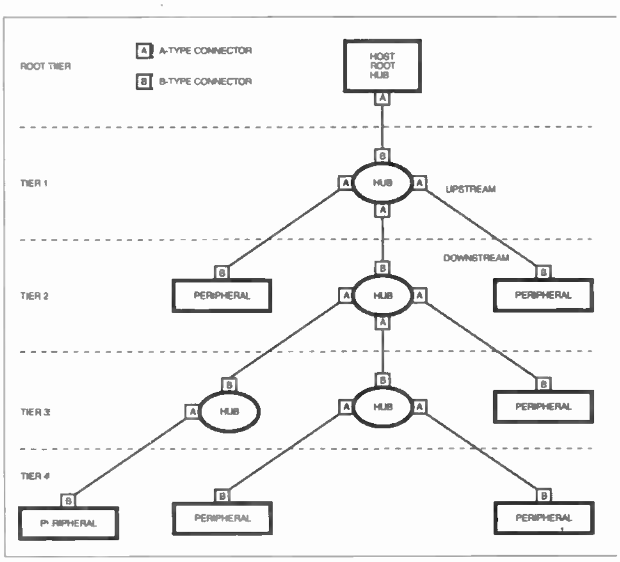


Fig.1. An example USB (Universal Serial Bus) structure showing Hubs, Nodes and Tiers

The Wide Ranging

The USB standard supports devices with wide ranging requirements, including those having a very low overall data rate but needing a fast response (e.g. mice), those requiring large amounts of data transfer in a time-independent but (hopefully!) loss-less manner (e.g. disk drives) and those requiring large amounts of time-dependent data, but coping with some data loss (e.g. audio or video input).

With the market for USB-enabled devices forecast to experience 18·3% annual growth between 2003 and 2008, topping 1 billion units by 2008, USB is obviously going to be around for quite a while (this data is from the high-tech market research firm In-Stat/MDR, see **www.instat.com**). It is therefore worthwhile trying to understand a little about USB.

A to B of USB

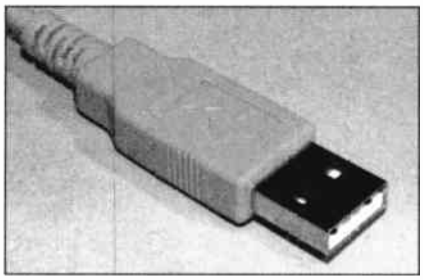
The structure and terminology of USB connections is illustrated in Fig.1. USB devices are connected to the **host** (usually a PC), also known as **Root Hub** using what is called a *tiered star topology*. The host is the *master* of the USB network at all times and controls all activity. USB devices such as mice, disks, cameras scanner and printers are called **peripherals** and can be connected to hubs.

Each hub connects to another hub (up to and including the root hub). On moving out from the host, each time we go through a hub we get to a new tier in the USB structure. USB connections can have up to 127 devices connected – most practical situations are far simpler than this.

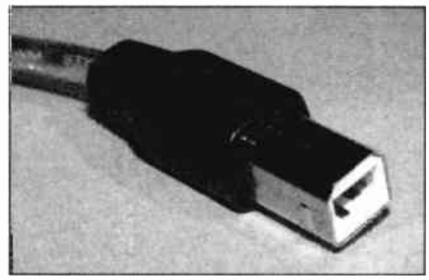
Stream-Line

When referring to a USB connection between a hub and a node, or between two hubs, the connection nearest to the host in the USB network is called the **upstream** connection and the other end is the **downstream** connection. You can buy USB hubs as individual items, and some devices such as keyboards, monitors and multicard readers now have hubs built in, as do some Apple Macintosh computer peripherals.

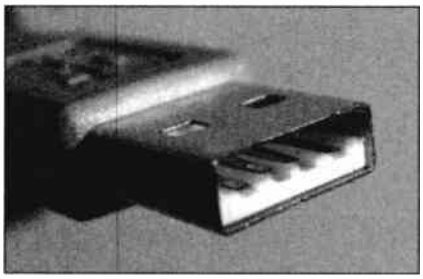
Hubs are USB devices having some "intelligence" and they permit multiple downstream USB devices to be connected to one upstream port, but once a hub has managed the connection of a new device they appears "transparent". To an application running on the PC communicating with a peripheral, the connection appears to be direct.



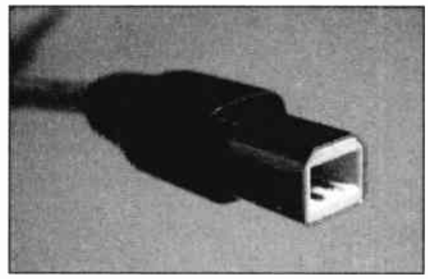
Type A USB upstream connector.



Type B USB downstream connector.



Close-up of Type A plug pins.



Type B box-shaped plug.

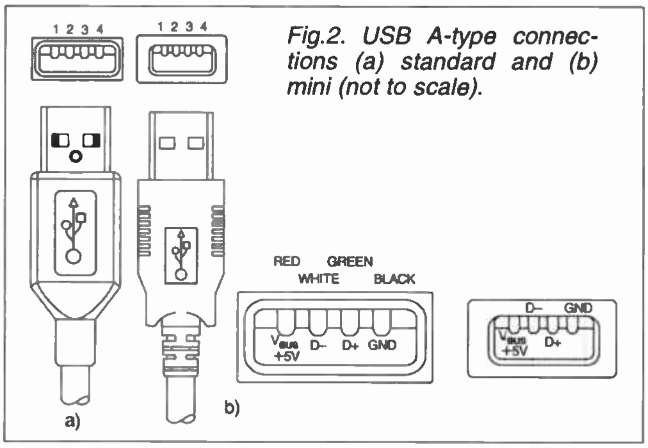


Fig.2. USB A-type connections (a) standard and (b) mini (not to scale).

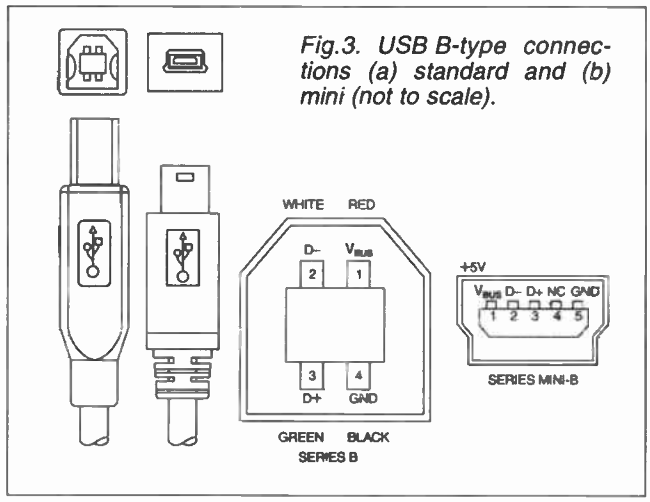


Fig.3. USB B-type connections (a) standard and (b) mini (not to scale).

Making a Connection

USB uses a four conductor cable – two for power and ground wires (28a.w.g. to 20 a.w.g.) and two signal wires (28a.w.g. twisted pair). There are two general types of USB connector – one at each end of a USB cable. The "A" type connector (see Fig. 2 and photos) is for the upstream connection and connects to the PC or distribution points on a hub, in the familiar rectangular USB socket.

The "B" type connector (Fig. 3 and photos) is for the downstream connection and connects to the peripheral device or to a hub's upstream link. (To remember which shape is which, an A-type is flat and a B-type connector is box-shaped.) The use of two connector types means you cannot connect things the wrong way round. USB cables are rated at different operational speeds with cables suitable for higher speed operation being more expensive. Sometimes it's impossible to tell the difference just by looking at USB1.1 and USB2 devices, but hopefully a logo or other symbol will help. Also available are tiny USB connectors that are needed to connect USB to e.g. a digital camera or Smartphone to a PC.

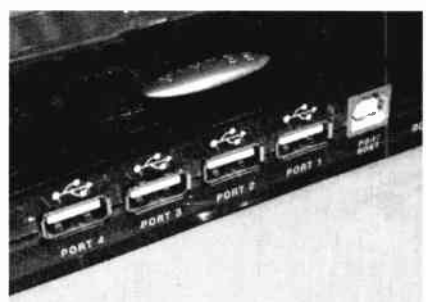
The web site **www.usb.org** contains specifications and industry news for those who want to know more. We can highly recommend the excellent web page published by Network Technologies, Inc. at **www.networktechinc.com/technote.html** showing many PC-related pinouts, downloadable as a PDF as well.

Powered the USB Way

USB can provide power as well as communications; in fact there are many novelty products that simply use a USB connector as a power supply. We've even seen a USB-powered mini electric fan for laptop owners! The USB connection provides a 5V supply of up to 100mA per peripheral without any special action being required. Up to 500mA can be supplied, but the USB device must initially consume 100mA before configuration is complete – this is what is required by the standard, but some novelty devices have no communication at all, and may not comply with this.

Any USB device needing more than 500mA must have its own separate power supply and is referred to as *self-powered*, although it may take up to 100mA to remain communicating with the host when its main supply is off. Devices just powered by the bus at 100mA or less are called *low-power bus-powered* devices. Devices which start at up to 100mA and then switch to up to 500mA from the bus are called *high-power bus-powered* devices.

Not all USB connections are required to provide 500mA – a hub without its own power supply, known as a bus-powered hub, only provides 100mA to each downstream device. Self-powered hubs have their own power supply and can provide 500mA to each attached device. The above photograph shows a four port USB hub, and it is generally very simple to fit an add-in card to a PC motherboard if you want to add a number of USB ports that way instead.



A USB hub showing four ports plus the B-type connector.

Although the supply is nominally 5V some variation is allowed by the specification and the voltage may drop as low as 4.35V. This should be taken into account when using the USB connection as a power supply.

Within reason, there is not really any limit to the amount of current that might be supplied by a USB connection. A hub

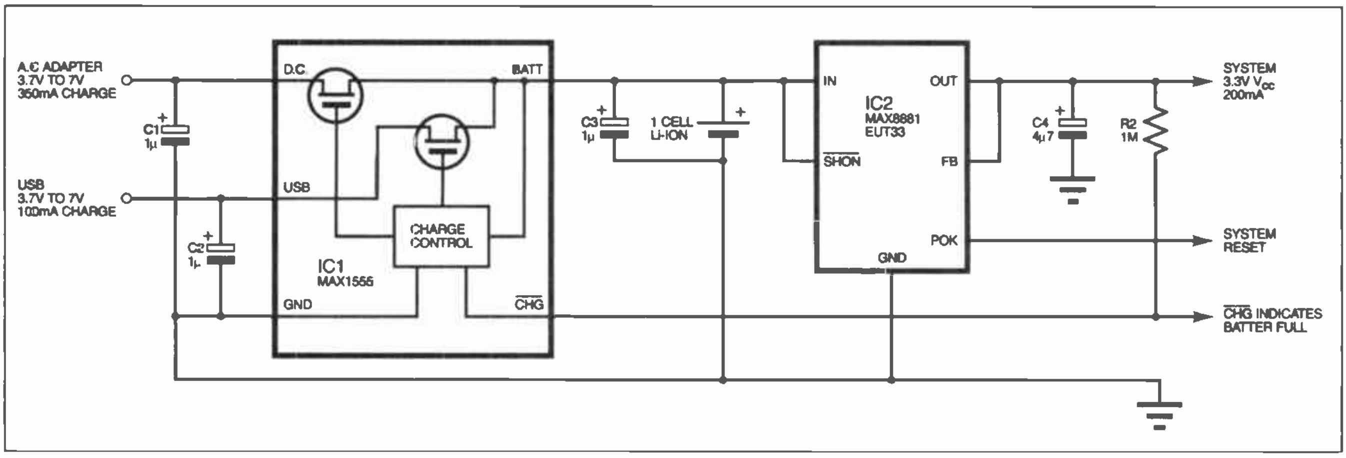


Fig.4. Example circuit diagram for a USB power circuit using Maxim devices (Courtesy Maxim).

or host may have a total capability of several amps, all of which could in theory be supplied to one device, for example, under fault conditions. The 100mA and 500mA threshold values are requirements for the available current, and are not upper limits. If a device draws too much power the hub must report the condition to the host.

The USB specification requires that no current is allowed to flow from the device back to the upstream connection.

USB devices can be connected to a powered-up PC in an action known as "hot plugging" or "hot swapping". In order to ensure correct operation, the USB connector is designed so the power is connected before the data lines. The outer power connectors are longer than the inner data connectors making sure that they connect first when the plug is inserted. (For the same reason, the earth pin on a UK mains plug is larger – it connects first and disconnects last.)

As an example of a USB power circuit see Fig. 4, which is a USB battery charger and power supply taken from a Maxim (**www.maxim-ic.com**) application note. We have not built or proven the circuit. The circuit would be suitable for relatively low power uses, and relatively low capacity batteries. Maxim produces a number of i.c.s for USB-based power supplies and battery charging including higher performance circuits than the one shown here.

The circuit in Fig. 4 uses power from either a rectified a.c. adapter (up to 350mA) or the USB connection, in order to charge a Lithium Ion battery, which in turn provides a regulated 3·3V supply at up to 200mA. As the current drawn from the USB connection is 100mA or less, the circuit can be connected to either a bus-powered or self-powered hub and does not need to communicate with the host.

No power for the load is drawn from the USB connection, so if an average of more than 100mA is drawn with the USB connected the battery will still flatten. If both the USB and a.c. adaptor are connected, power to charge the battery is taken from the mains adapter. The MOSFETs in the MAX1555 are switched to ensure that current cannot flow back on the power input connections. This relatively simple circuit may not perform well with a deeply discharged battery.

Next month we will look at some of the communications aspects of the Universal Serial Bus. *I.M.B.*

SHOP TALK

with John Becker

Super Vibration Switch

None of the components used in this design should present purchasing problems and will be available from the majority of our component suppliers. Even ultrabright l.e.d.s are so commonly available now that they deserve no special mention. It is worth pointing out, though, that the piezo disc is one of those types that has a somewhat fragile looking appearance. It is the thinness of this plate which allows the transducer to react so sensitively to really low-level sounds. Study the photographs while you browse your supplier's catalogue for this device. Although Neodium magnets are specified, Thomas tells us that virtually any other small magnet (7mm to 10mm dia) will work, although with reduced sensitivity.

The choice of relay type is entirely up to you, if you want to use one. All that matters is that its nominal working voltage is about the same as the circuit's supply voltage. Note that it is essential to use a d.i.l. socket for IC1 as this is a CMOS chip (so do treat it as such and discharge static electricity from your body before handling it – the traditional method of touching an earthed item will suffice).

Smart Karts

Hardware-wise, much of this month's version of the *Smart Kart* is the same as that described in Part 1, Oct '04. Regarding the additional electronic components required, it is worth noting that the ultrasonic transducers are standard 40kHz devices, normally sold as a transmitter/receiver pair. We know that they are stocked by **Squires** (☎ **01243 842424** or **www.squirestools.com**, codes 800-272 (Tx) and 800-274 (Rx), and **Sherwood Electronics** (mail-order – see their ad on page 908), codes UR1 and UT1. Squires also have a good selection of microswitches with integral lever, some of them available at very reasonable prices (see page 608 of their current catalogue). Although a fairly robust enclosed buzzer was used in the prototype, it is used internally and so any active (solid-state) type could be used providing that it will work at 4·8V d.c. Any high brightness l.e.d. will do for D2 and D3, and does not need to have a 5000mcd output. All the other components required are commonplace and widely available.

Wind Direction Indicator

The only item worth highlighting for this nicely-simple design is the 4-bit shaft encoder switch, which the author purchased from **Rapid Electronics** (☎ **01206 751166** or **www.rapidelectronics.co.uk**) code 68-1674. All the hardware came from his local d.i.y. stores. The p.c.b. is available from the *EPE PCB Service*, code 475 (see page 902). All other items are widely available from most component suppliers.

Versatile PIC Flasher Mk2

What a fun design this is – we just love the fact that kids can yell at the star to "wake up"! A few items are worth highlighting – first, the ultrasonic transducers are available as quoted earlier for the Smart Kart. The *n*-channel MOSFET 2SK2231 came from **Farnell** (☎ **0870 1200200** or **www.farnellinone.co.uk**), code 327-2175. Luxeon V (passionately bright) white l.e.d.s are also stocked by Farnell, code 432-5813, but be prepared for shock at the price, over £23 each. Again we stress that these devices can be injurious to eyesight and their positioning relative to potential viewers must be cautiously considered.

A kit for the control board is available from **Quasar Electronics Ltd**, see their advertisement on page 833. The LMC662 is stocked by **Squires** – see above (code 750-224) – all other components, including the electret mic insert, are widely available. The p.c.b.s are available from the EPE PCB Service, as usual!

PICs and Software

Fully programmed PICs for Smart Kart SK-2 and the Versatile PIC Flasher MK2 can be purchased from **Magenta Electronics** (☎ **0123 565435** or. **www.magenta2000.co.uk**) for the inclusive price of £5.90 each (overseas add £1 p&p).

The software for both designs is available on a 3.5in. PC-compatible disk (EPE Disk 7) from the *EPE* Editorial Office (see *EPE PCB Service* page for ordering and cost details). It is also available for free download via **www.epemag.co.uk**.

Dave will be back with you next month!

Versatile PIC Flasher Mk2

Steve Challinor

Updating a favourite flasher to provide it with environmental control!

THE original *Versatile PIC Flasher* (Dec '02) Christmas Star decoration was well received, perhaps because it contained much variety. It was controlled by a PIC16F84A microcontroller, of which eight pins were used as pulse width modulated (PWM) outputs. These constantly shifted in phase to each other, so generating a random effect on the various light emitting diodes. The five dual-in-line (d.i.l.) switches provided a choice of different speeds and modulation depths.

Following the original publication, Quasar Electronics introduced a kit for it in which they replaced the transistor output stages with a single i.c. (ULN2803) containing eight Darlington drivers. These drivers support a higher collector voltage, enabling even more l.e.d.s to be chained, and the use of the ULN2803 reduced the design to a very compact form.

Illuminated Ideas

It subsequently occurred to the author that speed and modulation choices do not necessarily have to be set by switches. Why not make the display externally controllable? It could even be made responsive to the environment!

For example, noise level could control the speed – the noisier the faster. Perhaps temperature could control the modulation; when it is cold the Star, or other form of display, could be hardly changing, but as the temperature increased it could become more active. And how about a proximity sensor to send the Star into its "shimmer" mode?

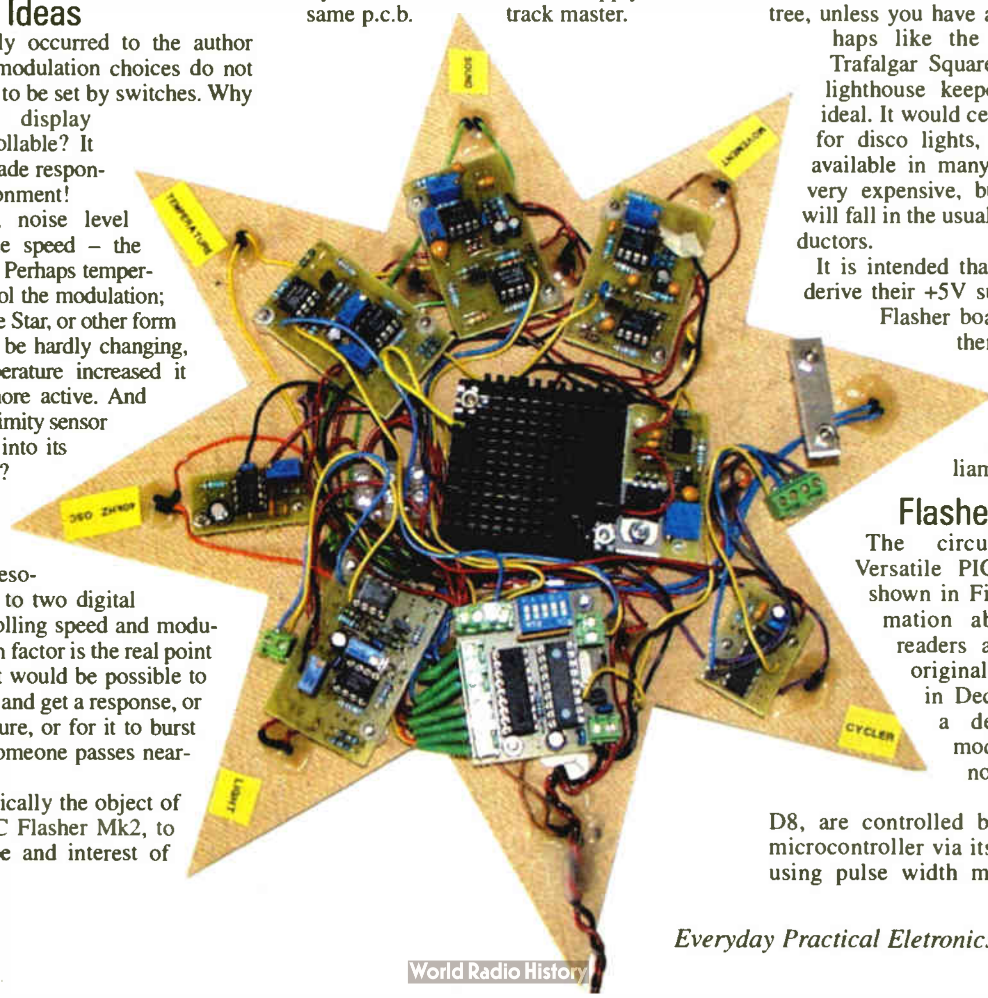
Of course, as an instrument of measurement, resolution is limited to two digital bits, those controlling speed and modulation, but the fun factor is the real point of this project. It would be possible to talk to your Star, and get a response, or tell the temperature, or for it to burst out flashing if someone passes nearby!

So, this is basically the object of the Versatile PIC Flasher Mk2, to extend the scope and interest of the original design. All circuits described will interface to the original flasher, but a new p.c.b. is also included here, as an upgrade to incorporate the ULN2803 driver. The design is not functionally different to the original, but it includes extra terminals for connecting to external control sources in place of or in addition to the switches.

The new design has been found to be great fun for the kids, who love shouting at it to "wake up"!

Sensor Boards

Four sensor boards are described, to detect Sound, Temperature, Light and Movement. These four circuits use the same format, i.e. transducer, amplifier, detector and comparator. It has thus been possible to use the same p.c.b. for all four circuits by the use of link wires. All the component layouts shown therefore apply to the same p.c.b. track master.



Interfacing to the PIC is by an open collector transistor (actually in the comparator device used) which is able to pull the PIC input pin low, provided of course that the d.i.l. switch is left open.

Although not really necessary with the Mk2 design, the switches have been retained to maintain similarity with the Mk1. They may be omitted if preferred.

Apart from the sensor boards, it was thought that a couple more items might be of interest. The first of these is a "Cycler", which cycles the Flasher through its repertoire in an orderly way, with times selectable up to several minutes.

The other circuit is a driver for the new 5W high power l.e.d. from Lumileds. This is a seriously bright device, and definitely not for the children! **It must be stressed that the light levels produced can be damaging to the eyes at close quarters.** This is not an item for the Christmas tree, unless you have a very big one, perhaps like the one in London's Trafalgar Square? Or, if you are a lighthouse keeper then it will be ideal. It would certainly also be good for disco lights, especially as it is available in many colours. It is still very expensive, but hopefully prices will fall in the usual way with semiconductors.

It is intended that the sensor boards derive their +5V supply from the PIC Flasher board, as they are not themselves fitted with any voltage regulator, and only require a few milliamps.

Flasher Circuit

The circuit diagram for Versatile PIC Flasher Mk2 is shown in Fig.1. For full information about its function, readers are referred to the original design published in December 2002. Only a description of the modified aspects will now be covered.

The l.e.d.s, D1 to D8, are controlled by the PIC16F84A microcontroller via its eight Port B pins, using pulse width modulation (PWM).

As said earlier, the original circuit used discrete transistors as its eight output drivers, these have now been replaced by a ULN2803A driver, IC2.

The length of the mark (on-period) controlling l.e.d. brightness is read from an array in programmed memory and thus one complete cycle, from off to maximum to off again, is obtained as the program reads in values from it. Each output has a slightly different array length, which gives a continual shift in phase, and gives an apparently random effect.

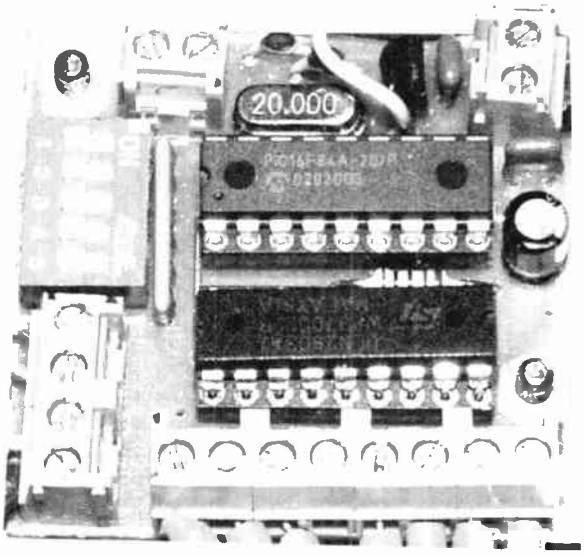
Port A is jointly under the control of five dual-in-line switches (S1a to S1e) and from external sources connected via terminal block pins (TP1 to TB5). For the latter to be used, the respective switches must be left open.

The logic status on Port A determines the program's execution mode. Port A pins RA0 and RA1 control the speed at which the array is read through, and RA2 and RA3 control the length of the array executed. In other words, they control the modulation rates of the l.e.d.s. Pin RA4 controls the mode which produces a "shimmering" effect at the top speed. Table 1 summarises the modes.

Although only one l.e.d. is shown attached to each output, several l.e.d.s can be chained in series, as stated in Table 3 later.

Table 1: Mode Settings

LSB/S1a RA1/TP1	***MSB/S1b RA0/TP0***	***Speed***
0	0	Fast
1	0	Medium fast
0	1	Medium slow
1	1	Slow
LSB/S1c RA2/TP2	***MSB/S1d RA3/TP3***	***Modulation***
0	0	100%
1	0	50%
0	1	25%
1	1	12·5%
S1e RA4/TP4/		***Profile***
0		Smooth
1		Flash



Main PIC Control printed circuit board.

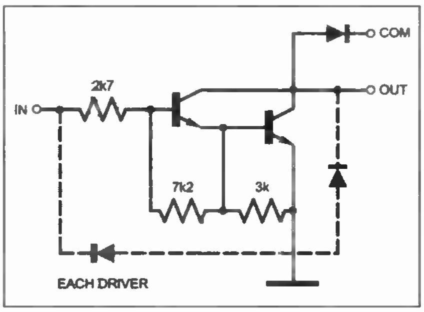


Fig.1a. Driver circuit.

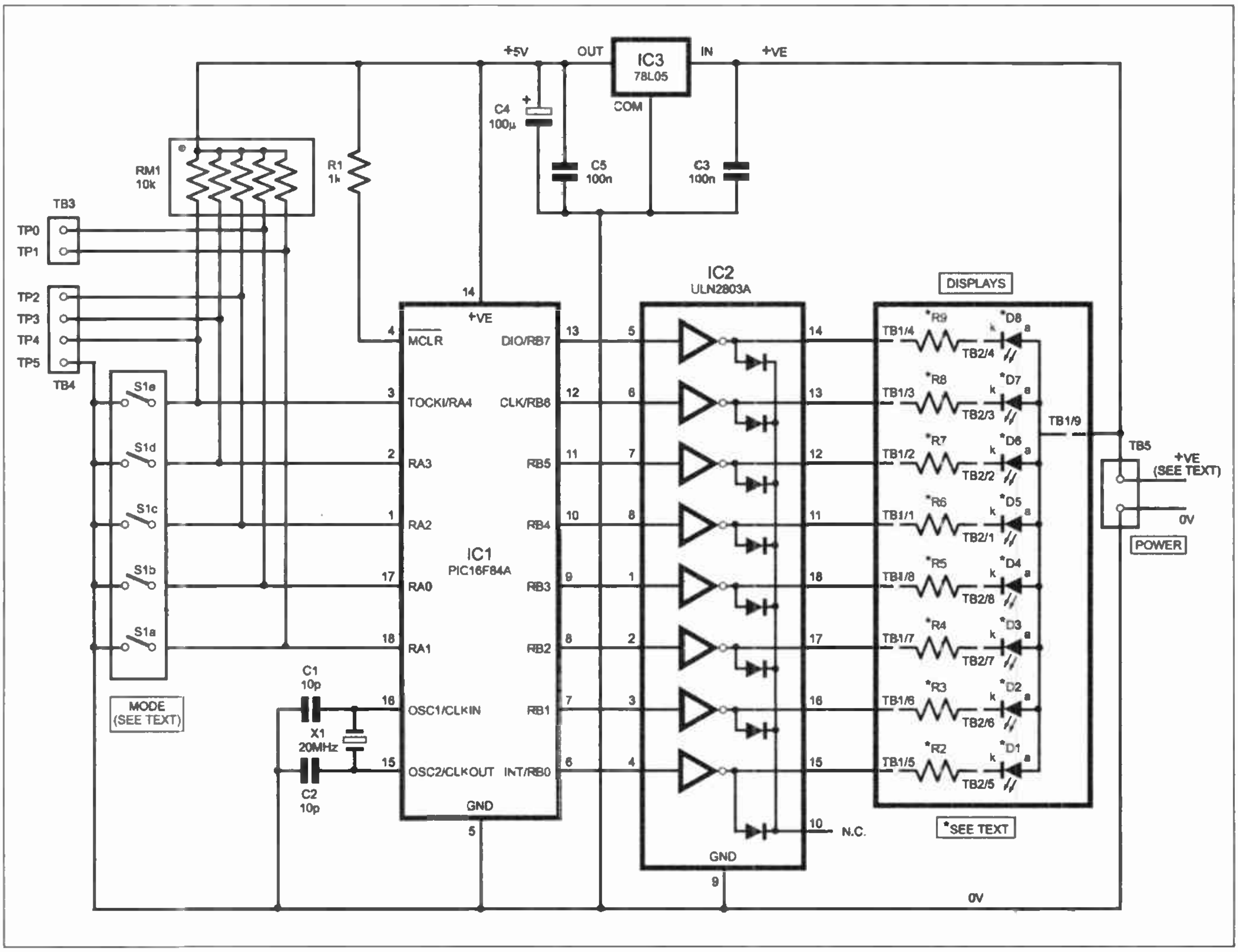


Fig.1. Complete circuit diagram for the main controller of the Versatile PIC Flasher Mk2.

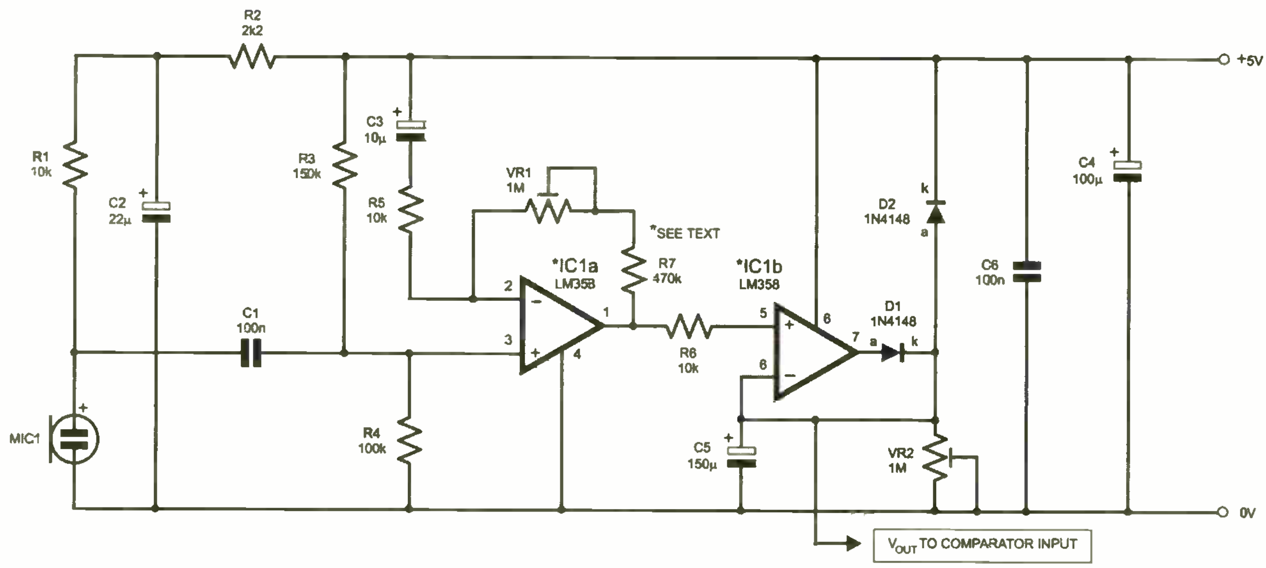


Fig.2. Full circuit diagram for the Sound Sensor stage.

Sound Sensor

The Sound Sensor circuit is shown in Fig.2. It uses an electret microphone (MIC1) and op.amp gain block (IC1a) in a conventional way, with capacitor C3 reducing the gain to unity at d.c. to provide stability. Preset potentiometer VR1 controls the a.c. gain, with resistor R7 setting a minimum value.

Connecting C3 to the positive rail is somewhat unusual. In the normal way this would be to 0V, but at power on there is a problem in that, as C3 slowly charges up through the very large resistance of VR1/R7, the output of IC1a would go high and charge up to full extent the peak detector capacitor, C5. There would then be a long delay on the high level outputs before C5 discharges down to base level (+2V). Taking C3 to +5V seemed the simplest solution.

The output signal from IC1a pin 1 then passes to the peak detector stage around IC1b, with the discharge time for capacitor C5 set by preset VR2. If the sound level drops suddenly, the current output level will be maintained briefly, depending on the setting chosen for preset VR2. If you do not want to adjust this, a fixed 1MΩ resistor would be fine.

Comparator Tree

The signal next passes to the comparator stage around IC2a and IC2b (see Fig.3) for conversion into the 2-bit code required by the PIC, where it may be applied to either the speed or modulation control.

Conventionally, the comparators would be used in a tree arrangement (see Fig.4), with each comparator up the tree switching at successive levels, according to the increasing reference voltage for each comparator. Then some decoding would be necessary to convert to a binary code.

However, for this simple 2-bit application, with only three levels to switch above the base level, a simpler solution was required. This was found by using one comparator to switch the voltage reference for the other comparator, as in Fig.3.

The trigger threshold for IC2b is set by resistors R12 and R13. The basic trigger threshold for IC2a is set by resistors R8 and R9, but the threshold can be changed by connecting R11 to the 0V line via transistor TR1, putting it in parallel with R9. This defines the low voltage threshold (IC2a).

When the comparator for the middle level switches (IC2b), it also switches off TR1, thus disconnecting R11 and letting resistors R8 and R9 set the level for the high reference, on the same comparator. IC2a will thus go high again as the reference exceeds the input level on pin 2. Resistors R14 and R10 provide some hysteresis so that there is no jitter at the thresholds.

The levels for the comparators are set at 2.75V, 3.2V and 3.5V, with the base level at 2.0V, the no-signal output level from IC1b. This is roughly a logarithmic scale, with a maximum output suited to the specified LM358. A rail-to-rail input and output op.amp, such as the LMC662, could be used, most general purpose dual op.amps should cope.

Note, though, that some (otherwise excellent) op.amps, such as the MAX492 are not suitable due to the protection diodes on the input lines, which will impede the action of the peak detector.

The open-collector outputs from comparators IC2a and IC2b set the binary code required in conjunction with the pull-up resistors (within resistor module RM1) situated on the Flasher board. In use, it was found that gain could be set high enough for very moderate sound levels to give maximum output, thus it is simply a matter of setting VR1 for the loudest sounds expected.

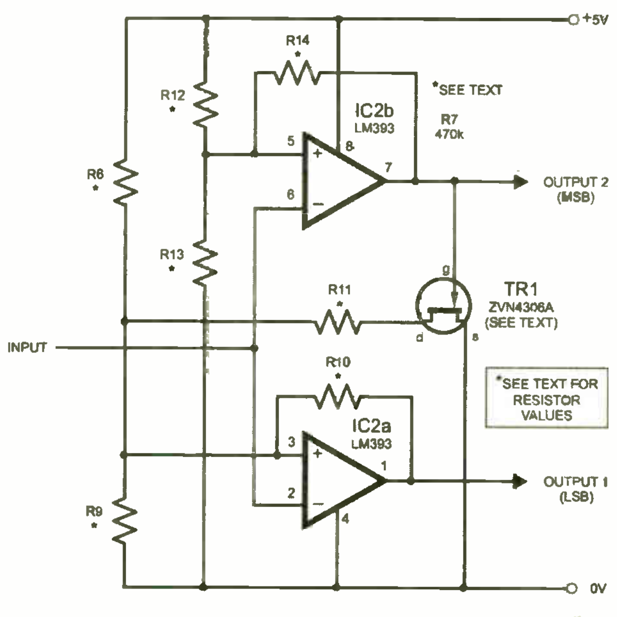


Fig.3. Circuit diagram for the Comparator.

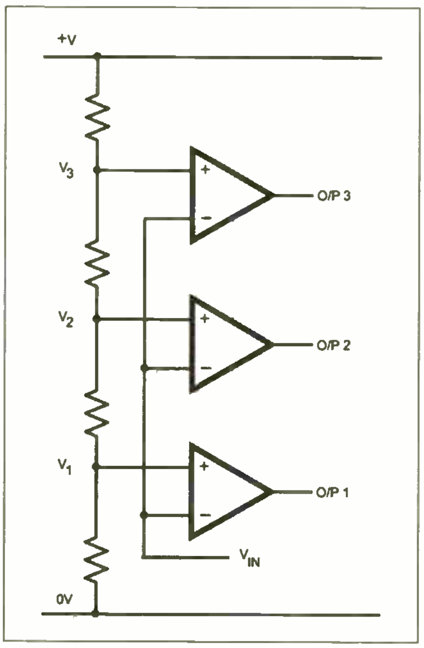


Fig.4. Circuit representation of a comparator "tree".

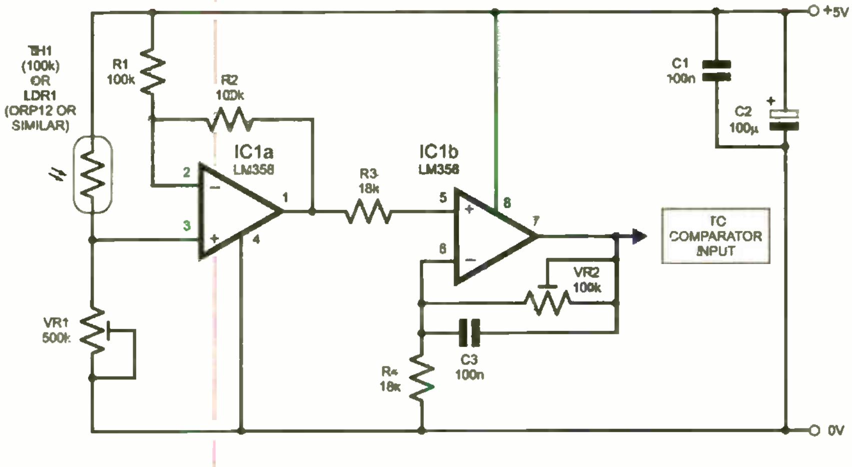


Fig.5. Circuit diagram for the Temperature/Light Sensor stage.

Table 2: Thermistor Values

Temperature (°C)	*Resistance (kΩ)*
-5	461·6
0	351·0
5	269·1
10	207·9
15	161·7
20	126·7
25	100·0
30	79·4
35	63·5
40	51·1
45	41·3
50	33·6
55	27·5
60	22·6
65	18·7

Temperature/Light Sensor

The circuit which can be used as a temperature or light sensor is shown in Fig.5.

A thermistor was chosen as the temperature sensing element (TH1), as it is simple to use and has a defined resistance/temperature characteristic (see Table 2).

In principle, and with a 350kΩ resistor in series with TH1, the voltage change from 0°C to 30°C would be 1.6V. This would be quite enough to pass directly to the comparator section for conversion to the 2-bit binary code. However, op.amp amplification stages IC1a and IC1b have been added to provide flexibility. It is thus possible to adjust the starting point and span of the scale.

Preset potentiometer VR1 is used to set the start of the scale, and VR2 sets the top end limit. Op.amp IC1a functions as a level shifter, with a gain of two, setting the start point at 0V (bottom of the temperature scale).

As an example, VR1 could be set at room temperature (setting IC1a pin 3 to +2.5V, or pin 1 to 0V) and then, holding the thermistor, adjust VR2 to set the full scale temperature limit (setting IC1b pin 7 to 3.5V). The full range is just over a few degrees.

Likewise, any starting point and any range can be chosen, within limits of course! The drawback of thermistors, though, is their non-linearity, although this is slightly offset by the series resistor (VR1 in this case). This is not a problem for a PIC, where a look-up table can adjust for inaccuracies.

In this case the log scale of the comparator stage also helps to make some improvement, but for this 2-bit application, accuracy is not the priority! The threshold voltages were set for 1.8V, 2.75V, and 3.5V, with some hysteresis when coming down.

The same considerations apply to the light sensor, a light dependent resistor (LDR). This changes its resistance from several megohms in dark conditions, to just a few kilohms (or less) in bright light. The settings for VR1 and VR2 may be made in the same way as before.

Movement Detector

A proximity sensor to send the flasher into "shimmer" mode is perhaps the most dramatic effect, especially if it takes someone by surprise! In this case the sensor detects movement and is based on the Doppler shift principle, using two 40kHz transducers.

The Transmitter circuit is shown in Fig.6. and is formed around a CMOS 7555 timer, used in oscillator mode. The 40kHz oscillation frequency is determined by capacitor C8, resistor R14 and the setting of preset VR2. The ultrasonic transmitter is X2 and is buffered by resistor R15.

The Receiver circuit is shown in Fig.7. The received signal is likely to be very low in amplitude and so a fair bit of signal processing is required to bring it up to a usable level.

Most general purpose op.amps are well down in open loop gain when handling 40kHz signals. Consequently, in the interests of circuit stability, two gain stages, IC1a and IC1b, are used to amplify the signal from the receiving transducer, X1. Furthermore, the use of rail-to-rail output op.amps, such as the LMC662, is recommended for the receiver in order to maximise the sensitivity of the circuit.

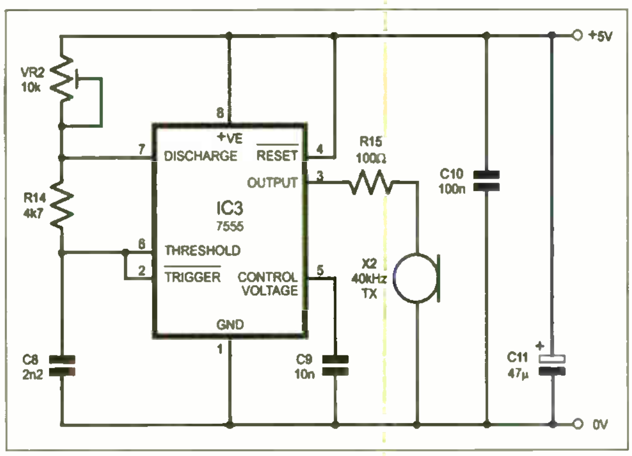
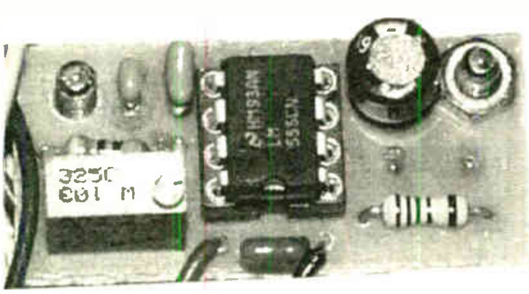
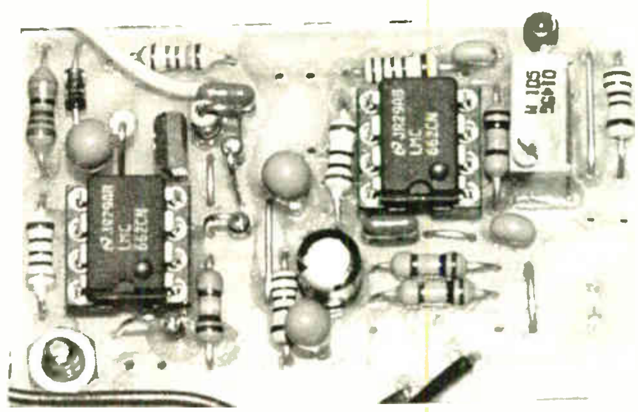


Fig.6. Transmitter circuit for the Movement Detector.





(Above) Completed Transmitter board.
(Right) Component layout on the Receiver board of the Movement Detector.

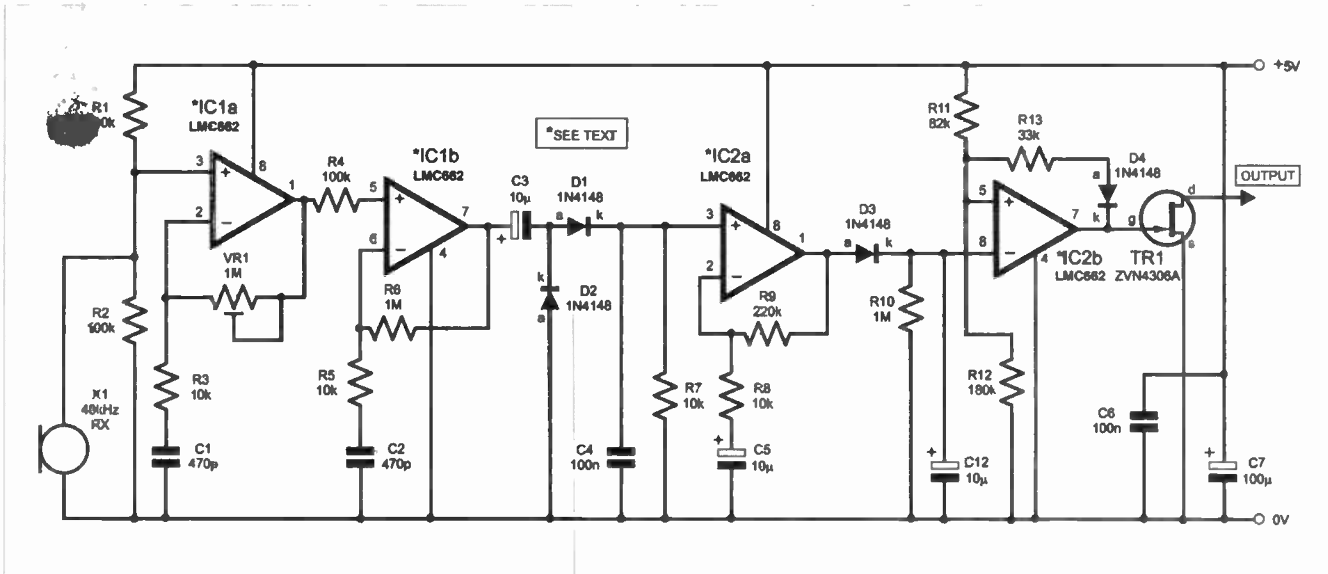


Fig.7. Complete circuit diagram for the Receiver section of the Movement Detector.

The low frequency Doppler shift signal output from IC1b pin 7 appears as amplitude modulation and is detected by diodes D1 and D2, with capacitor C4 and resistor R7 smoothing the signal into low frequency audio.

This is amplified by another gain stage, IC2a, following which diode D3 and capacitor C12 act as a peak detector. When the threshold voltage is reached (about 3.4V), IC2b acts as a comparator and its output pin 7 goes low. Via diode D4 and resistor R13, this low output pulls the voltage reference level at pin 5 down to about 1V. The combined result of charge on C12 and the reference voltage pulled down gives a time delay before the voltage on C12 is low enough to switch the op.amp high again.

The output from IC2b controls transistor TR1, whose drain (d) is then connected to the required PIC input.

Simple Cycler

The Simple Cycler circuit shown in Fig.8 is comprised of just a 74HC4060, IC1, which is a 14-stage binary counter with built-in oscillator. It requires only two external resistors, R1 and R2, and one capacitor, C1. Connections to the PIC may be taken from any of the 10 outputs. (Annoyingly, output Q11 of the 74HC4060 is not externally implemented!)

If two of the PIC input pins are connected to stages n and n+1 for example, all the binary codes for the 2-bit PIC inputs will be cycled through. Each stage divides by two, so fairly long time intervals can be achieved, given suitable oscillator components.

On the prototype, with the values shown, a mark or space on output Q7 was about one minute 12 seconds, and by the time the count reaches Q14, the delay is 128 times that. So times can be set to suit by selecting the appropriate outputs.

If, for instance, the modulation controls (PIC pins RA2 and RA3) are connected to Q7 and Q8, and the speed controls (RA0 and RA1) are connected to Q9 and Q10, then all four modulation states will be cycled through at each speed setting. This provides a very simple method of constantly changing the display.

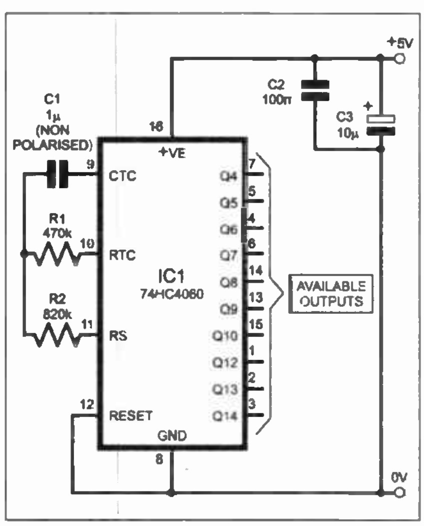


Fig.8. Simple Cycler circuit diagram.

Luxeon L.E.D. Controller

Luxeon V is the name for the new power l.e.d.s from Lumileds. These 5W devices run at 5.4V to 8.37V, at a current of up to 700mA. This can be quite a shock to the system, when you are used to l.e.d.s being 10mA cool-running devices!

However, these devices represent a brand new way of l.e.d. fabrication. For information visit the Lumileds website **www.lumileds.com** for highly informative tutorials.

Luxeon V devices doubtless have a very bright future (pun intended)! All sorts of applications come to mind, in particular the author is looking forward to car bulbs that will exceed the life of the car! The Farnell website **(www.farnellinone.com)** also shows a wide range of these devices, of various powers and colours.

The l.e.d.s are claimed to be 100 times brighter than standard small signal l.e.d.s, although it is hard to compare figures as the Luxeon light output is given in terms of luminous flux (typically 120 lumens), which is a measure of the entire light output from the device. The figure usually given is the mcd (millicandela) value, which is a measure of flux per unit area, or intensity. However, once this device is seen, the figures will not be disputed!

The use of a voltage dropping resistor from a fixed supply seemed impractical since it is preferable to have the Luxeon current adjustable. Consequently, it was

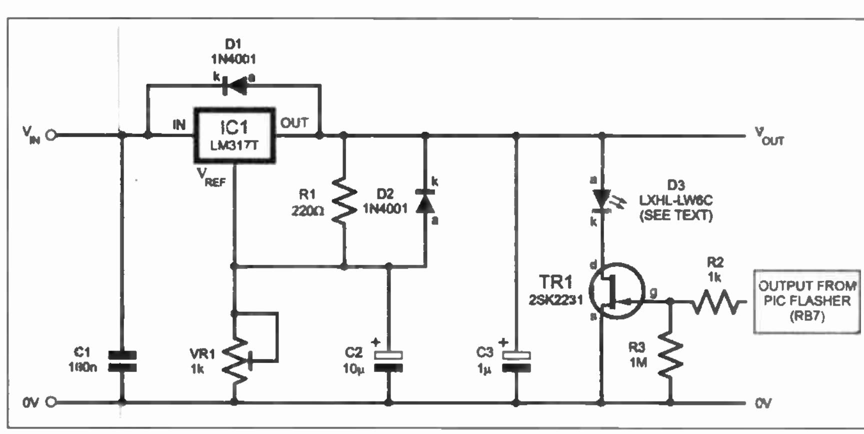


Fig.9. Circuit diagram for the Luxeon L.E.D. controller. It must be stressed that light levels generated by the l.e.d. can be damaging to the eyes.

decided to use a variable voltage regulator to control the l.e.d., as this can be easily adjusted for different currents and brightness. The resulting circuit is shown in Fig.9.

The LM317T can source up to 1.5A at voltages down to 1.2V, which is more than adequate. The regulator develops a constant voltage between its output and adjustment (V_{ref}) pins, and this gives an output voltage of $V_{ref} \times (1+R1/VR1)$, approximately.

Preset VR1 adjusts the output voltage from regulator IC1. Diode D1 protects IC1 against reverse voltage across it, diode D2 helps to limit the output voltage in respect of the current drawn. Note that the usual series resistor is absent, so it is important to adjust the output voltage to a suitable value before connecting the Luxeon l.e.d.

Diode D3 is the Luxeon l.e.d., which is turned on and off via MOSFET transistor TR1, which itself is under control of the PIC, via its RB7 output.

Construction

The printed circuit board (p.c.b.) for the Versatile PIC Flasher Mk2 has a similar functionality to that of the original board. However, as it uses a ULN2803 package instead of transistors for the eight output drivers, it is in a slightly more compact form than the original. It also supports a greater collector voltage (50V).

The p.c.b. component assembly and track details for the main control board are shown in Fig.10. Those for the sub-assembly boards, depending on function, are given in Figs.11 to 16. With the latter, choose the one you want, noting that the component values for the Comparator depend on which other circuit it is used with, see the respective Components lists. Boards are available from the *EPE PCB Service*, codes 476 (Main), 477 (Trans), 478 (Multi), 479 (Cycler) and 480 (Luxeon).

It is recommended that a soldering iron with a fine bit should be used as some of the pads and tracks are quite thin. The usual order of assembly is best, starting with the links, d.i.l. sockets, and then the components in order of ascending size. Ensure that the polarity sensitive components are inserted the correct way round.

Thoroughly check your assembly for solder and component positioning errors before applying power. Then check you have the right voltages before the d.i.l. i.c.s are inserted.

Sensor Boards

For the sensor boards, apart from the thermistor, the sensors can be mounted on the copper side, projecting through a hole in the Christmas Star, with the p.c.b.s mounted on spacers.

Although the prototype contained both the Luxeon driver and the sensor boards, this is not recommended if there is going to be any proximity to children, who are likely to enjoy playing with the sensors, but who must not be subjected to the high intensities of light emitted by the Luxeon l.e.d. Note that there is a separate pad provided for the Luxeon l.e.d. driver to be directly connected to the PIC at RB7.

It is also important to note that current limiting resistors for the other l.e.d.s are not fitted on the main board, so these will need to be inserted somewhere in the l.e.d.

COMPONENTS

Approx. Cost Guidance Only **£15**

Control Board

Resistors

R1	1k 0.25W 5% carbon film
R2 to R9	see Table 3
RM1	10k 5-way commoned resistor module, s.i.l.

See SHOP TALK

Capacitors

C1, C2	10p ceramic disc (2 off)
C3, C5	100n ceramic disc (2 off)
C4	100µ radial elect. 10V

Semiconductors

D1 to D8	l.e.d., see text regarding quantities and styles
IC1	PIC16F84A-20 microcontroller, preprogrammed (see *Shoptalk* page)
IC2	ULN2803 8-way Darlington driver
IC3	78L05 +5V 100mA voltage regulator

Miscellaneous

S1	5-way d.i.l. switch, p.c.b. mounting (optional, see text)
X1	20MHz crystal
TB1	8-way terminal block, p.c.b. mounting
TB2	9-way double terminal connector block
TB3, TB5	2-way terminal block, p.c.b. mounting (2 off)
TB4	4-way terminal block, p.c.b. mounting

Printed circuit board, available from the *EPE PCB Service*, code 476 (Flasher Main); 18-pin d.i.l. sockets (2 off); display construction material (see text); p.c.b. mounting supports (see text); connecting wire; solder, etc.

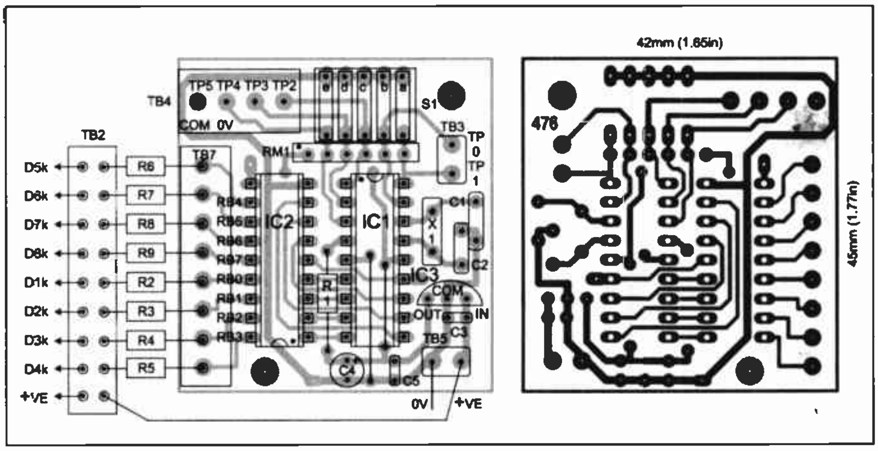


Fig.10. Component layout, wiring details and the full-size underside copper foil master pattern for the Main Control printed circuit board.

Table 3: Current Limiting Resistors for the l.e.d. chain

L.E.D.s (n) per output	R11 to R18 at 20mA Red/Yel/Green	Blue	White	1 Blue+ n(R/Y/G)	1 White+ n(R/Y/G)
+12V Power Supply					
1	470Ω	390Ω	470Ω	270Ω	330Ω
2	390Ω	180Ω	270Ω	220Ω	220Ω
3	330Ω	–	–	120Ω	150Ω
4	220Ω	–	–	–	–
+24 Power Supply					
3	1k	560Ω	680Ω	680Ω	820Ω
4	820Ω	390Ω	560Ω	560Ω	680Ω
5	680Ω	220Ω	390Ω	470Ω	560Ω
6	560Ω	–	220Ω	390Ω	470Ω

COMPONENTS

Movement Detector

Resistors

R1, R2, R4	100k (3 off)
R3, R5, R7, R8	10k (4 off)
R6, R10	1M (2 off)
R9	220k
R11	82k
R12	180k
R13	33k
R14	4k7
R15	100Ω

All 0·25W 5% carbon film.

See SHOP TALK page

Potentiometers

VR1	1M multiturn preset, top adjust
VR2	10k multiturn preset, top adjust

Capacitors

C1, C2	470p ceramic disc (2 off)
C3	10µ radial elect.10V
C4, C6, C10	100n ceramic disc (3 off)
C5, C12	10µ tantalum, 16V (2 off)
C7	100µ radial elect. 10V
C8	2n2 ceramic disc
C9	10n ceramic disc
C11	47µ radial elect, 10V

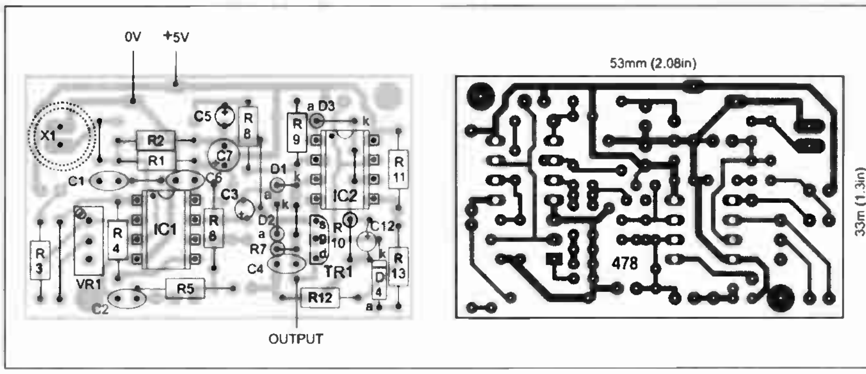


Fig.11. Receiver printed circuit board component layout and copper foil master.

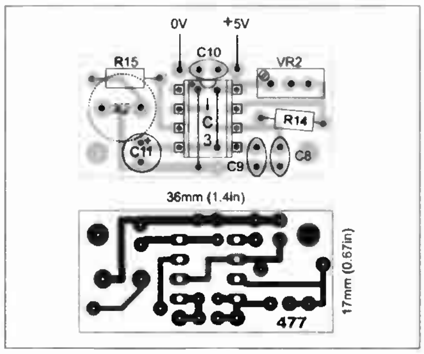


Fig.12. Transmitter board and master.

Semiconductors

D1 to D4	1N4148 signal diode (4 off)
TR1	ZVN4306A *n*-chan MOSFET (see text)
IC1, IC2	LMC662 dual op.amp (see text) (2 off)
IC3	7555 CMOS timer

Miscellaneous

X1, X2	40kHz ultrasonic transmitter receiver matched pair

Printed circuit board available from the *EPE PCB Service*, code 478 (Multipurpose Sensor), 477 (40kHz Oscillator); 8-pin d.i.l. socket (2 off); p.c.b. mounting supports (see text); connecting wire; solder, etc.

Approx. Cost Guidance Only **£18**

COMPONENTS

Sound Sensor and Comparator

Resistors

R1, R5, R6, R8,	10k (4 off)
R2	2k2
R3	150k
R4	100k
R7	470k
R9, R11	22k (2 off)
R10, R14	120k (2 off)
R12	12k
R13	18k

All 0.25W 5% carbon film.

See SHOP TALK page

Potentiometers

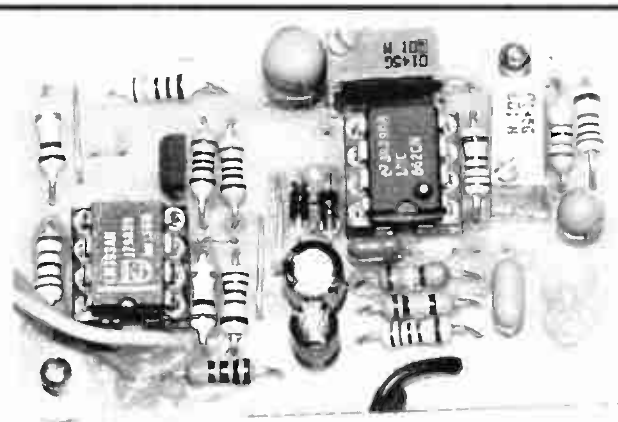
VR1, VR2	1M multiturn preset, top adjust (2 off)

Capacitors

C1, C6	100n ceramic disc (2 off)
C2	22µ radial elect, 10V
C3	10µ tantalum, 16V
C4	100µ radial elect. 10V
C5	150µ tantalum, 6.3V

Semiconductors

D1, D2	1N4148 signal diode (2 off)
TR1	ZVN4306A *n*-channel MOSFET (see text)
IC1	LM358 dual op.amp (see text)
IC2	LM393 dual comparator



Components mounted on the Sound Sensor/Comparator board.

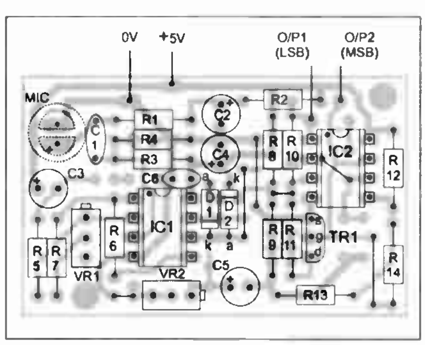


Fig.13. Component layout for the Sound Sensor/Comparator board. Note that this is the Multi-purpose board.

Miscellaneous

MIC1	electret microphone insert

Printed circuit board available from the *EPE PCB Service*, code 478 (Multipurpose Sensor); 8-pin d.i.l. socket (2 off); p.c.b. mounting supports (see text); connecting wire; solder etc.

Approx. Cost Guidance Only **£12**

COMPONENTS

Temperature/Light Sensor

See **SHOP TALK** page

Resistors

R1, R2	100k (2 off)
R3, R4	18k (2 off)
R8, R12	10k (2 off)
R9	22k
R10, R14	150k (2 off)
R11	6k8
R13	12k

All 0.25W 5% carbon film.

Potentiometers

VR1	500k multiturn pre-set, top adjust
VR2	100k multiturn pre-set, top adjust

Capacitors

C1, C3	100n ceramic disc (2 off)
C2	100μ radial elect, 10V

Semiconductors

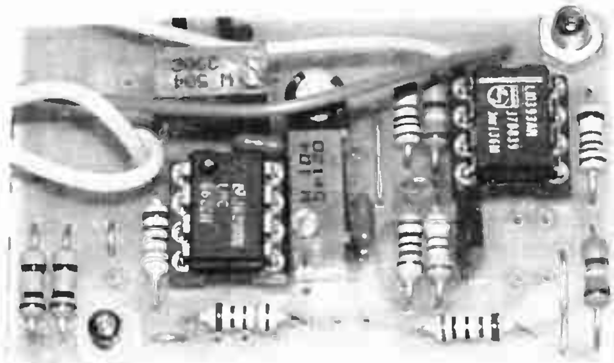
IC1	LM358 dual op.amp (see text)
IC2	LM393 dual op.amp comparator
TR1	ZVN4306A *n*-channel MOSFET

Miscellaneous

LDR1	light dependent resistor, e.g. ORP12 (Light Sensor only)
TH1	thermistor, 100k (Temp.Sensor only)

Printed circuit board available from the *EPE PCB Service*, code 478 (Multi Sensor); 8-pin d.i.l. socket (2 off); p.c.b. mounting supports (see text); connecting wire; solder, etc.

Approx. Cost Guidance Only **£12**



Temperature Sensor circuit board. The termistor is replaced with a light dependent resistor (LDR) for the Light Sensor.

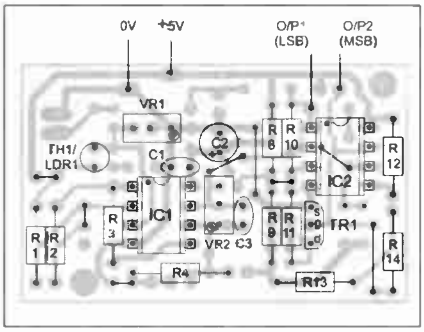


Fig.14. Component layout for the Temp/Light Sensor on the Multi-purpose p.c.b.

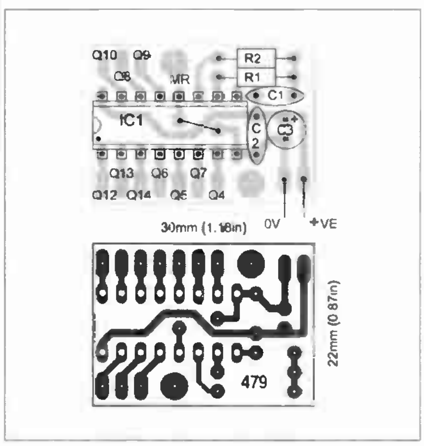


Fig.15. Simple Cycler printed circuit board component layout and foil master.

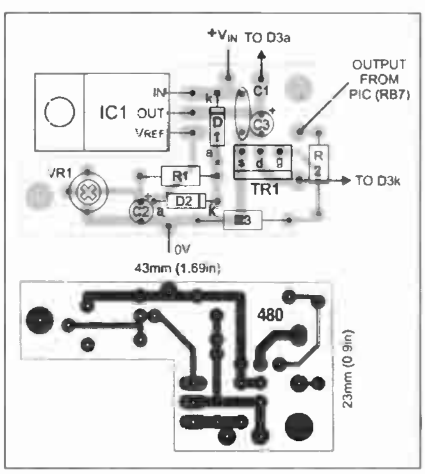


Fig.16. Luxeon V Controller circuit board. Beware: the light levels produced can be damaging to the eyes.

COMPONENTS

Cycler

See **SHOP TALK** page

Resistors

R1	470k
R2	820k

All 0.25W 5% carbon film.

Capacitors

C1	1μ axial elect, non-polarised, 10V
C2	100n ceramic disc
C3	10μ axial elect. 16V

Semiconductor

IC1	74HC4060 14-stage binary ripple counter

Miscellaneous

Printed circuit board available from the *EPE PCB Service*, code 479 (Cycler); 16-pin d.i.l. socket; p.c.b. mounting supports (see text); connecting wire; solder, etc.

Approx. Cost Guidance Only **£6**

COMPONENTS

Luxeon V Controller

See **SHOP TALK** page

Resistors

R1	220Ω
R2	1k
R3	1M

All 0.25W 5% carbon film.

Potentiometer

VR1	1k min. round preset

Capacitors

C1	100n ceramic disc
C2	10μ radial elect. 10V (or tantalum 6.3V)
C3	1μ tantalum 6.3V

Semiconductors

D1, D2	1N4001 rectifier diode (2 off)
D3	LXHL-LW6C Luxeon V l.e.d. (see text)
TR1	2SK2231 *n*-chan MOSFET
IC1	LM317T adjustable +VE voltage regulator

Miscellaneous

Printed circuit board, available from the *EPE PCB Service*, code 480 (Luxeon); heatsink, 48mm x 48mm x 8.9mm (see text); p.c.b. mounting supports (see text); connecting wire; solder, etc.

Approx. Cost Guidance Only **£30**

Incl Luxeon l.e.d.

chain. It is suggested that they are inserted into the on-board connector, and then a second terminal block is connected to their outer ends. The wires to the l.e.d.s can then be readily connected to this block. Table 3 shows the suggested resistor values for power supplies of +12V and +24V in respect of various l.e.d. colours.

Chains of up to 20, or more, l.e.d.s may be connected to the ULN2803 outputs, as long as their supply voltage does not exceed +50V. However, the limiting factor is probably going to be finding a power supply for a voltage that high! In any case, the power supply to the flasher board must not exceed +24V.

Heatsinking

The p.c.b. for the LM317 regulator, IC1, has a cut-out so that this device can be attached to the required heatsink. The heatsink specified is intended for microprocessor cooling, but is expensive, so you may want to improvise. It is very thin and has an adhesive and thermally conductive pad for attaching to the device.

Although Luxeon l.e.d.s are mounted on aluminium backing plates, more heatsinking than this is required. In the prototype, the Luxeon l.e.d. and voltage regulator were attached to the same heatsink, the l.e.d. directly underneath, the regulator on a small piece of aluminium connected to the heatsink.

A better method of heatsinking would perhaps be to make the Christmas Star (or other display) out of aluminium, then this could be the heatsink.

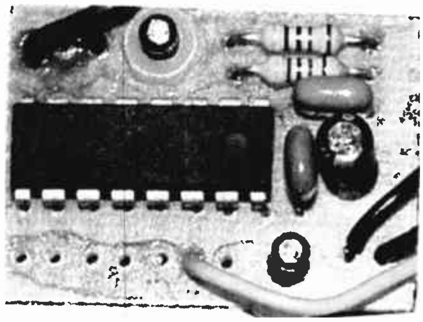
It is advantageous that the Luxeon l.e.d. should run as cool as possible as this will lead to a greater lifetime for it. It is worth noting, though, that the PWM control used here is the ideal way to drive a Luxeon l.e.d., as it significantly reduces the power dissipated, while still retaining the same peak voltage. In fact, it was found with the prototype, powered at 12V, that the l.e.d. ran cool enough without a heatsink at a high modulation settings (TP3 and TP4 both held low), although heating became pronounced with more continuous operation.

It was also found that the MOSFET transistor, TR1, switching the Luxeon l.e.d. ran cool at all settings without heatsinking, as it has a low "on" resistance of 0·2Ω. Even at 700mA this only amounts to a dissipation of 0·1W. With voltages greater than 12V, though, TR1 may require heatsinking.

Display Construction

A Christmas Star was again constructed as a display prototype, this time out of hardboard, in order to support so many printed circuit boards. From experience, sticky bottom p.c.b. supports invariably come off when stuck to a cardboard base! This time the author used 5mm brass supports, with countersunk screws through from the front. The star was attractively finished off using shiny card secured with double-sided adhesive sheet.

A Luxeon l.e.d. with its heatsink, despite previous comments, was situated in the centre surrounded by all the controller and flasher p.c.b.s, although obviously they cannot all be used at the same time! The author was fortunate to receive a reflector/lens, which fitted over the Luxeon and distributed the light more evenly, which finished off the Star nicely.



Simple Cycler board.

Although dearly wishing to know the source of the reflector, it came by such a dubious route as to be untraceable, unfortunately, as this is a very useful accessory.

The spare connector on the flasher p.c.b. was linked to +5V and then used as a common 5V supply. The Luxeon l.e.d. was connected to RB7 on the PIC, with all the other l.e.d.s distributed around driver outputs RB0 to RB6 on the ULN2803.

Connections

The sound, temperature and light level sensor boards may be connected to either pair of the 2-bit PIC inputs (see Table 1), whereas the cycler may be connected to all five, in any order you prefer. The movement sensor with only one output is best connected to the "shimmer" input (TP4).

It is worth adding a note of caution at this point. Although it was stated earlier that all the boards cannot be used at the same time, open collector outputs may be connected together using a single pull-up resistor. This is useful where several sources require access to the same single-wire bus such as, for example, a controller interrupt input, where several possible sources may require service.

However, the Cycler has active drivers from each rail, which would not suit connection to an open collector output.

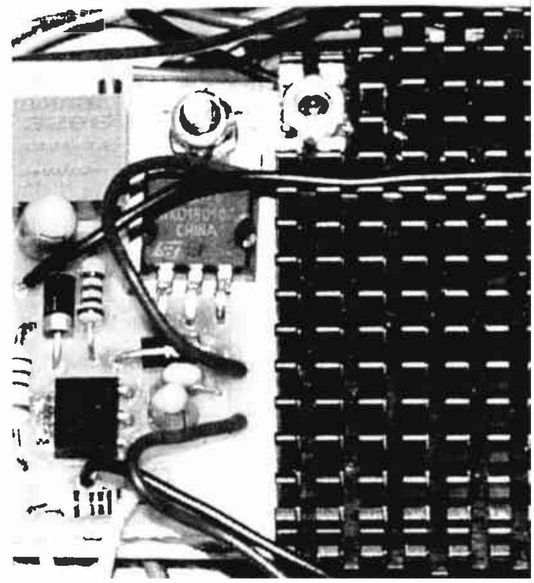
Also note that the switches may be switched on to override the open-collector control circuits, but they **must not** be switched on with any inputs to which the Cycler is connected.

Movement Detector Adjustment

To setup the Movement Detector, initially turn preset VR1 to maximum gain (fully clockwise) and adjust frequency control VR2 until the system springs to life. This will be indicated by the output from transistor TR1 going high (assuming a pull-up resistor is present by connection to a flasher board input via one of the TP0 to TP4 pins). The optimum setting for VR2 is quite narrow, adjust it for maximum voltage on C12.

Then back-off VR1 to minimum, anticlockwise. The voltage on the D3/R10 junction should slowly fall, until at about 1V the output from TR1 will go low. Moving your hand in front of the detector will then send the output high again.

Adjust VR2 for maximum effect, or if you have a scope, the 40kHz signal on IC1 can be monitored. Having done that, it is just a case of setting VR1 for sensitivity. This should be set as high as possible, without spurious signals causing false triggers. The state of incoming signals can be monitored by again observing the voltage on D3/R10. The prototype achieved a sensitivity such that a slight hand wave over a distance of two to three metres could be picked up.



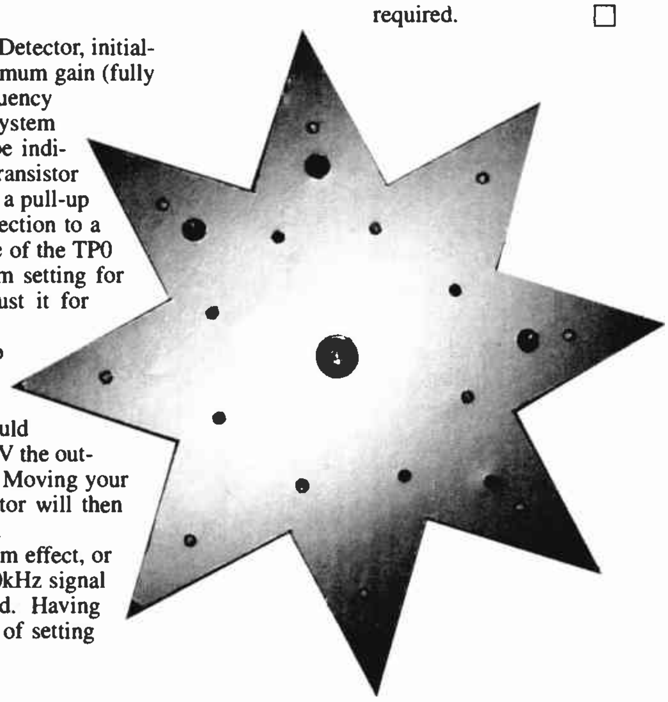
The Luxeon board attached to a heatsink – see text.

The transducers were mounted flat at about 15cms (6ins) apart on the author's Christmas Star.

Luxeon Setting

It is suggested that current for the Luxeon l.e.d. is set first, before connecting to the flasher. First check the output of the voltage regulator, IC1, and set for about 5V. Temporarily connect the gate (g) of TR1 to the 5V line. Connect the multimeter between the 5V line and the anode (a) of the l.e.d.

Adjust VR1 to give the maximum output current (700mA). Make a note of the regulator output voltage at this current, then it will not be necessary to repeat the current measurement. In all probability the maximum current will not be required. □




BS2-IC
BS2-SX
BS2E-IC
BS2P/24
BS2P/40
Parallax BASIC Stamps - still the easy way to get your project up and running!
LCD made easy! BPP-420L
Low power, easy serial interface
Display text & graphics with the G12864
Serial Alphanumeric and Graphic Displays, Mini-Terminals and Bezel kits
www.milinst.com
Animated Head
3-Axis Machine
Six-Legged Walkers
Robotic Arms
Bipeds
Robotic models for both the beginner and the advanced hobbyist
Servo Drivers
Motor Drivers
On-Screen Displays
DMX Protocol
U/Sound Ranging
Animatronics and Specialist Interface-Control Modules
Quadravox MP3 & Speech Systems
SensoryInc Voice Recognition
Parallax Ubicom Tool Kits
Tech-Tools PIC & Rom Emulators
BASICMicro PIC BASIC Compilers
Development Tools
Milford Instruments Limited Tel 01977 683665, Fax 01977 681465, sales@milinst.com

READOUT

Email: john.becker@wimborne.co.uk

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

All letters quoted here have previously been replied to directly.

WIN AN ATLAS LCR ANALYSER WORTH £79

An Atlas LCR Passive Component Analyser, kindly donated by Peak Electronic Design Ltd., will be awarded to the author of the *Letter Of The Month* each month.

The Atlas LCR automatically measures inductance from 1μH to 10H, capacitance from 1pF to 10,000μF and resistance from 1Ω to 2MΩ with a basic accuracy of 1%.

★ LETTER OF THE MONTH ★

Still Ripening

Dear EPE

Regarding the Ripe/Underripe discussion (*Readout Sept/Oct '04*), I think people like John Becker and I in company with a lot of others, have had the privilege of living through the most varied electronic age. My first project was a one-valve radio, also put together with a fire-heated iron. Relatives used to give me old radios to take apart and this formed my stock of components. A one-octave monophonic valve electronic organ was next.

Time moved on and germanium transistors came along, complete with their thermal runaway. We had to acquire metal bashing and woodwork skills because enclosures were not available then. Then it became possible to buy scrap computer boards from which we recovered logic chips. Throughout this time the electronics construction magazines helped us on our way. Then came the silicon revolution and everything changed.

The rate of progress was astonishing. One magazine was half way through a 12-part construction series for building a desk top calculator. It had many plug-in boards and a row of 7-segment displays. By the time part 6 was published, 4-function handheld calculators were beginning to appear in the shops.

My most complex project was the construction of a teletext decoder that contained over 100 discrete TTL chips. The 8 × 1K 1-bit memory chips were so expensive they were mounted in individual holders. The pages were selected by thumb-wheel switches. At the time, teletext was in its development stage and was not fitted in many TV sets. I had the privilege of working with the late John Linsley Hood for many years and built many of his projects.

Then along came the Nascom 8-bit computers with 1K (yes 1K) of memory which were built from a kit. This lead to standalone Z80 based projects. Now everything has been brought up to date with PICs.

Contributing to magazines like *EPE* over the years taught me more than I learnt during a formal education and made it possible for me to follow an interesting career as an instrument technician. To the younger readers, I would advise that even if you do not intend fully building the projects in the magazine, hook up parts of them on breadboard and learn how the individual sections work. In my opinion, you won't find a better practical grounding.

Regarding George Chatley's comments on battery charging (Oct '04), I read somewhere, it could have been in *Ingenuity Unlimited* many years ago, to recharge zinc cells, drill a minute hole in the top, inject some distilled water and then charge them from a half-wave rectified supply with a 2k2 resistor wired across the diode. Apparently, this prevents electrolytic action turning the carbon rod into an insulator.

John Brewer, via email

*Thanks John, yes interesting times they were, but continue to be so and I've become addicted to PICs and programming them etc. That calculator caused editor Fred Bennett a bit of a problem (*PE *it was, 1972 – so my* PE *25th Anniversary copy beside me says). He was right to continue the series though.*

You may by now have seen that I compiled a short tribute to PE *for our Nov '04 issue, commemorating its 40th anniversary. I previously devoted much of* PE *Nov 89 to its 25th anniversary.*

Are Free PSUs Safe?

Dear EPE,

With reference to Godfrey Manning's suggestion (*Readout* Sept '04) to use old PC power supplies for other jobs, I came across an article a while ago that stated that this is not safe practice – dangerous, in fact!

Unfortunately, I cannot remember the source of this info, only that it indicated that these PSUs need to be properly loaded or they could *explode*. I powered up one of these once and measured the no-load voltages and came to no harm, but was chary about doing so after reading the said article. After all, aren't these switch-mode PSUs something of a black art?

Perhaps someone could enlighten me? Thanks for a great magazine!

Harry Hall, Western Cape, South Africa, via email

It's not only the raw high off-load voltages that one should be beware of Harry, it is the fact that aging electrolytic capacitors which have been unused for some time, lose stability of their electrolyte, which needs "reforming" prior to being subjected to significant charging currents at higher voltages. Failure to do so could result in the capacitor rupturing, and maybe exploding.

Perhaps this is a subject which our Circuit Surgeons might care to discuss at length some time.

Batteries

Dear EPE

In response to the letter from George Chatley in *Readout* Oct '04, I have experimented over the years charging dry batteries, firstly using a home made charger based on an article many years ago from *EPE*, or *EE* as it may have been then, then with a purpose-built device from the Innovations people.

To be honest, whilst yes it does work, it is also hit and miss, and of the two main types I found alkaline batteries gave better results than zinc carbon ones, but the main downside I've found with both types is the tendency for the recharged batteries to leak and I've had several sets of battery terminals destroyed because of this.

With the higher capacity Nickel Metal Hydride rechargeables available, I've long given up charging dry batteries.

Dave Schuster, via email

Thanks for that Dave.

Recharging Batteries

Dear EPE,

I can tell George Chatley (*Readout* Oct '04), regarding battery charging, that long ago, I read about charging ordinary zinc/carbon batteries by pulsing them with "dirty" (unsmoothed) d.c. I imagine that this was in Pat Hawker's "Technical Topics" column in *RadCom*. Sorry, it was so long ago I've no further details, I don't know the specification for the charging regime – or its effectiveness.

As a youngster, still at the battery/bulb simple circuit stage, I noticed a new lease of life for expired cells (remember the leaky U2?) left to warm up on a central heating radiator. Watch out when passing high-current pulses, the meter is slow to respond and the instantaneous current could vastly exceed 10A. Wear safety goggles in case the rapid heating in the enclosed can causes an explosion! My suspicion is that George's current pulse knocks internal degradation products off the electrodes. With luck this can also work with NiCds (if they don't go Bang! in the process).

A while ago, getting fed up with the increasing number of battery-powered devices and the expense and waste of resources in changing expired cells, I commenced a maintenance campaign to renew with rechargeables whenever possible. At first I tried the impressive-looking "Pure Energy" rechargeable alkalines. Over a few years I found that these die if placed in equipment needing short bursts of high current (PMR "walkie-talkies" for example). The AAA size cells also frequently leak from the negative end. Low drain (continuous or intermittent) applications give good life (such as TV remote controls or low-power l.c.d. alarm clocks).

I'm also replacing some cells in higher-drain applications with NiMH. Now, the trouble here is the lower terminal voltage and it is also necessary to rotate these through a charger according to a maintenance schedule – or else they'll be empty when needed due to self-discharge. A couple of applications have stayed with primary cells. My "Megger" high-voltage insulation tester rapidly drained a 9V (nominal) NiMH that wouldn't then recharge. I'm not sure how the secondary cells will last with the extreme temperature range experienced by the emergency torch kept in the car. With domestic smoke alarms, I replace with the new Lithium batteries that should last as long as the devices themselves.

As for NiCds, why are they still made? NiMH gives the same terminal volts, often with higher capacity and responds to the same charge regime. It's just that they don't die of memory "(d)effect!" Suppose it spoils the fun of the accountants at the companies that want to consume excessive resources and sell even more batteries. If buying new equipment that incorporates a proprietary battery pack, insist on NiMH or else cross that manufacturer off your shortlist. Some older packs actually contain ordinary cells and can be broken open for replacement (with care, the manufacturer will have tried to maximise their income by making your life difficult!). In this case, conventional size cells (such as AA) are available with ready-to-solder tags.

Godfrey Manning G4GLM, Edgware, Middlesex.

Thanks Godfrey – interesting comments.

Dry Battery Charging

Dear EPE,

To continue the subject of dry battery charging, *Everyday Electronics* (as it was then) carried an excellent article by Alan Tong in Sept '91. The underlying principle was to subject the cell to periodic current reversals of a 4.5V a.c. 50Hz supply, with the reverse (incorrect polarity) current being about 20% of the forward current. This was achieved using two resistors in series with the battery and a rectifier diode across the lower value of the two. The resistors were chosen to limit forward charging current to the cell manufacturer's specification and reverse current to about 20% of the forward current. Typical resistor values for AA cells were 47Ω and 560Ω respectively.

**Leon van der Merwe,
Pretoria, South Africa, via email.**

Thank you Leon. It was a very popular design at the time but there were safety issues which it discussed. We prefer not to resurrect it now as there are safer and more sophisticated ways of doing it. And thanks too to Fred Yeates of the Isle of Wight who rang to give me the EE *issue date.*

Fans and Warts

Dear EPE,

Referring to Godfrey Manning's letter, *Crafty Cooling*, in *Readout* Sept '04, I worked for a big fan making company in my early days. By and large it is better to suck hot air out of a box than blow cold in – take a look at computer power units. Sucking air out allows the odd extra air flow from say unintended bolt holes and not quite fitting corners to add to the airflow.

The exception to the rule is for fans used in mines which, if they suck could discharge explosive methane gas all over the pit head with very interesting results, especially in the Union offices! Now when we come to the Sky+ Digibox, that fan only seems to become active if there is an *R* in the month, but when it does, it blows hot air out.

What is more to the point is the fact that fans should be inspected and cleaned regularly to knock the dust off. Be warned though, that while removing the dust of ages can make the fan more efficient, it can become a lot more noisy as well.

Regarding Thomas Scarborough's *Wart Zapper* (Sept '04) – over 50 years ago when I was a teenager, the school clinic sadists used to make a noose of horsehair and use it as a cheese-cutter on the wart. Then on went the gentian violet and you didn't know whether to tunnel down through the surgery couch or go into reverse and cling to the ceiling lights while screaming. Happy days!

I have seen them at our local clinic use a bit of card with a hole in it as a mask, and that CO^2 spray used for transistor cooling. You can either let the frostbite thaw or knock the meaty icicle off!

George Chatley, via email

Ah, George, that gentian violet – reviving school memories for me too. But Matron at least had the decency to apologise while she practised artistic sadism "for your own good".

R.F. Modules

Dear EPE,

I was a keen follower of the *Teach-In 2004* series by Max Horsey, having made up and tested the majority of the 10 monthly circuits. I recently wired up the radio link receiver and transmitter circuits of Part 7, initially using prototype boards before lifting a soldering iron.

Wireless communication was fine while both modules sat on my work bench, but off the bench the range was limited to a few metres. The Part 7 article and RF Solutions AM-RT5-433 and AM-HRR3-433 datasheets state that range is up to approximately 100 metres. In trying to improve the range, I tried everything: straight, coil and earth plane aerials, use of capacitors to decouple the power supply, etc.

Eventually, I concluded that the modules were either defective or limited to a range of just a few metres. Thus, the next work around was to opt for different modules. In reading RF's datasheet for the FM-RTFQ series of modules the closing section, Prototyping Hints, states: "never place a transmitter or receiver directly into VeroBoard or any similar prototyping board. This will severely restrict the range. Rather, use small lengths of wire from the prototyping board to the pins of the transmitter or receiver."

Following the suggested prototyping procedure and having now assembled the final circuits, both now work well, but I'll certainly be wary of mixing r.f. modules and prototype boards next time!

**Dr Graham M. Seed,
Heriot-Watt University, Edinburgh**

Thanks Graham, that's most useful.

Glitch-Free Switching

Dear EPE,

To add to the occasional debate about surface mount devices (SMDs), on the home-etching front surface mount does have the big advantage of not needing any holes drilling! I've found that 1206-size "chip" resistors and caps solder beautifully, whether NiAgSn or nickel-barrier terminated. It helps if the board is first placed on a non-slip mat, the component is then held down by a bamboo kebab stick in a chemistry-set clamp.

For the avoidance of doubt, the stick and not the kebab is made of bamboo! Amazing what helpful items the supermarkets can offer electronics enthusiasts.

I'm beginning to be an SMD enthusiast, never thought I'd hear myself saying that!

Godfrey Manning G4GLM, via email

And it's not only supermarkets, Godfrey – any DIY store stocks whole ranges of things that can be used by the imaginative to achieve functions the manufacturers never dreamed of! Plastic plumbing is a good example of a product that often finds beneficial use in an electronic project! I once even put a paint roller to use in a weather centre – part of the wind speed rotor. I'm pleased you're getting enthused with SMDs.

PIC12F629 Info

Dear EPE,

I'm not sure if this has been covered before, but I've made a rather interesting discovery while trying to help someone get a PIC12F629 running with my software from **www.bigclive.com**.

If a cheap programmer is used to erase a PIC12F629 and it erases the factory calibration value, then this can cause the chip to appear dead when used with software that calls the calibration value. What *should* happen is that the program calls the location 3FFH which immediately executes a RETLW command that returns the calibration value for loading into the OSCCAL register. If it has been deleted then there is actually a NOP instruction at 3FFH instead and this causes the software to roll over back to its start. Since the calibration routine is usually at the beginning of a program, this causes an infinite loop that even the Watchdog can't fix.

If the clock accuracy isn't important in the software, then you can avoid this problem by either not bothering to load the OSCCAL register, or loading it with 0xFF which makes the oscillator run at it's fastest speed.

The moral of the story? Not using the OSCCAL routine will make your software compatible with the cheap programmers that inadvertently delete the calibration value.

Clive Mitchell, via email

Forewarned is forearmed, Clive – thank you. Andrew Jarvis will be looking at such issues through PIC N' Mix.

Trailer Light Check

Dear EPE

As a caravanner, I have to check the lights on my caravan are working ok before moving off. This requires a second person to assist. Is it possible for the *EPE* boffins to come up with a device that can be attached to a vehicle to enable the driver (unassisted) to check the lights on a trailer?

William Rabbitt, via email

In fact we did one about nine years back William. Too far back, though, for us to supply copies. Maybe someone might offer us another sometime ...

Brushless Motor Control

Dear EPE,

Thanks for an inspiring mag to get our teeth into, I look forward to every copy falling through the letter box!

Can you tell me if you are considering a brushless control for the R/C modelling world? These circuits are impossible to find at present but have taken the electric flight scene by storm (with Lithium batteries – vertical climb into the clouds).

Most on the market are MicroP driven, MOSFET 3-phase output 10A to 25A with back-EMF sensing, have few components but cost typically £35 to £125 to buy. I am sure the circuit would be an absolute winner with many readers.

Bob of Craftyinventions

Sorry Bob, there's nothing in the pipeline. Maybe your letter here might inspire someone with the right knowledge to offer us a circuit.

Monitoring the Deluge

Shortly after going to press with Thomas Scarborough's Thunderstorm Monitor (Nov '04), I received a couple of emails from him:

07 October 2004 09:03. Dear John, Three days ago I wrote to a professor in New Zealand: "Otherwise, my Thunderstorm Monitor shows that unusually heavy rains are due. The met office says light showers, and my family are poking fun at me and calling me "Noah" and so on. Let's see whether I am vindicated!". Fifteen minutes ago, a flood warning came over the radio!

08 October 2004 09:11. Hello John, I bought today's paper with the headline, "Storm chaos in city. Streets flooded." I want to show it to the congregation on Sunday. I was freely predicting it. And while the sky was still completely overcast this morning, and the paper predicting showers on page 1, I said we're headed for clear skies and sunshine. That looks also to be coming true.

The met office has a problem here, since we're surrounded by two major oceans – they don't get in much data. It genuinely looks as though weather may be predicted days in advance with atmospheric charge. I haven't made it a science, but I have a feel for what my Thunderstorm Monitor is saying (mounted on my desk here).

Incidentally, I once read of a man in New York who ordered a top of the range barometer, and it appeared to be stuck on "Hurricane". He sent it back with a strongly worded complaint. The next day a hurricane struck! The company framed the letter and put it on the wall, along with the newspaper clippings.

**Thomas Scarborough,
South Africa, via email**

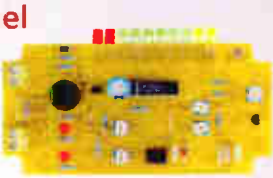
Well proud of you we are Thomas. Brilliant!

Thomas's last remark followed my comment to him about Michael Fish, who retired recently as BBC TV's chief weather forecaster, and who notoriously said on air many years ago, in reply to a viewer's query, that there were no hurricane's about to arrive in Britain. That night we had the worst hurricane in living memory, causing utter devastation in the south of England.

Build-it-yourself High Performance Electronic Kits for Cars

These projects offer fantastic tuning and performance modifications for your car. All projects are from the book High Performance Electronics Projects for Cars - published by Silicon Chip Magazine, Australia's leading Electronics magazine, available separately (Cat. BS-5080 for £6.35). See 2004 catalogue pages 12 & 13 for details.

Keep an Eye on Your Car's Fuel Mixture and Performance



KC-5374 £8.15

It is quite common for the fuel mixture to become very lean in turbocharged and supercharged motors under high load conditions. This not only decreases potential power, but can also cause engine problems. This kit displays the fuel mixture on a series of LEDs, with an integrated buzzer that sounds when the mixture is critically low. Kit supplied with PCB and all electronic components. Requires engine to be fitted with an EGO (Exhaust Gas Oxygen) sensor.

60 mins — DETAILED

A Cheap Nitrous Fuel Mixture Controller

KC-5382 £7.25

Nitrous oxide systems can be expensive to set up, but now you can do it for much less. This project pulses a fuel injector at a preset rate, adding a fixed amount of nitrous fuel when you activate it. It will save you a bundle on dedicated fuel solenoids and jets. It can also be used to control electronic water pumps, cooling fans, and more. Kit supplied with PCB and all electronic components.

*Please check local laws regarding the use of Nitrous Oxide systems in your vehicle.

90 mins — COMPLEX

Duty Cycle Meter Kit

KC-5375 £15.95

Super fast real time sampling! Automatically cut-in an extra fuel pump when your injectors reach a certain level and more! Includes a simple duty cycle generator for testing. Kit supplied with PCB and all electronic components.

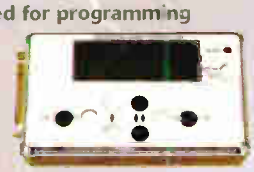
60 mins — DETAILED

Hand Controller Kit for Digital Adjusters

KC-5386 £23.65

Real time or programming display! This controller is used for all of the digital adjuster kits available. It can be connected for programming then removed, or left connected for real time display. Kit supplied with silk-screened and machined case, PCB, LCD, and all electronic components.

90 mins — COMPLEX



Re-Map Your Fuel Curve After Upgrading Injectors!

90 mins — DETAILED

KC-5385 £23.20

A huge revolution in Do It Yourself automotive modifications has occurred. This project allows you to re-map your air/fuel ratio throughout the entire load range. One use for this is upgrading your fuel injectors, then re-mapping the fuel supply to eliminate the need for new engine or fuel management systems. It offers incredible mapping resolution, and features rival many commercially available units costing hundreds of dollars more! Kit supplied with PCB, machined case, and all electronic components. Programmed via Digital Hand Controller (KC-5386 shown below left).

High Range Adjustable Temp Switch Kit with LCD Readout

3 hours — COMPLEX

KC-5376 £20.30

Range up to 1300°C! Keep an eye on critical temperatures such as brakes, turbo manifolds, intercoolers, and more. Trips a relay at a preset level to trigger an alarm, water spray cooling, and more! Kit supplied with PCB, LCD readout, and all electronic components.

Intelligent Turbo Timer Kit

60 mins — DETAILED

KC-5383 £13.05

There are turbo timers, and there are intelligent turbo timers. It determines how hard the car has been driven, and idles for an appropriate time after ignition switch cutoff. Kit supplied with PCB, and all electronic components.

Explanation of icons used for kits.

DETAILED — The kit requires a good knowledge of electronics to understand its operation and troubleshooting techniques may be required.

COMPLEX — The kit may require several settings to complete and possibly require some mechanical assembly. Troubleshooting techniques [illegible]

60 mins — [illegible]

ORDER on-line: www.jaycarelectronics.co.uk

Check our website! Information & easy, safe, fast ordering.

- Entire Jaycar 2004 Catalogue on-line - over 6,000 products.
- 128-bit Secure on-line ordering - safe & secure.
- Search by category, keyword or catalogue number, & advanced search.
- Over 3,500 product datasheets & application notes available on-line.
- And we're from Australia so you can trust us!

www.jaycarelectronics.co.uk

TOLL FREE ORDERING 0800 032 7241

(We are open 11pm to 7:30am GMT, which equates to 9am to 5:30pm our time)

For those that want to write: 100 Silverwater Rd Silverwater NSW 2128 Sydney Australia

Jaycar Electronics

Wind Direction Indicator

Mike Feather

Originally designed for use by yachtsmen, it could equally form part of any amateur weather monitoring station.

ALTHOUGH designed originally for the use of yachtsmen, this simple wind direction indicator could equally well find application in an amateur weather forecasting station.

For the yachtsman, an instantaneous knowledge of the direction of the wind relative to a craft is an essential factor in maximising the performance of the boat. The traditional method of assessing this is by glancing up at the burgee – a simple vane/pointer arrangement attached to the top of the mast. Whilst this can be useful, the modern yachtsman will probably prefer to have all the information regarding his craft available on instruments placed in one location – in the same way that car instruments are co-located on the dashboard for easy observation.

An electronic wind direction indicator system would therefore need a sensor located at the mast head, developing some form of signal – analogue or digital – representing the direction of the wind. After appropriate processing, the signal would then drive a display, again perhaps analogue, perhaps digital, showing the wind direction relative to the boat.

Wind Direction Sensors

Three basic detection techniques are in common use for electronic wind direction sensing: wind vanes, hot-wire devices, and ultrasonic methods.

Wind Vanes: the vane is attached to a shaft which will rotate, so in order to determine the wind direction, it is necessary to sense the shaft's angular position. This can be done in a number of ways, one of which would be to attach the shaft to a potentiometer, the output of which would then provide an analogue voltage dependent upon the wind direction. The general arrangement of such a system is shown in Fig.1.

Clearly the potentiometer would need to be very linear and there would need to be some arrangement for allowing positional measurement through 360° rather than the 270° of a conventional potentiometer.

Hot-Wire devices: these use three heated filaments – normally platinum – located at equal spacings around the outside of a vertical cylinder. Depending upon the wind direction, each filament will experience a different degree of cooling and hence change in its resistance. The differential change in resistance can be measured and used to compute the wind direction and the horizontal component of its speed.

Ultrasonic methods: in one technique, three ultrasonic transducers are located at the apexes of an equilateral triangle. Wind speed and direction affect the transit time of ultrasonic pulses travelling between the transducers and accurate measurement of this time can be used to determine the two quantities. A typical device of this type is shown in Fig.2. A similar technique uses four sensors in a square, as used in John Becker's *PIC Met Office Mk2*, Sep/Oct '03).

The hot-wire and ultrasonic methods offer a number of advantages over the wind-vane approach, but they require fairly complex circuitry and microprocessing capability in order to compute the wind direction.

Coded Disc

Another approach involves optoelectronic sensing of the position of an encoded disc attached to the wind vane shaft. The disc is made of a transparent material and carries a pattern of opaque sectors. Opto-switches determine the presence of these sectors and hence the angular position of the shaft.

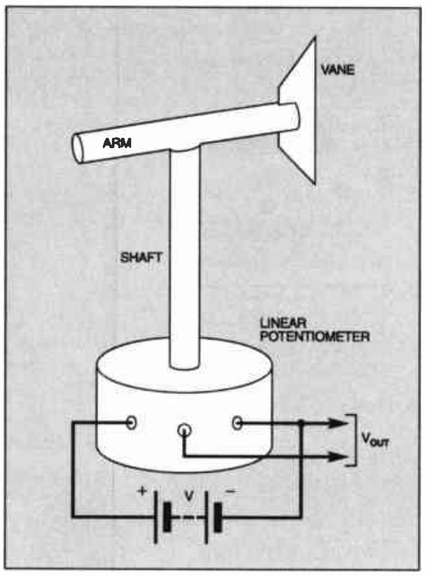


Fig.1. Using a potentiometer to sense shaft position.

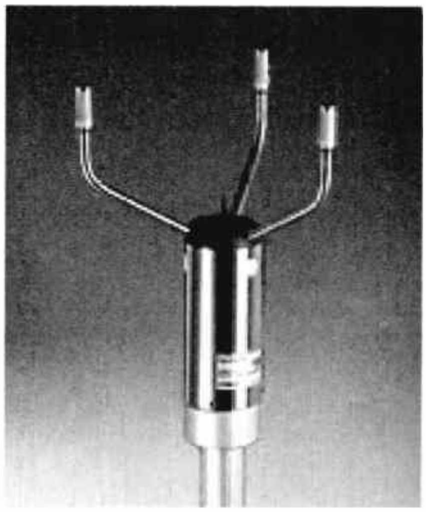


Fig.2. An ultrasonic wind sensor.

A disc with just two sectors – one transparent, one opaque – and one optoswitch would provide just two (2^1) shaft positions, i.e. a resolution of 180°. Four sectors would require two optoswitches but would be capable of resolving four (2^2) shaft positions, in other words a resolution of 90°. Two such encoder disc patterns are shown in Fig.3.

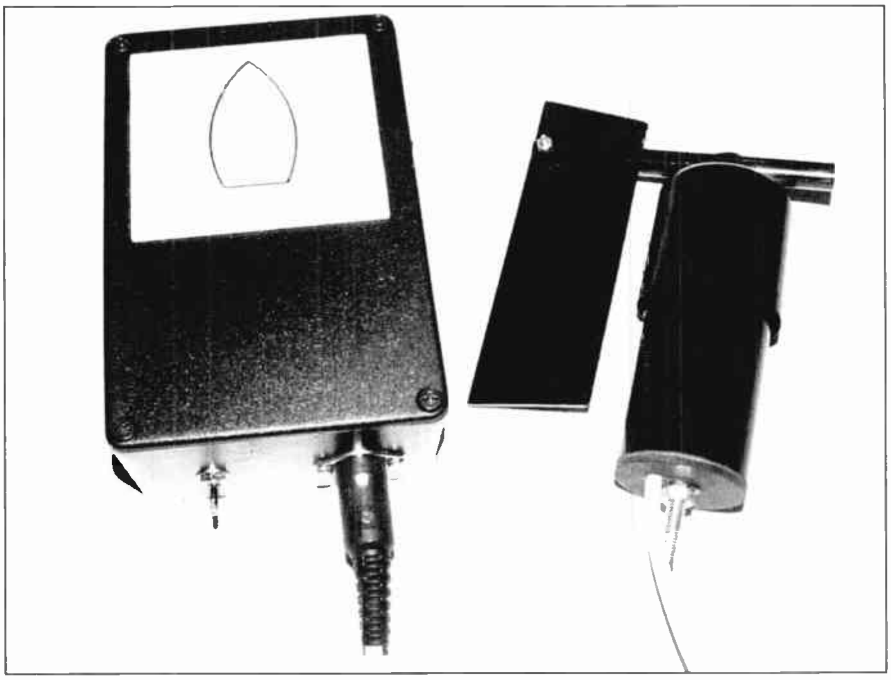
A common approach is to use a disc with 16 sectors arranged in four concentric bands and four optoswitches: such an arrangement can sense 16 (2^4) positions of the shaft, representing a resolution of 22·5°. This is usually adequate for the measurement of wind direction in practical situations.

Gray Encoding

Rotary position encoders of this type produce a digital output in the form of a 4-bit binary number, but they generally employ the Gray code rather than the natural binary code. In the Gray code, each binary number differs from the preceding number by only one bit. This is very useful for digital input devices as it removes the necessity for ensuring that, if two or more bits need to change

Table 1: Natural binary and Gray codes compared.

Decimal Number	Binary Number	Gray Code
0	0000	0000
1	0001	0001
2	0010	0011
3	0011	0010
4	0100	0110
5	0101	0111
6	0110	0101
7	0111	0100
8	1000	1100
9	1001	1101
10	1010	1111
11	1011	1110
12	1100	1010
13	1101	1011
14	1110	1001
15	1111	1000



The electronic control box and vane/encoder masthead assembly.

simultaneously, then the sensor must ensure that this happens.

Table 1 shows the 3-bit natural and Gray codes for the decimal numbers 0 to 15, whilst the disc pattern required for a 4-bit Gray encoder disc is shown in Fig.4.

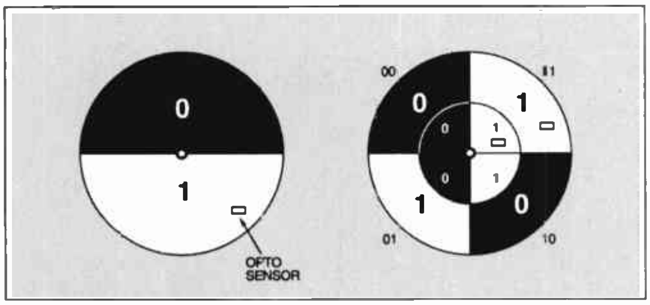


Fig.3. Encoder disc pattern for 180° and 90° resolution.

Shaft position encoders of this type are available commercially, but they tend to be quite costly and, whilst it is possible to make such a system in the workshop, the sensor array in particular, can be quite tricky to implement.

A relatively inexpensive ready-made alternative is available in the form of a 4-bit mechanical shaft encoder. A typical example of its coding table is shown in Fig. 5. It consists basically of a 16-position rotary switch with contacts arranged to produce a 4-bit Gray coded output.

As supplied, these switches incorporate a fairly strong detent spring/ball arrangement which prevents easy rotation of the spindle. With care, however, this can be removed so allowing relatively free movement. Whilst not designed for what is likely to be a lifetime of almost continuous rotation, the author has used a number of these devices in wind sensing designs and they have continued to operate satisfactorily over a considerable period of time.

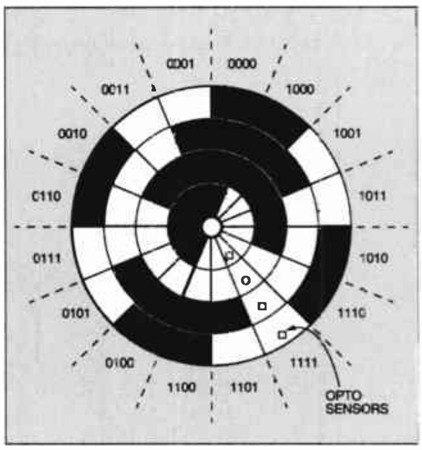


Fig.4. Encoder disc pattern for 22·5° resolution (Gray encoded).

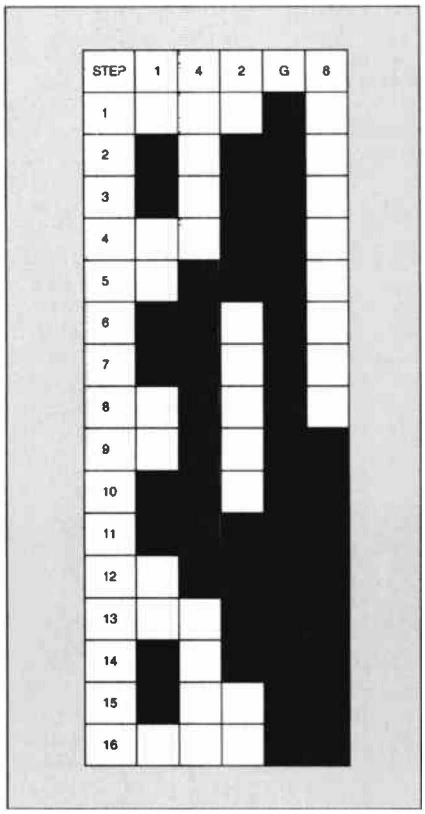


Fig.5. A 4-bit 16-position incremental output rotary switch encoder.

Circuit Concept

The block diagram in Fig.6 shows the basic concept of the Wind Speed Indicator described here.

The input device is the modified mechanical shaft encoder switch referred to above. The processing element of the system includes two operations on the signal produced by the encoder. First, the 4-bit Gray code, representing the wind direction, needs to be converted into a natural 4-bit binary number. This is achieved by a

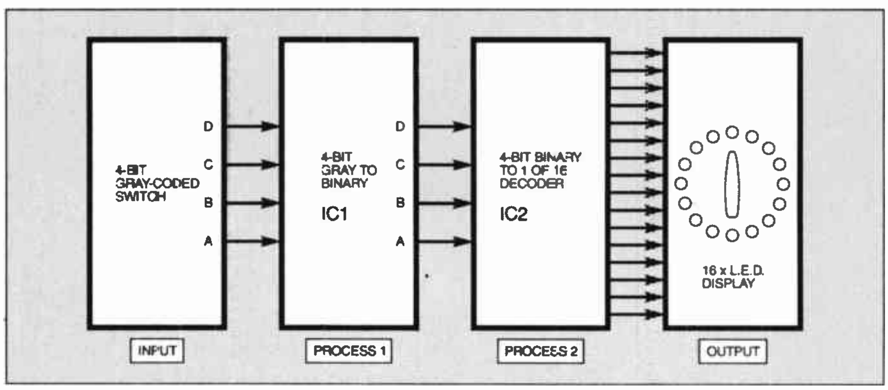
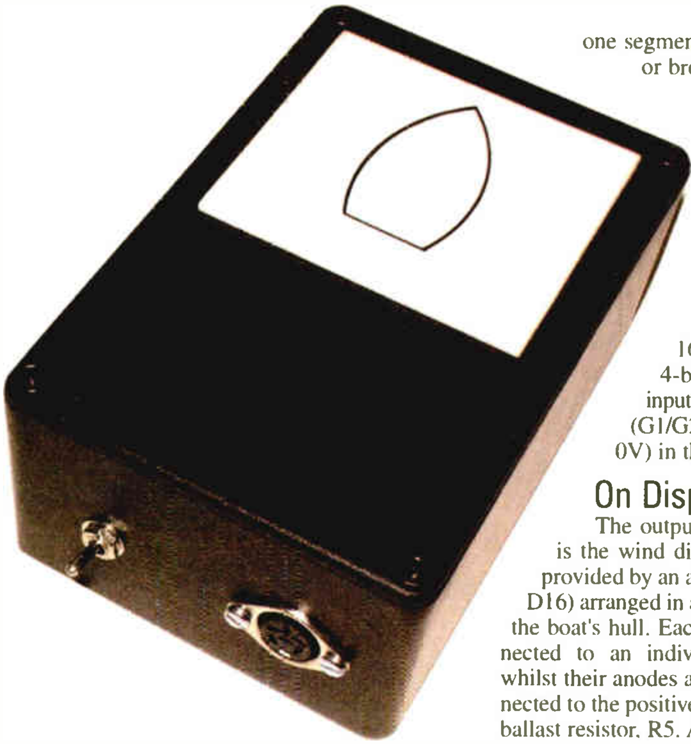


Fig.6. Block schematic diagram for the Wind Direction Indicator.



simple combination of three 2-input XOR (exclusive-OR) gates, as shown in Fig.7.

Note that input D, the most significant bit (MSB), is the same for both Gray and natural binary codes – as Table 1 shows.

Circuit Diagram

The complete circuit diagram for the Wind Direction Indicator is shown in Fig.8.

The shaft encoder is notated as switch S1, its outputs fed via connectors PL1 and SK1 to the three XOR gates detailed in Fig.7, IC1a to IC1c. Their inputs from the switch are biassed normally low by resistors R1 to R4, preventing them from "floating" as the switch wafers rotate between one segment and the next, making or breaking contact.

The resulting 4-bit binary code is fed to the data inputs of IC2, a 74LS154 4-bit binary to 1-of-16 decoder. Only one of its 16 outputs (Y0 to Y15) will go low (logic 0) for each of the 16 possible values of the 4-bit binary code on its inputs. The "strobing" inputs (G1/G2) are disabled (held at 0V) in this application.

On Display

The output section of the system is the wind direction display. This is provided by an array of 16 l.e.d.s (D1 to D16) arranged in a circle around a plan of the boat's hull. Each l.e.d. cathode is connected to an individual decoder output, whilst their anodes are commoned and connected to the positive power rail via a single ballast resistor, R5. Any output pin selected by the input turns on the related l.e.d. Only one l.e.d. can ever be on at any time.

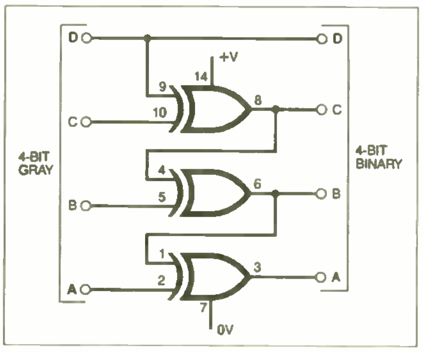


Fig.7. Gray to binary conversion using EXOR gates.

COMPONENTS

See SHOP TALK page

Resistors

R1 to R4	2k2 (4 off)
R5	270Ω

All 0·25W 5% carbon film or better.

Capacitor

C1	100n ceramic disc

Semiconductors

D1 to D16	3mm superbright red l.e.d., (16 off)
D17	1N4001 rectifier diode
IC1	74LS86 quad 2-input XOR gate
IC2	74LS154 4-bit binary to 1-of-16 decoder

Miscellaneous

S1	4-bit shaft encoder switch
S2	min. s.p.d.t. toggle switch
PL1	5-pin DIN plug
SK1	5-pin DIN socket

Printed circuit board, available from the *EPE PCB Service*, code 475; 14-pin d.i.l. socket; 24-pin d.i.l. socket; plastic case, size 150mm × 100mm × 55mm; connecting wire; solder, etc.

Approx. Cost Guidance Only **£18** *excl. case*

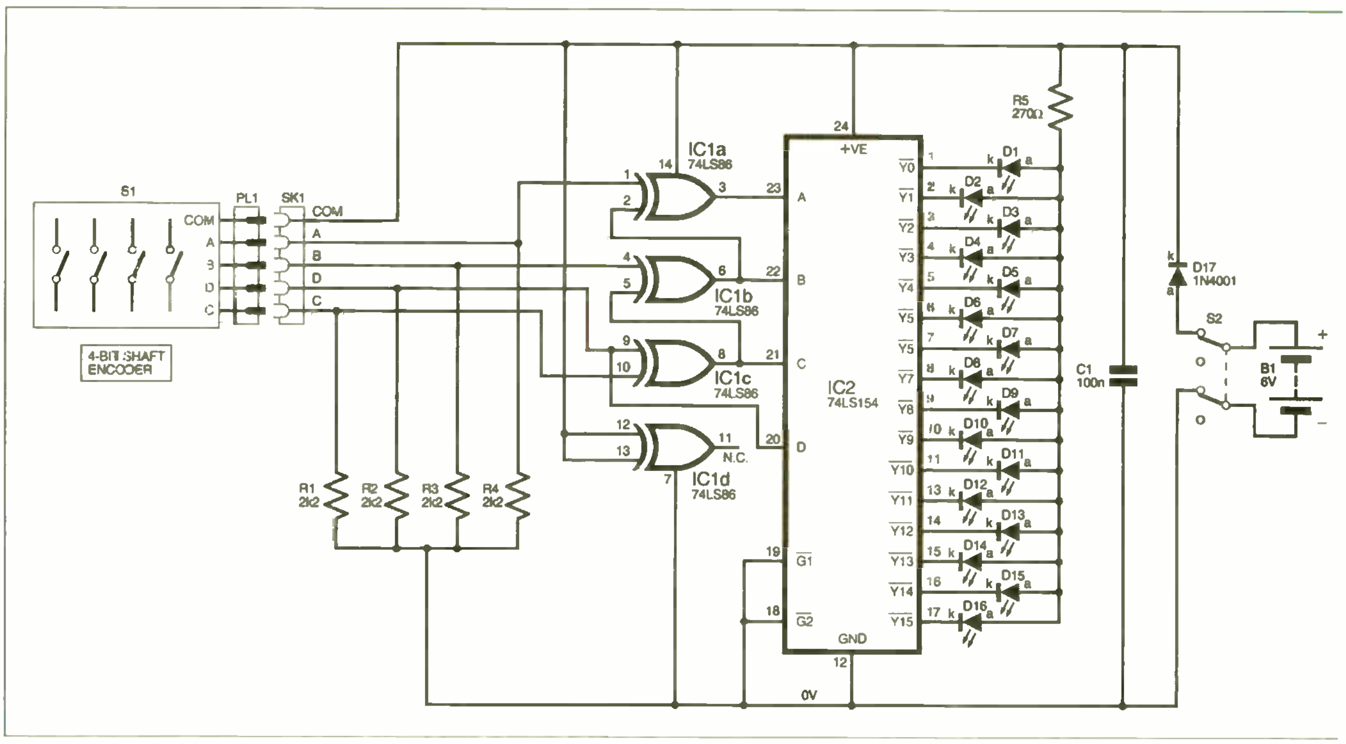


Fig.8. Complete circuit diagram for the Wind Direction Indicator. The encoder switch S1 is mounted in the vane assembly.

The circuit is powered by a 6V battery (B1), switched into circuit by S2. Diode D17 prevents mishap if the battery is connected the wrong way round. Capacitor C1 helps to stabilise the positive supply line. A 9V battery **must not** be used to power this circuit.

Construction Board

The printed circuit board component and track layouts for the Wind Direction Indicator are shown in Fig.9. This board is available from the *EPE PCB Service*, code 475.

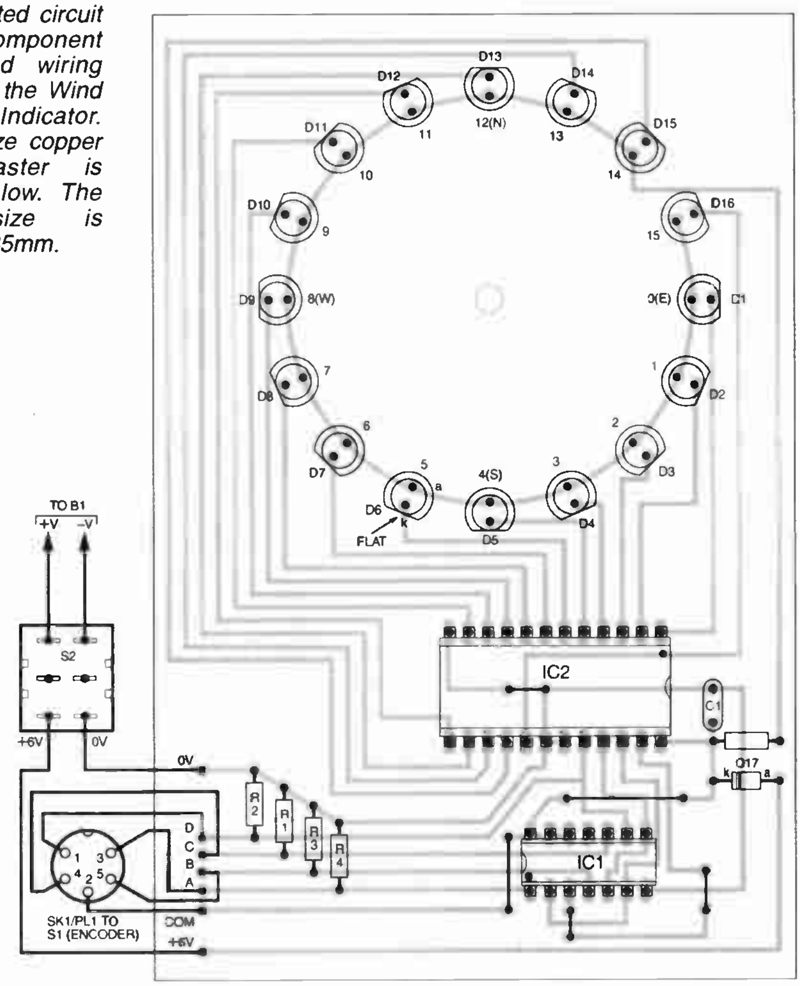
Assemble the board in the usual order of ascending component size, using sockets from IC1 and IC2. Do not insert the i.c.s until the board has been fully assembled and checked, and then ensure they are inserted the correct way round.

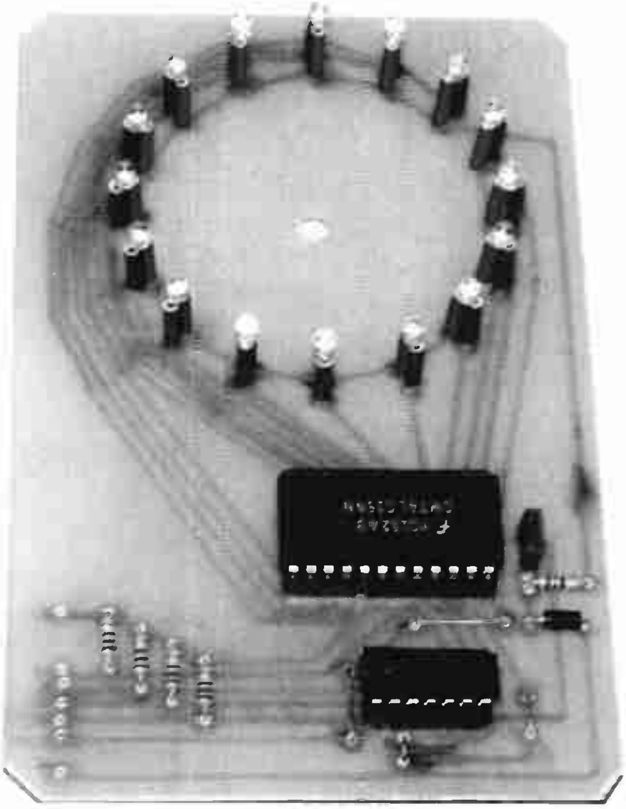
The l.e.d.s must all stand at the same height above the board and this must be sufficient to clear the tops of the i.c.s in their sockets. This is around 10mm and l.e.d. spacer mounts (preferred) could be used. If these are not available, then short lengths of P.V.C. sleeving can be slid over each leg of each l.e.d. Correctly observe the l.e.d. polarity. The shorter lead is normally the cathode (*k*).

Following checking, IC1 and IC2 can now be inserted into their sockets, again noting correct orientation. Take care with the 74LS154 – one or more of its 24 pins could easily be bent during insertion.

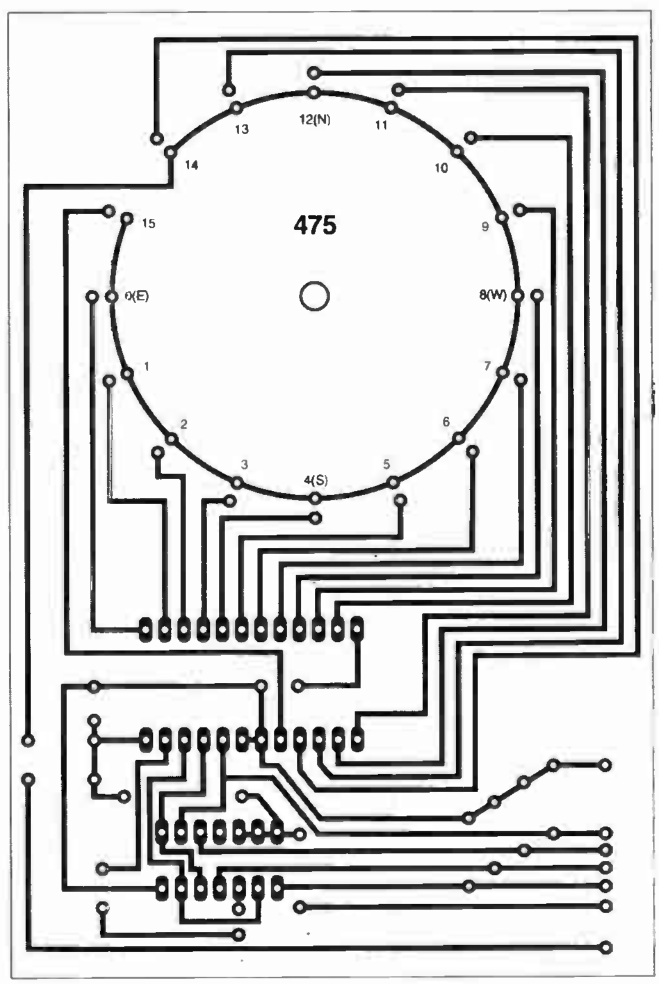
The unit can now be briefly powered up. The l.e.d. connected to IC2 output Y0 (pin 1) should be on since, with no encoder connected, the Gray input code is effectively 0000 resulting in a binary input of 0000 to the decoder, which causes output Y0 to go low. If this is not the case, the p.c.b. should be checked carefully for faults.

Fig.9. Printed circuit board component layout and wiring details for the Wind Direction Indicator. The full-size copper track master is shown below. The p.c.b. size is 128mm × 85mm.





Layout of components on the prototype Wind Direction Indicator printed circuit board. The track master is shown on the right.



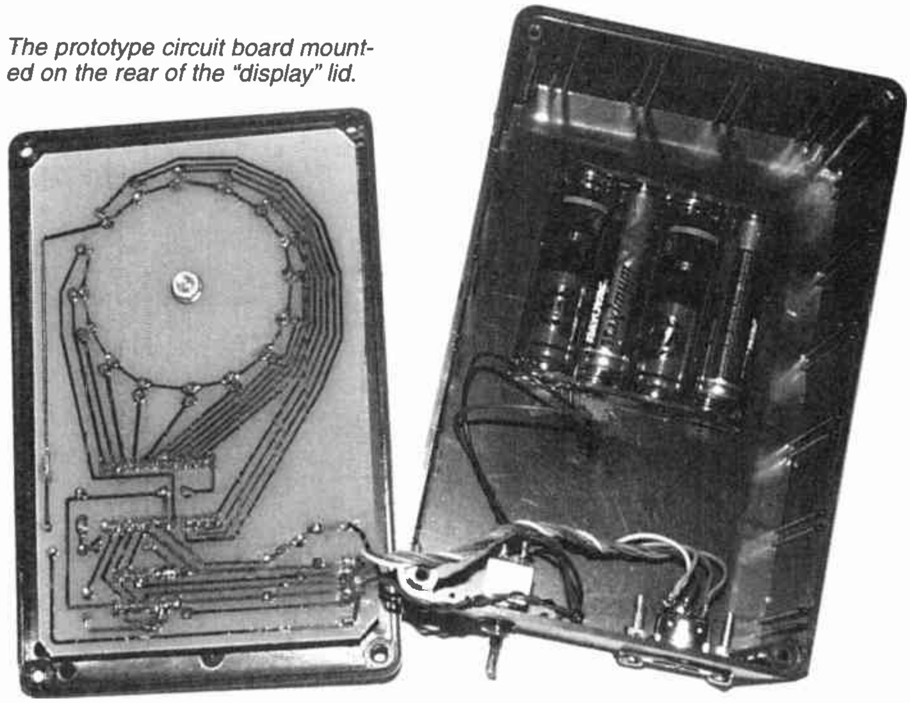
The circuit board is mounted in a plastic case measuring 150mm × 100mm × 60mm approx. into which holes should be drilled for switch S2 and socket SK1. Use multi-colour stranded wire (ideally ribbon cable) to connect SK1 back to the p.c.b.

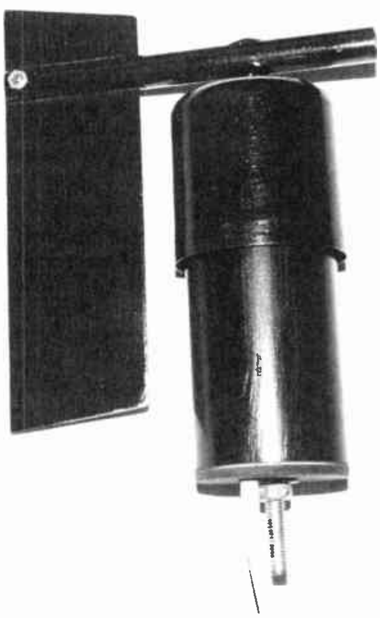
Encoder Switch

The encoder switch (S1) assembly now needs to be opened (carefully), to remove the detent spring and ball. Using a Stanley (or similar) knife blade, shave off the tops of the black plastic pillars which hold the switch p.c.b. to the rotor and gently separate the two. The spring and ball arrangement should now be obvious and can be very easily removed.

Push the p.c.b. back on to the mounting pillars and, using the bit of a soldering iron, melt the ends of the pillars slightly so that the p.c.b. is held in place once more. It need not be very robust as, when mounted in the vane unit, the switch is held together by other means.

The prototype circuit board mounted on the rear of the "display" lid.





Finished vane/encoder unit.

Vane Construction

The vane design has been kept deliberately simple and uses easily obtainable parts and materials in order that it can be assembled easily by the average constructor. There can, no doubt, be many variations on the basic design, but the principal requirements are that: a) the vane must be able to rotate at low wind speeds, and b) the unit must be waterproof and reasonably robust.

The enclosure tube is cut from 43mm outside diameter polythene water drain piping. The two end caps are made from 13mm MDF. These need to be a push fit into the tube and should have a small flange as shown in Fig.10. Ideally these items would be produced using a small wood or metal turning lathe but, with care and patience, they can be made up with appropriate hand tools.

The lower plug is fitted with a centrally mounted M6 × 40mm bolt and nut for mounting purposes. Similarly, the cylindrical MDF mount for the encoder switch should be a tight fit inside the encoder tube.

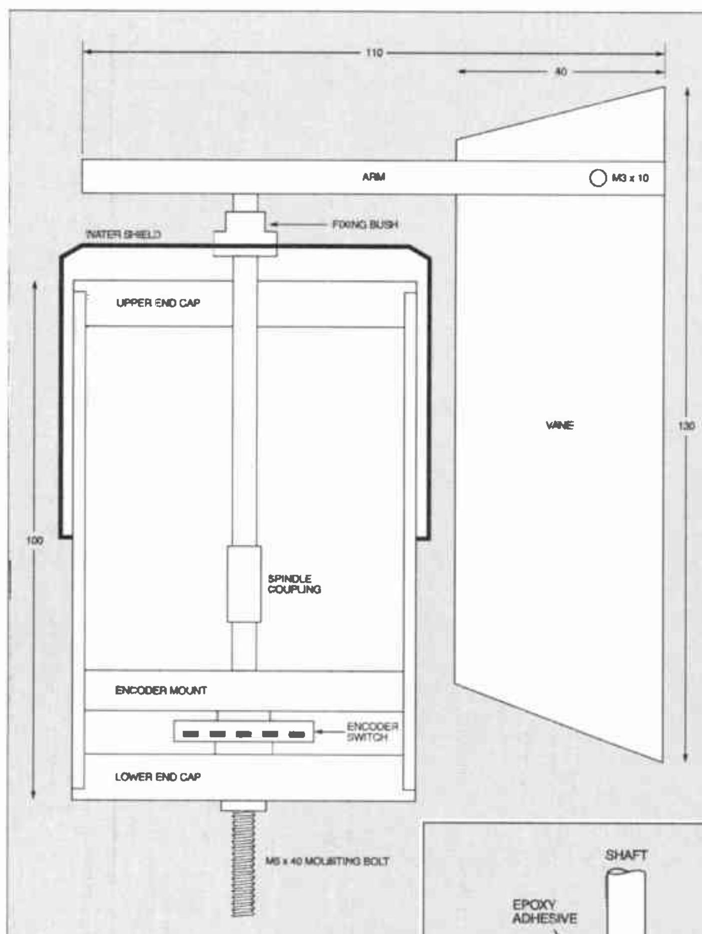


Fig.10. General arrangement of the vane/encoder unit.

You will need . . .

Polythene drain tubing, 120 × 43mm o.d.; 13mm MDF for end caps and encoder mount: 6mm steel or (better) brass rod; 6 × 40mm stainless steel bolt and nut; short length of 10mm softwood dowel for spindle coupler; aerosol cap for water shield; bush/locknut from old potentiometer; short length of 10mm o.d. aluminium tube; 1mm aluminium sheet for vane.

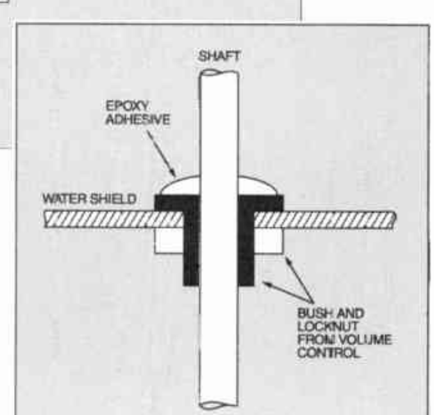


Fig.11. Suggested method of fixing the water shield to the shaft.

The fixing bush of the switch is too short to pass through the mount, so the switch is simply screwed tightly into a 9·5mm hole in the centre of the mount. The switch spindle should then protrude a distance of about 7mm – just sufficient to allow it to be coupled to the top section of the shaft. A short piece of 6mm steel rod was used for this: brass or stainless steel would be preferable in terms of corrosion resistance.

For the prototype, the coupler itself was made from a 20mm length of 10mm softwood dowel drilled through with a 5·5mm hole. This permits a push fit (quite tight!) on both shaft and switch spindle. Alternatively a standard spindle coupler could be used.

The shaft passes through a 6·5mm hole in the upper MDF end cap. Its length should be cut to allow approximately 25mm of it to protrude above the cap when coupled to the switch and with the switch pushed against the head of the fixing bolt in the lower end cap.

The water shield is a plastic aerosol cap. These come in various shapes and sizes and

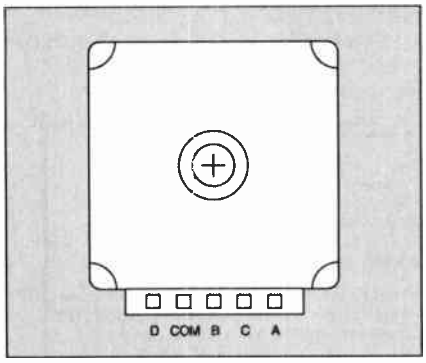


Fig.12. Connections to encoder switch (viewed from shaft side).

it should not be difficult to find one which will clear the outside of the enclosure tube by 2mm or 3mm. It needs to be fixed centrally to the shaft and one way of doing this is to use the bush and locknut from a cheap rotary potentiometer. The arrangement is shown in Fig.11.

A 10mm aluminium tube is used for the arm which supports the vane. This is drilled with a 6mm hole, into which the shaft will eventually be glued with epoxy adhesive. First, though, the tube should be slit along its length for a distance of approximately 40mm. Use a hacksaw for this and then separate the two halves slightly.

The vane is made from 1mm aluminium sheet and it should be possible to push this into the slit. It may be necessary to increase the width of the slit with a needle file. An M3 × 10mm nut and bolt are used to secure the vane in the slit.

The signal wires can now be soldered to the encoder switch. Fig.12 shows the order of the five connecting tags. The cable passes through a hole in the lower end cap.

Vane Assembly

The following steps outline the final assembly of the vane/encoder unit:

1. Push the encoder switch and its MDF mounting a little way into the enclosure tube
2. Pass the cable through the hole in the power end cap and push the cap into the end of the tube
3. Using a piece of wide tube or something similar, push the encoder switch and its mounting down the enclosure tube so that the back of the switch rests firmly against the head of the M6 fixing bolt in the lower end cap

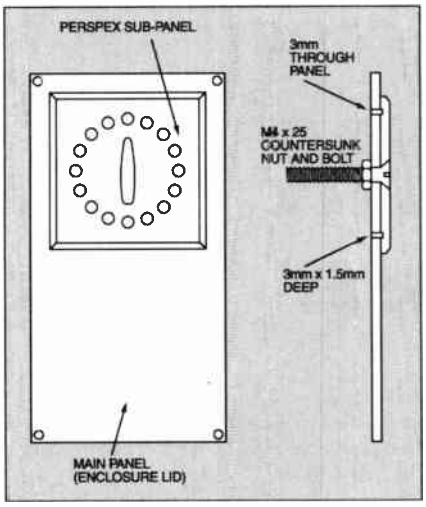


Fig.13. Front panel and sub-panel details.

4. Push one end of the shaft coupler on to the shaft and the other on to the switch spindle. Push the upper end cap into place
5. Check that the shaft rotates reasonably freely. It may be necessary to increase slightly the diameter of the hole in the upper end cap
6. Slide the water shield assembly on to the protruding shaft followed by the arm/vane and fix them to the shaft using epoxy adhesive

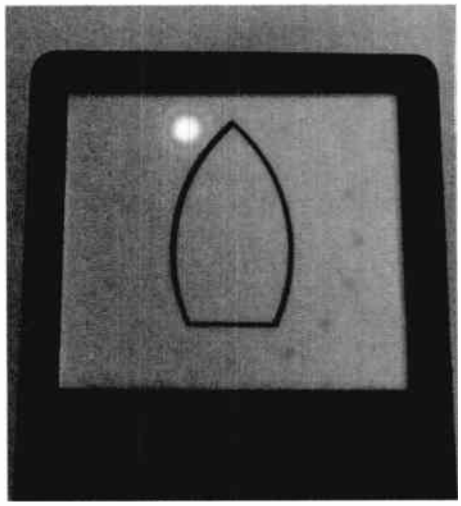
Check once again that the vane/ arm/shaft assembly is free to rotate. The unit can now be connected to the display section and the complete system tested.

The end caps can be glued into the enclosure tube in order to improve the robustness and waterproofing of the vane/encoder unit, but doing this makes it difficult to access the encoder switch or shaft coupler, should this ever become necessary.

Final Stage

The final stage of the assembly process involves attaching the p.c.b. to the front panel of the display unit enclosure. It is necessary to drill 16 3mm holes in the panel in order to accommodate the l.e.d.s: the p.c.b. layout diagram can be used as a template to locate the holes.

The l.e.d.s should fit neatly into the holes and the p.c.b. can be fixed to the front panel using a single M4 × 25mm CSK bolt with washers and nuts either side of the board. The prototype incorporated a translucent white Perspex sub-panel which carried the hull outline of the boat. (If the system is to be used as part of a fixed weather station, then this can



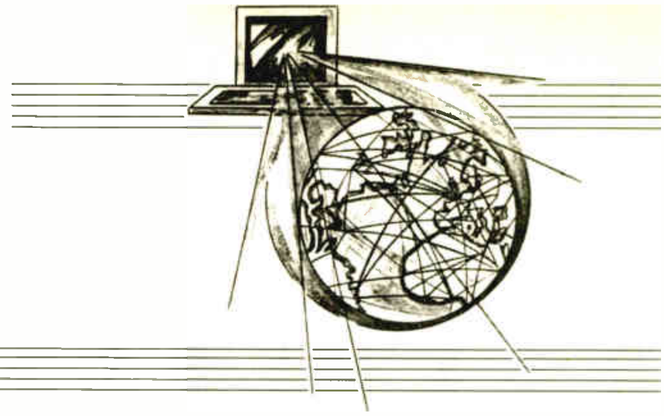
An l.e.d. showing through the sub-panel.

be replaced by a compass card legend.)

The translucent panel needs to have shallow 3mm drillings to accommodate the tops of the l.e.d.s: it is fixed to the front panel of the display unit with contact adhesive. Fig.13 shows the general arrangement of the front panel and sub-panel. The battery holder is fixed to the base of the case.

The system can now be tested again and, if all is well, the vane/sensor unit may be mounted in the desired position. The length of the interconnecting cable does not appear to be important and satisfactory operation is possible with several metres of cable. For weather station use, it will, of course, be necessary to align the unit in the appropriate compass direction. □

SURFING THE INTERNET



NET WORK

ALAN WINSTANLEY

IN previous articles, some of the perils and pitfalls of domain name registration were described. Particular attention was given to a number of scams being practised by some of the less reputable elements of the Internet industry, including the unsavoury habit of "slamming", when a third party domain supplier "butts in" and tries to trick a domain name owner into changing their registry, often for a hefty fee. Some slammers' mailshots are clearly an attempt to trick, whilst others are more honest and up-front about their objectives. Hopefully, *EPE* readers now know what to watch out for if they receive an official-looking warning letter inviting them to renew a domain.

There are many occasions when domain names have to be transferred from one ISP to another. The procedure is straightforward but there are a few caveats.

Domain owners can come unstuck when they suddenly realise that "their" domain is not actually theirs to begin with, but was simply being "rented" to them by a supplier. There may be no choice but to continue to meet the supplier's fees, and it may be impossible to transfer the domain elsewhere without paying a hefty release fee.

To move a domain to another ISP, in the case of a *.co.uk* domain, the current registrant simply notifies his ISP to change the domain's "IPS tag" to that of the new ISP. An IPS tag is an identification label for an Internet Service Provider, such as "SWIFTINTERNET" or, say, "TCP", who are both UK-based ISPs. Nominet's database is subsequently updated to account for the change of ISP, and it should only take an hour or two (if that) for the database to be revised.

It is critical that the IPS tag is described 100% accurately, because once the domain IPS tag is changed by the old ISP, then they have no further responsibility and domain owners are consequently on their own after severing the link.

The new "receiving" ISP then acquires the domain name and sets up the email servers, the web server and maintains the all-important name servers. For a short duration, the domain name may be in no-man's land until the changes of ISP details are propagated around the Internet.

Allow 24 hours for the changes to work through the system, but strange things can happen during this period, including an old web site being visible to some Internet users but not others. It takes time for all ISPs' name servers to be updated for the change of details, so for a short period, your domain name may be "off the air" or pointing to the wrong server.

More Than One ISP

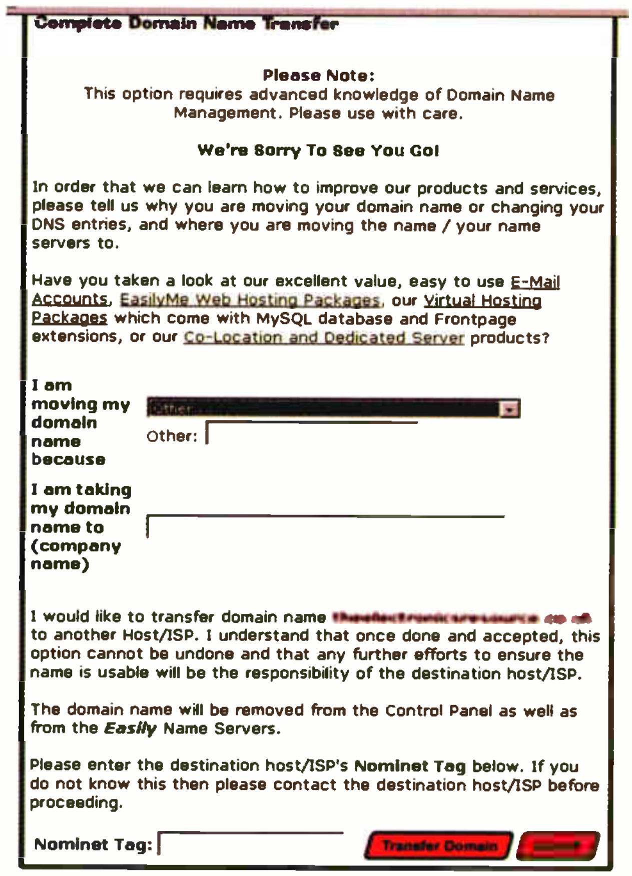
As a useful but generally misunderstood option, it is possible to use one ISP solely for hosting the domain name, and set up the domain's DNS configuration so that both web and email services are provided by an alternative ISP instead. It is feasible to have a domain name hosted by, say, Easily Ltd. with the domain setup pointing to Demon Internet for the provision of email and/or web hosting. Domain owners must then maintain two contracts and ensure that both ISPs' fees are met.

It is certainly possible to use multiple ISPs to provide various aspects of your Internet services. There may be good technical reasons why two or more ISPs are used, including compatibility problems with a customer's network email services: keeping the domain with one ISP whilst letting another handle email services works well for some users.

It is worth noting that domain suppliers might offer a "preferred" option to be retained purely as the host of the domain, and let the nameserver details point to another ISP that will handle email and web. This is a common way that an ISP gets to keep a grip on the domain, allowing them to charge a repeat fee to the owner, who must pay another ISP for web and email services. The bottom line is, if you seek to exercise your right to transfer a domain name entirely to another ISP, make sure that's what you do!

Selling a Domain – Dot-coms

Occasionally, a domain name is transferred or sold to another party. The process of transferring the registrant is relatively straightforward, but Nominet will go to extreme lengths to diligently verify the identities of the current and the new "acquiring" registrant to avoid fraud. The only way that *.co.uk* domains can be transferred to another party is via a Transfer Form (see below) prepared by Nominet. Covering letters from both parties are sent along with the requisite fee (£35) before the transfer can take place.



Complete Domain Name Transfer

Please Note:
This option requires advanced knowledge of Domain Name Management. Please use with care.

We're Sorry To See You Go!

In order that we can learn how to improve our products and services, please tell us why you are moving your domain name or changing your DNS entries, and where you are moving the name / your name servers to.

Have you taken a look at our excellent value, easy to use E-Mail Accounts, EasilyMe Web Hosting Packages, our Virtual Hosting Packages which come with MySQL database and Frontpage extensions, or our Co-Location and Dedicated Server products?

I am moving my domain name because

Other:

I am taking my domain name to (company name)

I would like to transfer domain name [redacted] to another Host/ISP. I understand that once done and accepted, this option cannot be undone and that any further efforts to ensure the name is usable will be the responsibility of the destination host/ISP.

The domain name will be removed from the Control Panel as well as from the ***Easily*** Name Servers.

Please enter the destination host/ISP's **Nominet Tag** below. If you do not know this then please contact the destination host/ISP before proceeding.

Nominet Tag: Transfer Domain

Domain name transfer form.

Dot-coms are usually messier to transfer between ISPs. In principle, rather than simply tell the "old" ISP to point the domain to a new ISP (his competitor), in the case of a dot-com the new "acquiring" ISP sends a message to the old "releasing" ISP, who in turn sends a "Is this transfer correct?" to the domain name holder. If he fails to confirm within five days that the release can go ahead, the transaction times out and you have to start all over again.

Whereas a *.co.uk* can be moved within minutes, a dot-com can sometimes take weeks. Selling a dot-com to another party can be a tortuous process that might entail faxing details to the current registrar: procedures vary so plan carefully.

Next month – more aspects of domain selling and valuation, and a roundup of some of the writer's favourite Internet software releases. You can contact the writer at **alan@epemag.demon.co.uk**


PEAK
electronic design ltd
not just intelligent
but smart
Peak Electronic Design Ltd
Atlas House, Kiln Lane
Harpur Industrial Estate
Buxton, SK17 9JL, UK
Tel. 01298 70012
NEW!
atlas SCR
model SCR100
Triac detected
Sensitivity 75mA
on - test
scroll - off
PEAK electronic design ltd
SCR100
£99
atlas SCR
model SCR100
the atlas SCR
• Automatically analyse Thyristors and Triacs.
• Automatically identify all three leads.
• Automatic test currents from 100µA to 100mA!
LCR40
£69.00
DCA55
£49.00
SCR100
£99.00
Passive components, semiconductors,
power devices, network cabling
Choose your perfect analyser
New Low Prices!
limited time only
"Star Pack"
LCR and DCA
in carry case
£118.00
Carry cases
£15.00
SMD Tweezer
Probes for LCR
£19.00
Spare Battery
£1.75
the atlas LCR
• Automatically identify Inductors, Capacitors and Resistors.
• Inductors from 1µH to 10H.
• Capacitors from 1pF to 10,000µF.
• Resistors from 1Ω to 2MΩ
• 1% Basic accuracy.
• Automatic frequency selection.
atlas LCR
PEAK
on - test
scroll - off
LCR40
£69
accessories & carry cases
PEAK
ESR Measurement
model
ESR60
available December 2004
Semiconductor Analysis
£49
model
DCA55
Cat5 Cable Testing
£79
model
UTP05
www.peakelec.co.uk
all prices include UK Delivery and VAT
Don't just test it...
...Analyse it!

INTERFACE

Robert Penfold

SIMPLE VOLTAGE CONTROL USING YOUR PC

DIGITAL to analogue conversion enables a PC to be used for many applications, including such things as the control of model railways, lighting, and temperature. Precision digital to analogue converter chips are available and typically offer 12-bit resolution. This sort of precision is usually required from an analogue to digital converter, where many applications involve precise measurements. The same is not true of many applications that use a digital to analogue converter.

With something like a model train controller it is impressive to have a digital controller that provides over four thousand speeds, but this represents considerable overkill. Moving the speed up or down by 10 or 20 units would probably give no perceptible change in the speed of the train.

A high quality digital to analogue converter does not just provide a huge number of output voltages. Each voltage can be set with a high degree of precision, which is fine for something like a computer controll.e.d. power supply unit. On the other hand, with something like lighting or motor control it will not really matter whether the output voltage is precisely 12V or 11·9V. There will probably be no noticeable difference between these two output voltages.

Rough and Ready

Many applications simply require a reasonable range of output potentials, but do not require the sort of precision offered by a modern digital to analogue converter. There are simple and inexpensive methods of using a computer port to provide a controllable output voltage, and these are usable for many everyday applications. However, one slight drawback of most "rough and ready" methods is that they are relatively slow. This renders them unusable for some applications, but a fast response time is not needed for simple applications such as lighting and motor control.

Probably the simplest form of digital to analogue converter is one that relies on basic pulse width modulation (PWM) to vary the average output voltage from a digital output. A PWM signal can be generated using simple software and a single output line. A lowpass filter is used to smooth the pulses to produce a reasonably ripple-free d.c. output at the average output potential.

Some devices, such as l.e.d.s and small d.c. electric motors, do not even need the smoothing. They will work properly from a pulsed supply provided the output frequency is more than about 50Hz but not into the megahertz range.

How It Works

The waveforms shown in Fig.1 help to explain the way in which PWM operates. In the top waveform the mark-space ratio is 4 to 1, which means that the output is at the V+ level for 80 percent of the time. The average output voltage is therefore 80 percent of V+, or about 4V when using a 5V supply.

In the next three waveforms the mark-space ratios are 3 to 2, 2 to 3, and 1 to 4, giving respective average output voltages equal to 60, 40, and 20 percent of V+. With a 5V supply this equates to 3V, 2V, and 1V respectively.

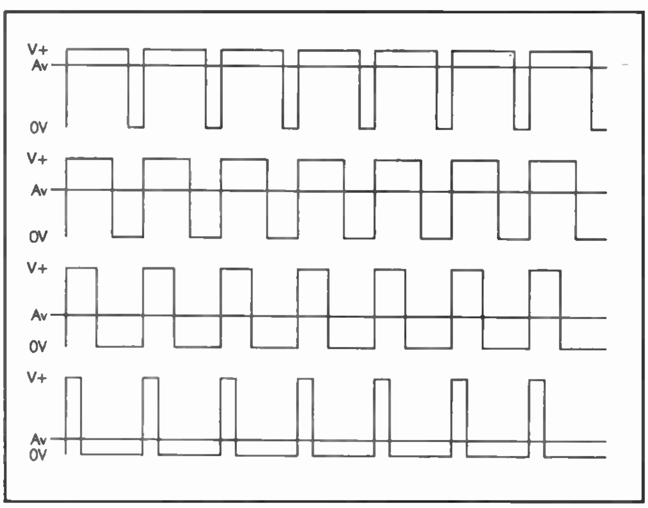


Fig.1. Waveforms showing that the average output voltage can be varied by altering the mark-space ratio of a pulse signal.

By using a suitable mark-space ratio it is possible to obtain any output potential from fractionally more than 0V to slightly less than the V+ level.

Software

Generating a simple PWM signal on a digital output of a PC's printer port is quite easy, and several approaches are possible. One way is to use the Time function of Visual BASIC to control the timing of the signal. Although the notional resolution of the Time function and the VB Timer component is one millisecond, the real resolution is not as good as this. Nevertheless, it is still possible to obtain a reasonable degree of control without resorting to a very low output frequency.

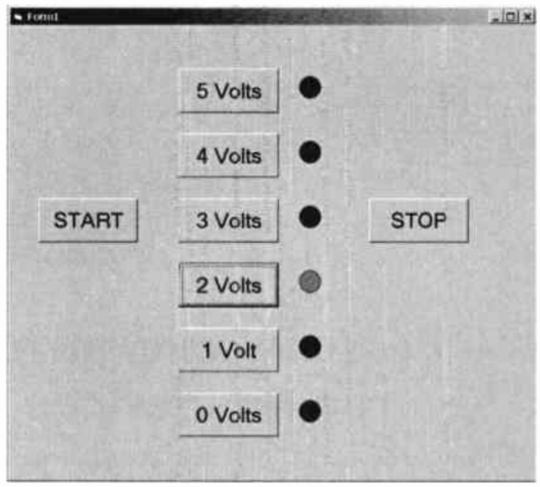


Fig.2. Screen shot showing the demonstration program in operation, with the output set at two volts.

An alternative method, and the one used in the demonstration program, is to use a pair of loops to control the timing. A drawback of this method is that the output frequency is dependent on the speed of the PC used. The faster the PC, the higher the output frequency of the PWM signal.

In practice this is not of great importance, since the output frequency should be more than adequate using old PCs, but it will not be excessive when using the latest super-fast PCs. A high degree of resolution can be obtained using this method.

Demonstration

The demonstration program is shown in operation in Fig.2, and it uses a column of six buttons to provide voltages from zero to five in one volt increments. The initial part of the program declares three variables, two of which are integer variables. These are Mark and Space, and their values respectively control the mark and space times. The third variable (Control) is a byte, and it is used to start and stop the timing loop.

Operating the Start button (Command1) launches the main routine, which is as follows:

```
Private Sub Command1_Click()
Mark = 1
Space = 32000
Control = 0
Shape1.FillColor = &HFF&
Shape2.FillColor = &HFF&
Shape3.FillColor = &HFF&
Shape4.FillColor = &HFF&
Shape5.FillColor = &HFF&
Shape6.FillColor = &HFF00&
Do While Control = 0
Out &H378, 1
For Delay = 0 To Mark
Next Delay
Out &H378, 0
For Delay = 0 To Space
Next Delay
DoEvents
Loop
End Sub
```

The first three lines provide suitable starting values for the three variables. A value of 0 ensures that the main loop will operate indefinitely, while the values of Mark and Space set the output voltage at its minimum level.

Each button has an accompanying "l.e.d." indicator, and the idea is for the l.e.d. to be green for the button that is active and red for the other five. The l.e.d.s are simply "round-shape" components, and a series of six instructions set them to the appropriate starting colours (&HFF for red, &HFF00 for green).

Do While

Next the program goes into the main loop, which is a Do While type. In this case the loop operates while Control is at a value of 0. A pair of For...Next loops then provide delays that generate the mark and space delays, with the Mark and Space variables being used to control the delays. The Out instructions set the output line low or high, as and when appropriate. Note that **Inpout32.dll** must be available to the program for these instructions to work.

The DoEvents instruction gets the program to check for events such as mouse clicks. Without this instruction the program will simply hang up in the loop with no way out other than using Control-Alt-Del so that it can be halted using the Windows Task Manager. Note that getting a program stuck in a loop will also block access to any other programs that are running at the time.

On The Button

Operating one of the six voltage buttons sets suitable values for Mark and Space, and also sets the "l.e.d.s" to the appropriate colours. The one shown below is for the 4 Volts button, but all six use the same basic scheme of things.

```
Private Sub Command3_Click()
Mark = 25600
Space = 6400
Shape1.FillColor = &HFF&
Shape2.FillColor = &HFF00&
Shape3.FillColor = &HFF&
Shape4.FillColor = &HFF&
Shape5.FillColor = &HFF&
Shape6.FillColor = &HFF&
End Sub
```

The routine for the Stop button is shown below. This sets the value of Control at 1. which halts the main Do While loop. The Out instruction sets the output line low, and

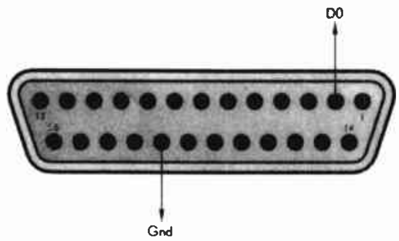


Fig.3. The demo program provides an output signal on D0 of the printer port.

a series of six instructions then sets all the "l.e.d.s" to red. The program can be started again by operating the Start button, and the required voltage can then be selected.

```
Private Sub Command7_Click()
Control = 1
Out &H378, 0
Shape1.FillColor = &HFF&
Shape2.FillColor = &HFF&
Shape3.FillColor = &HFF&
Shape4.FillColor = &HFF&
Shape5.FillColor = &HFF&
Shape6.FillColor = &HFF&
End Sub
```

The demonstration program uses buttons to control the output voltage, but the Mark and Space variables could obviously be controll.e.d. by other means. A slider or other onscreen control could be used to provide a continuously variable output voltage. Another possibility would be to read values from a sensor and vary the output voltage accordingly.

Hardware

The output line used by the demonstration program is D0, and connection details for the parallel port are shown in Fig.3. It is assumed that printer port 1 at base address &H378 is used, but the program is easily modified to suit other addresses, or other output lines.

In most cases the output signal from the printer port will need a fair amount processing before it is suitable for a given application. As a minimum, it will have to be amplified to give suitable drive voltages and currents. In order to obtain a reasonably smooth d.c. output level it will be necessary to use a good lowpass filter. As pointed out previously, filtering is not needed in all applications. Indeed, smoothing the output signal can be counter-productive.

Smoothing is not usually needed when driving a small d.c. electric motor, and it is likely to give inferior results. Driving a motor at low speeds using a low voltage tends to give poor results, with small variations in loading resulting in noticeable speed changes. Little increase in loading is needed in order stall the motor.

A pulsed signal having a low average voltage drives the motor at full power during the brief pulses. These bursts of full power usually give much better speed regulation and certainly reduce the tendency for increased loading to stall the motor.

A pulsed signal is also better when driving an l.e.d. or a bank of l.e.d.s. Using a variable d.c. voltage gives an odd control characteristic due to an l.e.d. typically requiring a forward potential of about two volts before it starts to conduct. Steadily increasing the output voltage results in nothing happening at first, with the l.e.d. abruptly switching on once the threshold voltage is reached.

The software could be written to allow for this factor, but it is an unnecessary complication. Using a pulsed signal renders the threshold voltage irrelevant, with the l.e.d. fully switching on during each pulse. This gives a sensible control characteristic without the need for any software or hardware tricks.

Filtering

Clearly many applications will require filtering. The circuit diagram shown in Fig.4 has a fourth order active filter based on IC1. This has a cut-off frequency at about 100Hz, which is low enough to give a low level of ripple on the output. On the other hand, it is high enough to give a reasonably fast response time. Making resistors R1 to R4 higher in value will give a lower ripple level, but with increased response time.

The amplifier (IC2) at the output of the circuit enables the maximum output potential to be varied from approximately 5V with preset VR1 (wired as a variable resistor) at minimum resistance to about 12V with it set near its maximum value. The minimum output voltage will be little more than zero when the unit is used with most PC printer ports. With an "awkward" printer port the output from the port could be processed by a CMOS buffer in order to rectify the problem.

Note that the CA3140E used for IC1 and IC2 is a MOS device and that it consequently requires the normal anti-static handling precautions. Also note that this device is a type that can be used in d.c. applications without the need for a negative supply. Most other operational amplifiers will not work in this circuit.

Precision digital to analogue conversion will be covered in the next *Interface* article, including a computer controll.e.d. PSU.

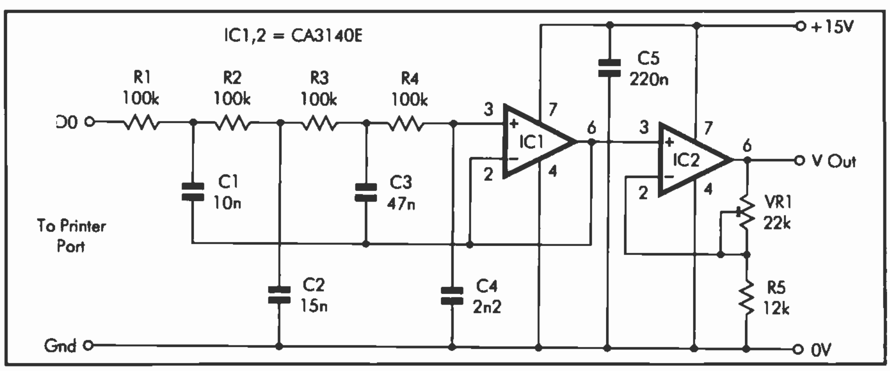
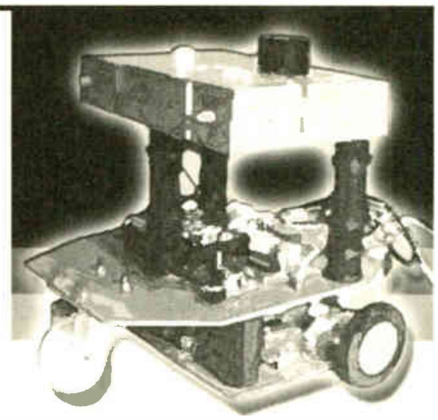


Fig.4. Circuit diagram for a low-pass filter and output amplifier. Preset VR1 provides maximum output voltages from 5V to 12V.

Constructional Project

Smart Karts

Owen Bishop



Part 3 – Bumpers, Light Sensor and Proximity Detector

PARTS 1 and 2 of this series described the initial hardware and software for a mobile hobby robot, Smart Kart, version SK-1. This month we show how to modify it to perform entirely different tasks. Because of the modular plan of the basic Smart Kart, much of the first version is used again now in version SK-2. The controlling software, though, is new and specific to SK-2, requiring another pre-programmed PIC microcontroller.

Sensors

The main difference between the two versions is their set of sensors. SK-1 has only a pair of downwardly directed infrared sensors used for following lines, but SK-2 bristles with three different types of sensor:

- A pair of bumpers mounted at the front, acting as touch sensors
- A single forwardly directed visible light sensor
- An ultrasonic proximity sensor, also forwardly directed

SK-2 has four built-in program routines, selectable by switches on the upper deck. These allow one, two or even all three of the sensors to give the robot a varied range of behaviours.

Getting Started

We first describe the mechanical aspects of SK-2, then discuss the new electronic circuits, after which we examine the new software (next month).

SK-2 has a completely new upper deck, with a new set of circuit boards. The first step is to remove the parts of SK-1 that are to be replaced. Unplug the cables that join the Processor board to the boards in the upper deck. Remove the three separators that support the upper deck. Unplug the cable joining the two infra-red (IR) sensors to the Processor board and remove both sensors from the middle deck.

The middle and lower decks need no further alterations, except for mounting the bumpers on the middle deck, described shortly. Keep the three separators ready for supporting the new upper deck.

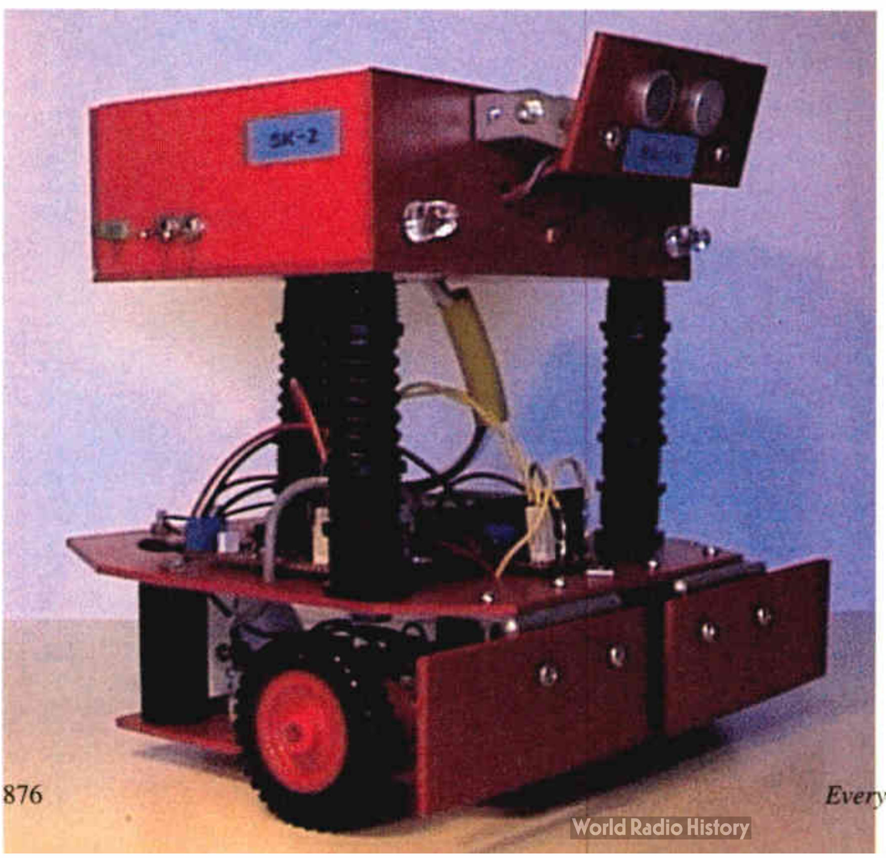
Upper Deck

The new upper deck is again a shallow box made from panels of 3mm expanded PVC, hardboard or plywood. Table 3.1 lists the pieces required.

For guidance, the top photo on the opposite page shows the finished assembly of the new upper deck, illustrating how the pieces go together, along with the six lid supports glued inside the front, rear and side walls of the deck. The lid simply drops into the box, resting on the supports. It needs some kind of knob or finger grip, to make it easy to remove the lid for servicing. A small plastic "foot" was bolted at the centre of the lid in the prototype (see far right photo on the opposite page).

The space above the lid is intended for carrying small light-weight objects such as potato crisps and sweets! One program described later can make SK-2 become a robot waiter, serving food to guests.

It is best to drill the various pieces before assembling them, but the exact positions and diameters of the holes depend on the size of the components used. Assemble the upper deck, using PVA or other suitable adhesive to glue the panels together by their edges.



Bumpers

Two bumper panels extend the full width of the robot. Each panel is mounted on a butt hinge, but not symmetrically, the panels extending sideways to shield the wheels from contact with obstacles. One part of the hinge is bolted to the middle deck, taking the place of the sensors of robot SK-1.

You will probably need to drill an extra hole or two because most hinges have two or three fixing holes in each part. At the same time, drill a 3mm hole for the bolt that secures the bumper circuit board, and a pair of 5mm holes for the wires connecting the board to the bumpers. The other part of the hinge, with its bumper panels bolted to it, hangs vertically downward as shown in Fig.3.1.

Low-cost hinges vary a lot in stiffness, even hinges of the same type and make. For use in the bumpers you will need to check through several hinges at your DIY store to find a pair that are very loosely jointed.

In operation, there is a gap of one or two millimetres between the actuator lever of the sub-miniature microswitch and the vertically-hanging part of the hinge (see photo opposite). The microswitch contacts are normally open. When the panel makes contact with an obstacle, the panel is pushed backwards to press on the actuator lever and the switch contacts close.

Table 3.1. Cutting and Drilling Guide

Piece	*Dimensions (mm)*	*Holes for...*
Upper deck - bottom	165 × 136	separators (3), slot for cable, mounting buzzer
Upper deck - lid	104 × 159	finger grip
Upper deck - front	165 × 50	white l.e.d.s (2), LDR leads (2), U/S mounting, leads from U/S transmitter & receiver
Upper deck - rear	165 × 50	–
Upper deck - left side	104 × 50	flashing l.e.d. (red)
Upper deck - right side	104 × 50	flashing l.e.d. (green)
Upper deck - lid supports (6)	30 × 25	–
Bumper boards (2)	100 × 40	bolting to hinge
Rims for bumper boards	100 × 10	–
Microswitch mounting panels (2)	50 × 30	mounting boards (2), microswitch bolt
Tx/Rx mounting panel	90 × 35	transducers (2), mounting bolts (2)

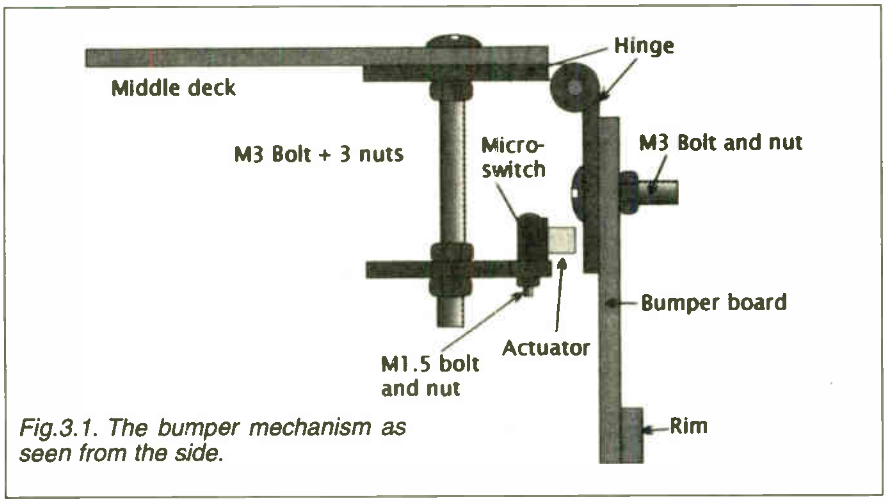
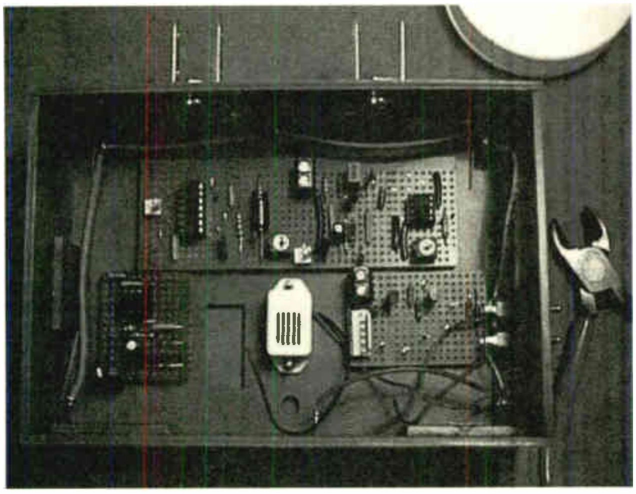
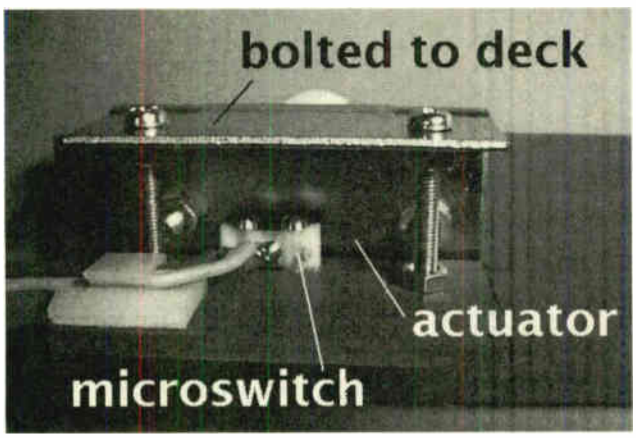


Fig.3.1. The bumper mechanism as seen from the side.



Interior of the upper deck. It shows the lid supports glued to the inside walls.



Rear of the left bumper, assembled but not bolted to the middle deck.

COMPONENTS

General

Semiconductors

D4	5mm red flashing l.e.d.
D5	5mm green flashing l.e.d.

Miscellaneous

8-way header socket; 0·9mm pin-header and socket; connecting wire; solder, etc.

Mechanical

PVC board cut and drilled as in Table 3.1; knob for upper deck lid; assorted M1.5, M3 and M4 bolts and nuts; Meccano or similar parts for mounting ultrasonic transducers; hinges for bumpers (2 off); glue for upper deck panels; Blu-tack or similar.

Bumpers

Resistors

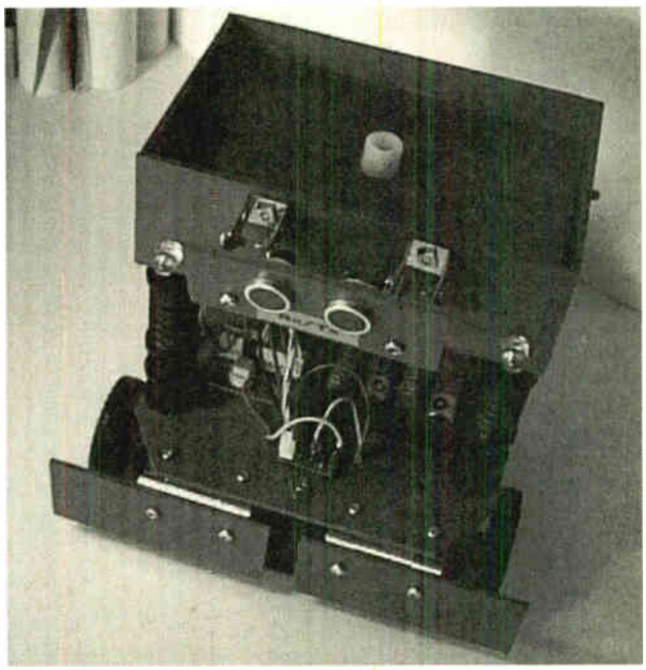
R1, R2 — 10k (2 off)
All 0.25W, 5% carbon film, or better.

Miscellaneous

S1, S2	sub-miniature microswitch (2 off)
PL1	0·9mm pinheader and socket
TB1	2-way screw terminal block, p.c.b. mounting

Stripboard, 9 strips x 10 holes; connecting wire; solder, etc.

Approx. Cost Guidance Only **£10**



The ultrasonic transducers are mounted on an adjustable tilting panel. The Bumper circuit board is located at the front-centre of the middle deck.

The panel has a narrow strip of board glued along its bottom edge. This ensures that the panel is pushed back when the robot runs into a flat vertical surface such as a wall.

Bumper Circuit

The Bumper interface circuit is shown in Fig.3.2, just needing to connect the two normally-open microswitches to the PIC microcontroller, IC1, at its RB4 and RB5 pins, see Fig.3.2, and Fig.5 Part 1.

Pins RB4 and RB5 are configured as inputs, normally held low by resistors R1 and R2 in Fig.3.2. When a bumper is pressed, the respective switch, S1 or S2, is closed and the corresponding PIC input is taken high, indicating a "bump".

The stripboard assembly is shown in Fig.3.3. It needs a 3mm hole drilled in it for attaching to the middle deck with an M3 plastic bolt and nut. Connect a pair of wires about 8cm long to each microswitch.

Solder a p.c.b. pin header socket to the other end of the wire. Thread the wires through a cable clip and the hole in the deck. Secure one wire in the positive side of terminal block TB1 and plug the other on to the appropriate p.c.b. pin, either TP1 or TP2, depending on the switch it is associated with.

Prepare a twin lead about 10cm long with a 2-way header socket on one end. Its other end goes later to a 6-way header socket for connecting to the Processor board. Prepare two power leads (about 12cm long) to run from terminal block TB1 to the power supply terminal block (TB6) on the Processor board.

To test the board when connected to the microswitches, apply power and monitor the voltage at the header connector PL1. The voltage should be 0V normally, but rise to the 4.8V supply level at the appropriate pin when either bumper is pressed. It should return to 0V when the pressure is released.

Light Sensor

The Light Sensor is a light-dependent resistor (LDR), connected as in Fig.3.4.

The circuit is simply a potential divider, formed by LDR R3, resistor R4 and preset VR1. This is tapped to provide an output to the PIC, via AND gate IC2a on the processor board. In dim light, the resistance of the LDR is high so that the output is at a level which is seen by the gate as logic 0.

As the light level rises, the LDR's resistance falls and the tapped voltage rises, eventually above the threshold level at which the gate regards as logic 1, above about half the supply voltage, 2·4V. VR1 controls the divider's sensitivity to the light changes.

The light sensor's stripboard assembly details are shown in Fig.3.5.

The LDR is glued to the front of the upper deck, and there are two 1mm holes for the leads to pass into the deck. The polarity is not important.

It was found in trials that the sensor has better directional sensitivity if it is shielded by a short tube. This is glued to the front of the deck, surrounding the LDR, with its open end looking ahead. The prototype used a piece of the same ABS tubing as was used for the separators (Part 1), about 20mm in diameter and 35mm long.

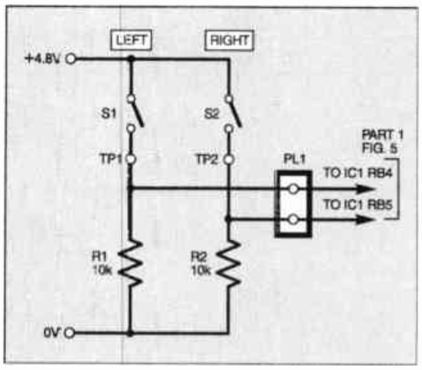


Fig.3.2. Circuit diagram for the bumpers. Switches S1 and S2 are miniature microswitches.

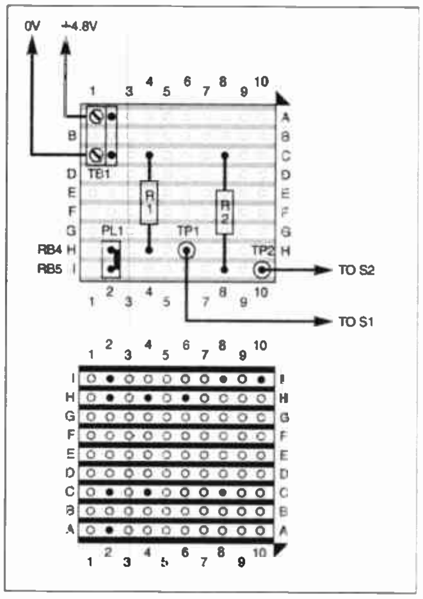


Fig.3.3 Stripboard component layout on the Bumper board.

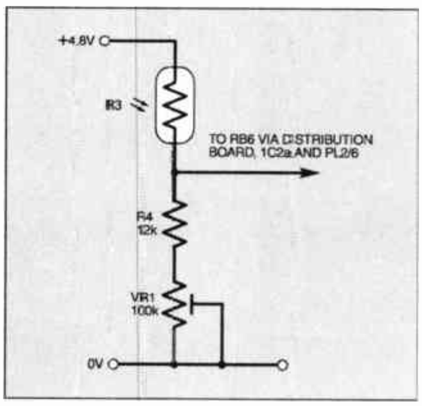
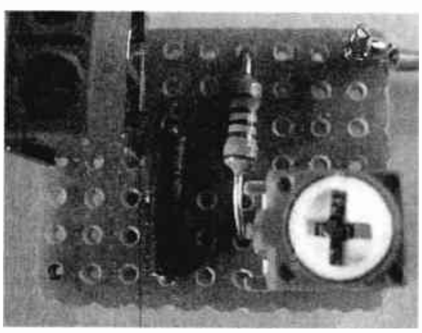
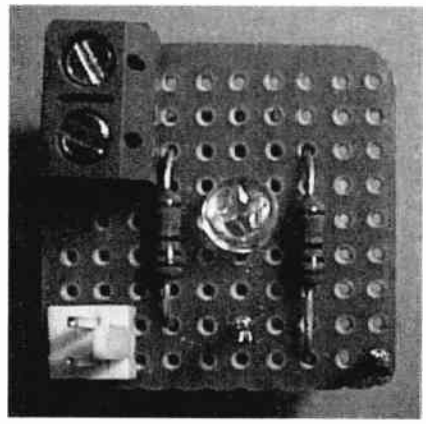


Fig.3.4. Circuit diagram for the light sensor.



Completed Light Sensor circuit board.



Layout of components on the Bumper Board.

Solder a 12cm wire to terminal pin TP3. Fit the other end of this wire with a pin header socket so that it can be connected to pin 5 of the Distribution board (see later).

To test the board, connect the LDR to the positive power line and terminal

COMPONENTS

Light Sensor

Resistors	
R3	ORP12, light dependent resistor or similar
R4	12k, 0·25W 5% carbon film, or better.
Potentiometer	
VR1	min. preset, horiz.
Miscellaneous	
TB2	2-way p.c.b. mounting screw terminal

Stripboard, 8 strips x 9 holes; connecting wire; solder, etc.

Approx. Cost Guidance Only **£3**

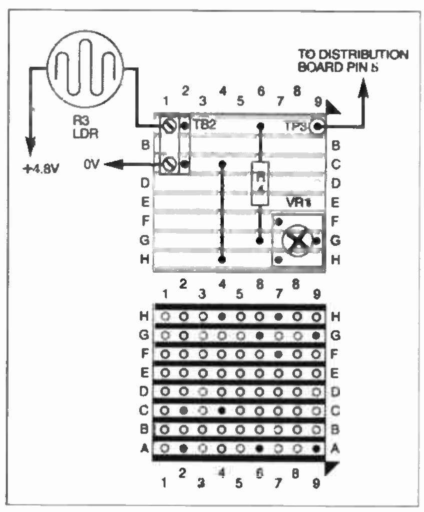


Fig.3.5. Light sensor stripboard component layout and wiring details.

block TB2 as shown, plus a 0V connection. Turn preset VR1 to a mid-way position. Connect a voltmeter between 0V and LDR's connection at TB2. The voltage will be only a few millivolts if the LDR is fully shaded, but rise to 4V or more in bright room lighting. Leave the adjustment of VR1 until later.

Ultrasonic Proximity Sensor

The circuit diagram for the Ultrasonic Proximity Sensor Transmitter is shown in Fig.3.6. It is based on a 4011 quad 2-input NAND gate. Two of the gates, IC1a and IC1b, are used as a conventional CMOS astable circuit whose oscillation frequency is set by capacitor C1, resistors R6 and R7, plus preset VR2, which adjusts the frequency. Gates IC1c and IC1d buffer the outputs from IC1a and IC1b and drive the ultrasonic transmitter transducer, X1, in push-pull mode.

The input at IC1a pin 13 acts as an *enable* input and is controlled by the output from PIC pin RA4. This is an open drain output so it needs a pull-up resistor, R5. The astable is enabled when RA4 goes high.

In the Receiver circuit, Fig.3.7, the ultrasonic echo signal is received by transducer X2. It is first amplified by the 2-stage amplifier based on transistors TR1 and TR2. The output from TR2 is rectified by diode D1 and smoothed by capacitor C4. The result is a voltage level at point *A* that varies between 1·4V and 2·7V when X2 is not receiving ultrasound echoes, but falls to 1·2V when a strong enough echo from an object is detected.

The rectified signal goes to op.amp comparator IC2's inverting input, pin 2. The signal is compared with a reference voltage set by preset VR3, and applied to IC2's non-inverting input, pin 3. The output at IC2 pin 6 is low when there is no echo, but swings high when an obstacle ahead of the Smart Kart is detected. This signal is routed to the PIC by way of AND gate IC2b (Fig.5 Part 1) to further sharpen its action.

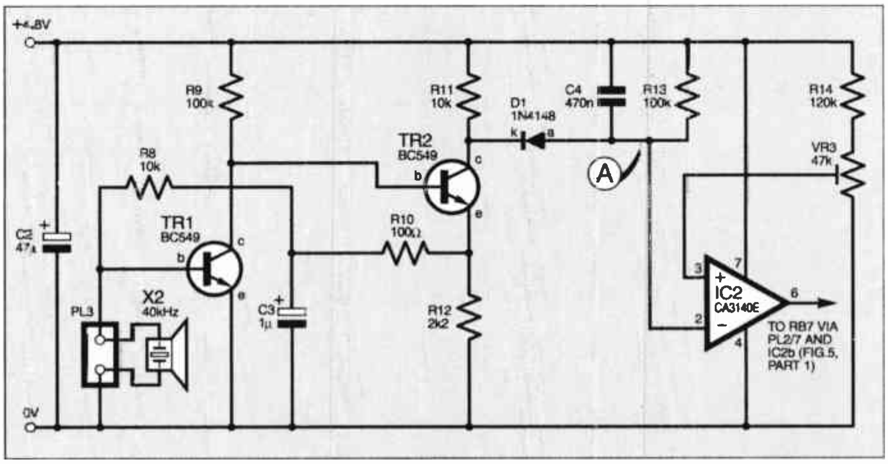


Fig.3.7. Circuit diagram for the Ultrasonic Sensor Receiver.

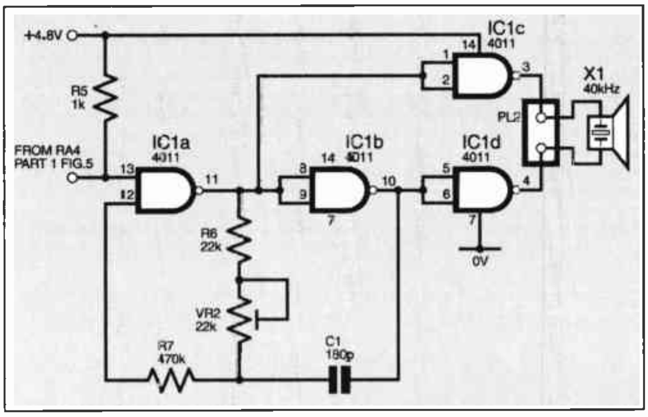


Fig.3.6. Circuit diagram for the Ultrasonic proximity Sensor Transmitter.

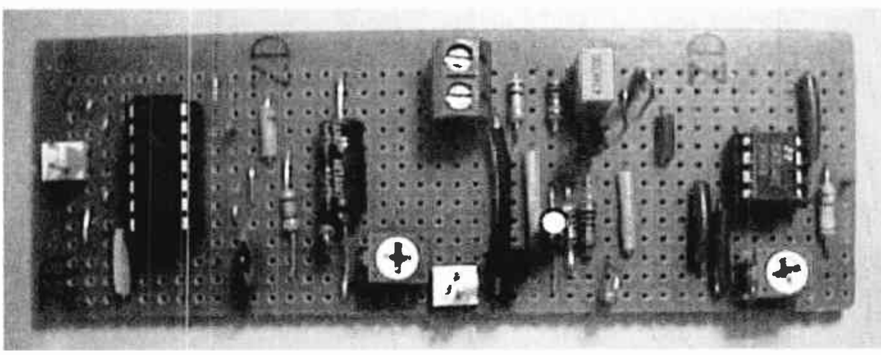
Sensors

Ultrasonic transducers are usually sold as a pair, and you need to identify which is the transmitter (Tx) and which is the receiver (Rx). The information is normally printed on the transducer's body.

The transducers are mounted side-by-side on a panel that can be tilted downward to scan the region ahead for obstacles. The sensor can detect objects several metres away, but tilting the board down reduces the range to one metre or less, depending mainly on the size of the object.

Cut a pair of circular holes in the panel, making them a tight fit around the transducers. Smear a coating of adhesive on the sides of the holes and push the transducers into place.

There are several possible ways of mounting the panel. Meccano parts were used in the prototype. A downward tilt of about 15° is a good starting position.


Layout of components on the Ultrasonic Transmitter/Receiver Sensor board.

COMPONENTS

Ultrasonic Sensor

See SHOP TALK page

Resistors

R5	1k
R6	22k
R7	470k
R8, R11	10k (2 off)
R9, R13	100k (2 off)
R10	100Ω
R12	2k2
R14	120k

All 0.25W 5% carbon film, or better.

Potentiometers

VR2	22k min. horiz. preset
VR3	47k min. horiz. preset

Capacitors

C1	180p disc ceramic
C2	47µ axial elect. 10V
C3	1µ axial elect. 10V
C4	470n polyester

Semiconductors

D1	1N4148 signal diode
IC1	4011 quad 2-input NAND gate
IC2	CA3140E CMOS op.amp
TR1, TR2	BC549 *npn* transistor (2 off)

Miscellaneous

PL2, PL3	2-way pinheader socket and plug (2 off each)
TB3	2-way screw terminal block p.c.b. mounting
X1	40kHz ultrasonic transmitter
X2	40kHz ultrasonic receiver

Stripboard, 13 strips x 43 holes; 8-pin d.i.l. socket; 14-pin d.i.l. socket; connecting wire; solder, etc.

Approx. Cost Guidance Only **£11**

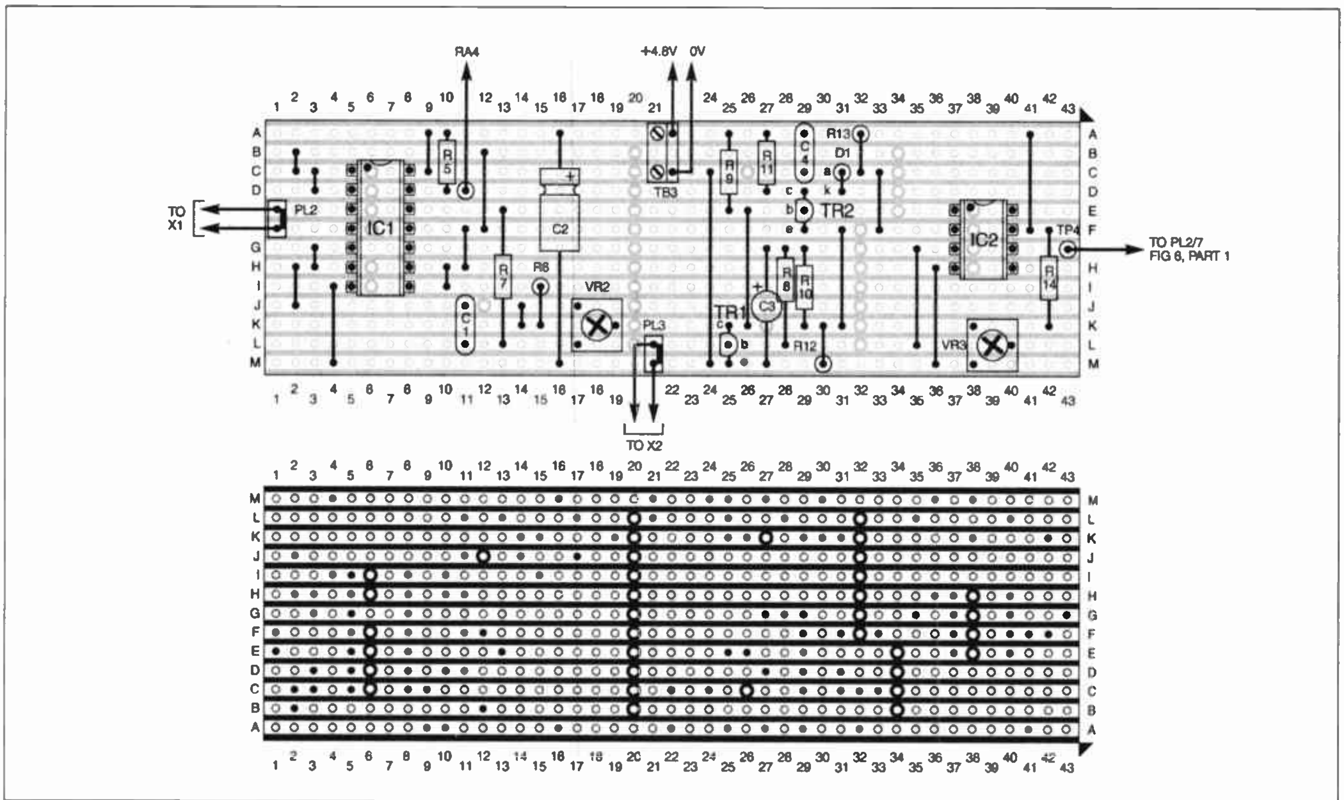
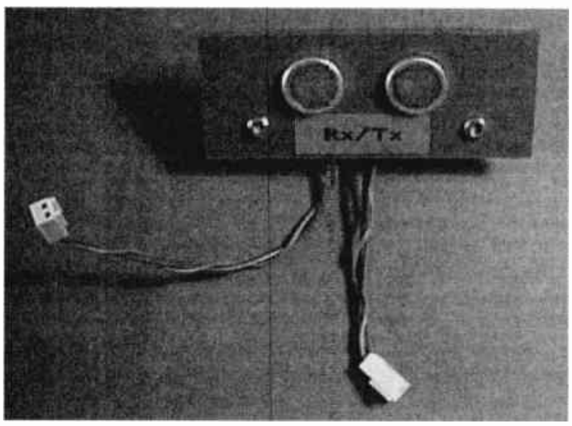


Fig.3.8. Layout of components on the Ultrasonic Transmitter/Receiver board.

Ultrasonic Board

The Transmitter and Receiver circuits are assembled on the same board, as shown in Fig.3.8. The copper strip is *not* cut between pins 5 and 10 of IC1.

Both circuits are powered by the supply going to terminal block TB3. The transducers, X1 and X2, are connected to the board via short twin leads, ending in a 2-way header sockets, which connect appropriately to PL2 and PL3. Note that the pin connected to the transducer's case is the 0V pin.



The ultrasonic Transmitter and Receiver transducers mounted side-by-side on a tilting panel.

In the receiver circuit, solder a lead of about 8cm to pin TP4. Fit the other end of this lead with a pinheader socket so that it can be connected to the Distribution board (see later).

To test the board, have the two transducers mounted on their panel and connect them to the board. Switch on the power supply and use an oscilloscope or a test-meter with a frequency function, to measure the frequency at pin 3 or pin 4 of IC1. Adjust VR2 to bring the frequency as close as possible to 40kHz. This can also be achieved experimentally, as follows:

Support the transducer panel so that there is nothing in front of it for several metres. Set VR3 to its mid-way position and connect a voltmeter to pin TP4. Switch on the power. With nothing in front of the transducers, the output at TP4 should be low (a few millivolts).

Wave a small object, such as a book, in front of the transducers at a distance of about 40cm – the output at TP4 should go high (about 3·9V). If it does not, carefully adjust VR3 until the oscillation frequency matches the 40kHz frequency to which the transducers are tuned.

Distribution Board

The Distribution board takes over some of functions of the Effects Board in Part 1. The circuit diagram in Fig.3.9 shows a pair of white l.e.d.s which are switched by transistor TR3 under the control of PIC output RB0. Similarly, buzzer WD1 is controlled by RB1 via transistor TR4.

The two program selecting switches, S3 and S4, have pull-down resistors, R18 and R19, so that they provide low inputs to RB2 and RB3 when open, but provide high inputs when closed. The board also acts as a connection (via PL4) to the PIC for the outputs of the light sensor and ultrasonic boards.

Build the board as shown in Fig.3.10. The positive supply at terminal TB4 does not directly connect to items on the board. Instead it acts as an anchor-point for the positive supply wire coming up from the Processor board (Part 1 Fig.6).

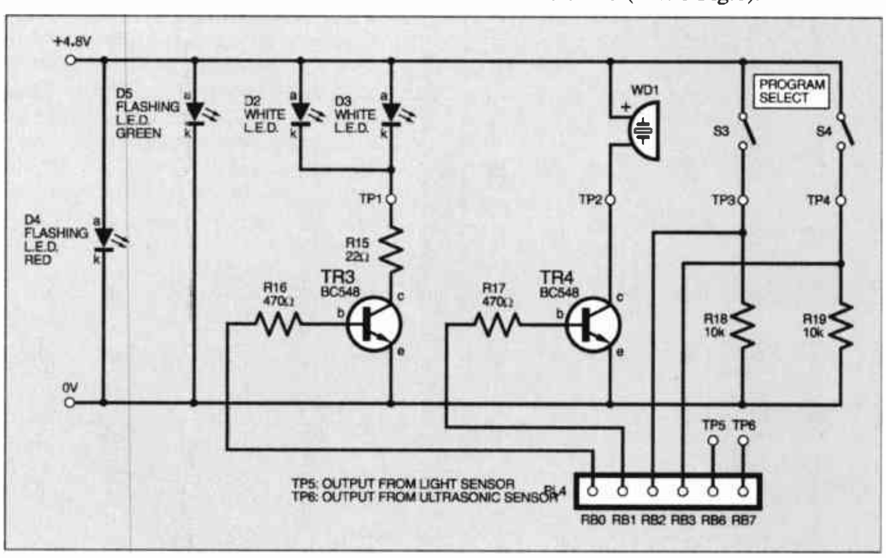


Fig.3.9. Circuit diagram for the Distribution board. The flashing l.e.d.s D4 and D5 simply function as pilot lights.

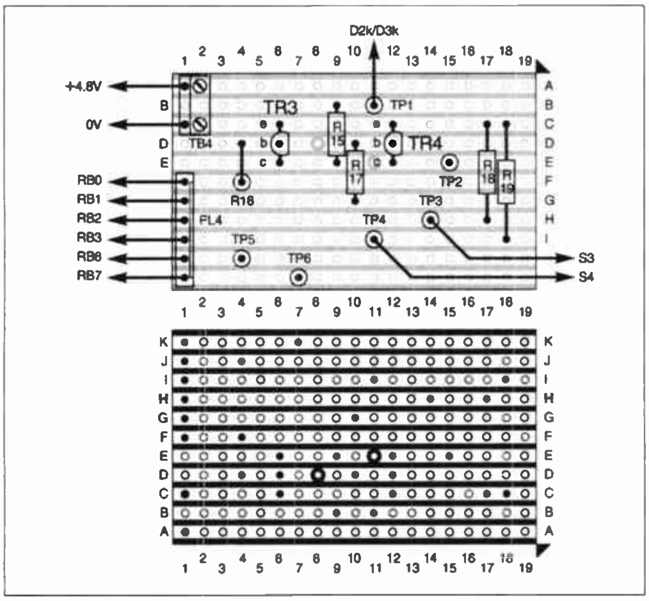
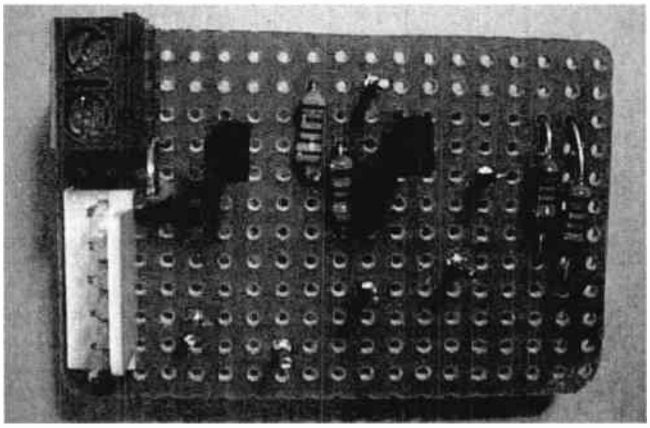


Fig.3.10. Distribution stripboard component layout and wiring. The completed board is shown above right.



Switches S3 and S4 are mounted on the right wall of the deck. Position them so that their levers are down when the switches are open, and up when they are closed. The effect of this arrangement is that input to the PIC is low with the lever down and high with the lever up. Mount the switches so that S3 (least significant digit) is to the right of S4.

Connecting the System

Most of the inter-board connections are made inside the upper deck. Fix the boards using Blu-tack or similar, as shown in the photograph. The ultrasonic board runs along the front of the deck. The light sensor board is to the left of the slot. The buzzer and Distribution board are to the right.

The common positive connecting wire begins at the positive screw terminal of the Distribution board (Fig.3.10), and runs to the anode of D5 (green right flashing l.e.d.), S4, S3, anode of D3 (right white l.e.d.), LDR R3, anode of D2 (left white l.e.d.) and the anode of D4 (red left flashing l.e.d.).

Another positive wire joins the positive terminals of the Distribution and Ultrasonic boards. The positive terminal of buzzer WD1 is soldered to the positive terminal of one of the switches. There is no positive connection to the light sensor board.

Connections to the l.e.d.s are made by cutting the l.e.d. wires to about half length, bending them around the common wire, and soldering. In the prototype, and as shown in Part 1, a continuous bare wire was run around the inside of the box slipping a length of sleeving on between soldering points.

A common negative connecting wire runs from the cathode of D5 to the cathode of D4, the light sensor board, the ultrasonic board and the distribution board. Note that these l.e.d.s are connected directly across the positive and negative rails, without switching and without ballast resistors. They are on for the whole time the system is switched on, acting as pilot lamps.

Other connections to be made are: Distribution board, as in Fig.3.10, Ultrasonic board transducer connections, Light sensor board LDR to TB2. Finally make the nine connections to the processor board:

- Positive and negative supply: from the screw terminal on the Distribution board to the terminal on the Processor board.
- A 6-way cable with a 6-way header socket at one end (to mate with PL4, Fig.3.10) and an 8-way cable at the other (to mate with PL2 on the Processor board). The two additional lines on PL2 (RB4 and RB5) are connected to the 2-way cable from the Bumper board.
- A single wire from the indicated pin on the Ultrasonic board to the RA4 point on the Processor board.

These wires need to be about 15cm long. For tidiness, they can be threaded through a short length of 10mm diameter sleeving.

Testing the System

When all the wiring is complete, but without the PIC in its socket, and with the power switched off, carry out a continuity check on the positive and 0V lines as described in Part 1. Then switch on the power and confirm that the voltage is 4·8V at all places that you would expect (or maybe a little more if the cells are fully charged).

Connect flying leads to the power lines and check the action of applying one or the other to the pins of the PIC's socket:

Pins 1, 2, 17, 18: Control the motors, as described in Part 1 (with motor power on)

Pin 8: Headlamp l.e.d.s come on when high.

Pin 9: Bleeper sounds when high.

The red and green l.e.d.s flash all the time.

With the meter probes to 0V and the positive probe to one of these pins, monitor the following:

Pin 4: Normally high; goes low for as long as the reset button is pressed. Pin 6: Low when S3 is off; high when it is on. Pin 7: Low when S2 is off; high when it is on. Pin 10: Normally low; high when left bumper pressed. Pin 11: Normally low; high when right bumper pressed. Pin 12: High when the light sensor receives light; low when it is shaded. Pin 13: With pin 3 unconnected or high, the voltage at pin 13 is high when the ultrasonic sensor detects an object; low when there is no echo received. With pin 3 low, the sensor is disabled and pin 13 is always low.

COMPONENTS

Distribution board

Resistors

R15	22Ω
R16, R17	470Ω (2 off)
R18, R19	10k (2 off)

All 0.25W 5% carbon film, or better.

Semiconductors

D2, D3	10mm white l.e.d., high brightness (5000 mcd),(2 off)
TR3, TR4	BC549 *npn* transistor (2 off)

Miscellaneous

S3, S4	sub-min s.p.d.t. toggle switch (2 off)
PL4	6-way header socket and plug
TB4	2-way screw terminal block p.c.b. mounting
WD1	solid-state buzzer

Stripboard 11 strips x 19 holes; 0·9mm pinheader and socket (6 off each); connecting wire; solder, etc.

Approx. Cost Guidance Only **£8**

If all of the above checks are passed, you are ready to insert the PIC microcontroller, which must have been programmed with the SK-2 hex code, and begin operating the Smart Kart with its four new modes.

If you have a suitable meter or an oscilloscope, measure the signal frequency at pin 16 of the PIC. It should be in the region of 14kHz.

RESOURCES

Software, including source code files, for the Smart Kart Part 3 (SK-2) is available on 3.5-inch disk from the Editorial office (a small handling charge applies – see the *EPE PCB Service* page). It can also be downloaded *free* from the *EPE* Downloads page, accessible via the home page at **www.epemag.co.uk**. It is held in the PICs folder, under SmartKart.

Next month: SK-2 Software.

EVERYDAY PRACTICAL ELECTRONICS

BACK ISSUES

We can supply back issues of *EPE* by post, most issues from the past three years are available. An *EPE* index for the last five years is also available at **www.epemag.wimborne.co.uk** or see order form below. Alternatively, indexes are published in the December issue for that year. Where we are unable to provide a back issue a photocopy of any *one article* (or *one part* of a series) can be purchased for the same price. Issues from Nov. 98 are available on CD-ROM – see next page – and issues from the last six months are also available to download from **www.epemag.com**. Please make sure all components are still available before commencing any project from a back-dated issue.

DID YOU MISS THESE?

AUG '03

PROJECTS • EPE PIC Met Office–1 • Alarm System Fault Finder • Master/Slave Intercom • Electronic Two-Up • Radio Circuits–3 (Regenerative Receivers).
FEATURES • Digital Command Control for Model Trains • Ingenuity Unlimited • Circuit Surgery • Interface • Techno Talk • New Technology Update Net Work – The Internet Page.

SEPT '03

PROJECTS • PIC-A-Colour • Vibration Alarm • Priority Referee • EPE PIC Met Office–2 • Radio Circuits–4 (Tuning Systems).
FEATURES • Using the PIC's "High" Operator • Practically Speaking • Ingenuity Unlimited • Circuit Surgery • Net Work – The Internet Page.

OCT '03

PROJECTS • RC Car Wars • Serial Interface for PICs and VB6 • Practical Radio Circuits–5 (Super Regen. Receiver) • Spooky Bug.
FEATURES • PIC Breakpoint • Ingenuity Unlimited • Interface • Techno-Talk • New Technology Update • Net Work – The Internet Page.

NOV '03

PROJECTS • PIC Random L.E.D. Flasher • Cardboard Clock • Practical Radio Circuits–6 (S.S.B. and Direct Conversion Receiver) • Anyone At Home?
FEATURES • Teach-In 2004 – Part 1 • Ingenuity Unlimited • Practically Speaking • Techno Talk • Circuit Surgery • New Technology Update • Net Work – The Internet Page.

DEC '03

PROJECTS • PIC Nim Machine • Practical Radio Circuits–7 (Superhet Tuner) • PIC Virus Zapper Mk2 • Christmas Cheeks.
FEATURES • Teach-In 2004 – Part 2 • Electrotherapy • Circuit Surgery • Ingenuity Unlimited • Techno Talk • High-Speed Decimal To Binary For PICs • Interface • Network – The Internet.

JAN '04

PROJECTS • Car Computer • Practical Radio Circuits–8 (Dual-Conversion SW Receiver) • Bedside Nightlight • PIC Watering Timer.
FEATURES • GPS to PIC and PC Interface • Practically Speaking • Teach-In 2004 – Part 3 • Ingenuity Unlimited • Techno Talk • Circuit Surgery • New Technology Update • Net Work – The Internet Page.

FEB '04

PROJECTS • PIC LCF Meter • Sonic Ice Warning • Jazzy Necklace • PIC Tug-of-War.
FEATURES • Surface Mount Devices • Circuit Surgery • Teach-In 2004 – Part 4 • Interface • Ingenuity Unlimited • Techno Talk • Net Work – The Internet Page.

MAR '04

PROJECTS • Bat-Band Convertor • Emergency Stand-by Light • MIDI Health Check • PIC Mixer for RC Planes.
FEATURES • Teach-In 2004 – Part 5 • New Scientist CD-Rom Review • Circuit Surgery • Techno Talk • Ingenuity Unlimited • Practically Speaking • Net Work – The Internet Page.

APRIL '04

PROJECTS • EPE Experimental Seismograph Logger 1 • Infra-Guard Monitor • Loft Light Alarm • PIC Moon Clock.
FEATURES • USB To PIC Interface • Ingenuity Unlimited • Teach-In 2004 Part 6 • Interface • Techno Talk • Circuit Surgery • New Technology Update • Net Work – The Internet Page • Pull-Out – Semiconductor Classification Data.

MAY '04

PROJECTS • Beat Balance Metal Detector • In-Car Laptop PSU • Low-Frequency Wien Oscillator • EPE Experimental Seismograph Logger–2.
FEATURES • Coping With Lead-Free Solder • Teach-In 2004 – Part 7 • Ingenuity Unlimited • Techno Talk • Circuit Surgery • Practically Speaking • Pic-N'-Mix • Net Work – The Internet Page.

JUNE '04

PROJECTS • PIC Quickstep • Crafty Cooling • MIDI Synchronome • Body Detector Mk2.
FEATURES • Clinical Electrotherapy • Ingenuity Unlimited • Teach-In 2004 – Part 8 • Interface • Circuit Surgery • Techno Talk • PIC-N'-Mix • Net Work – The Internet Page.

JULY '04

PROJECTS • Portable Mini Alarm • Bongo Box • Hard Drive Warbler • EPE PIC Magnetometry Logger–1.
FEATURES • Making Front Panel Overlays • Practically Speaking • Teach-In 2004 – Part 9 • Ingenuity Unlimited • Circuit Surgery • Techno Talk • PIC-N'-Mix • Net Work – The Internet Page.

AUG '04

PROJECTS • EPE Scorer • Keyring L.E.D. Torch • Simple F.M. Radio • EPE PIC Magnetometry Logger – 2.
FEATURES • PIC To PS/2 Mouse and Keyboard Interfacing • Techno Talk • Circuit Surgery • Teach-In 2004 – Part 10 • Interface • Ingenuity Unlimited • PIC-N'-Mix • Net Work – The Internet Page.

SEPT '04

PROJECTS • EPE Wart Zapper • Radio Control Failsafe • Rainbow Lighting Control • Alphamouse Game.
FEATURES • Light Emitting Diodes – Part 1 • High Speed Binary-To-Decimal For PICs • Practically Speaking • Ingenuity Unlimited • Techno-Talk • Circuit Surgery • PIC-N'-Mix • Network – The Internet Page

OCT '04

PROJECTS • EPE Theremin • Smart Karts – Part 1 • Volts Checker • Moon and Tide Clock Calendar.
FEATURES • Light Emitting Diodes – 2 • Circuit Surgery • Interface • Ingenuity Unlimited • Techno Talk • PIC-N'-Mix • Network – The Internet Page • ROBOTS – Special Supplement

NOV '04

PROJECTS • Thunderstorm Monitor • M.W. Amplitude Modulator • Logic Probe • Smart Karts - 2.
FEATURES • Light Emitting Diodes-3 • Floating Point Maths for PICs • Ingenuity Unlimited • PE 40th Anniversary • Circuit Surgery • Techno Talk • PIC-N'-Mix • Net Work – The Internet Page.

BACK ISSUES ONLY £3.50 each inc. UK p&p.
Overseas prices £4 each surface mail, £5.50 each airmail.

We can also supply issues from earlier years: 1999 (**except** Feb., May, Aug., Sept., Dec.), 2000 (**except** Feb., Mar., July, Oct.), 2001 (**except** May, Aug. to Nov.), 2002 (**except** June, Aug. to Nov.) Where we do not have an issue a photocopy of any ***one article*** or ***one part*** of a series can be provided at the same price.

ORDER FORM – BACK ISSUES – PHOTOCOPIES– INDEXES

☐ Send back issues dated ....

☐ Send photocopies of (article title and issue date) ....

☐ Send copies of last five years indexes (£3.50 for five inc. p&p – Overseas £4 surface, £5.50 airmail)

Name ....

Address ....

.... Tel: ....

☐ I enclose cheque/P.O./bank draft to the value of £ ....

☐ Please charge my Visa/Mastercard/Amex/Diners Club/Switch £ .... Switch Issue No. ....

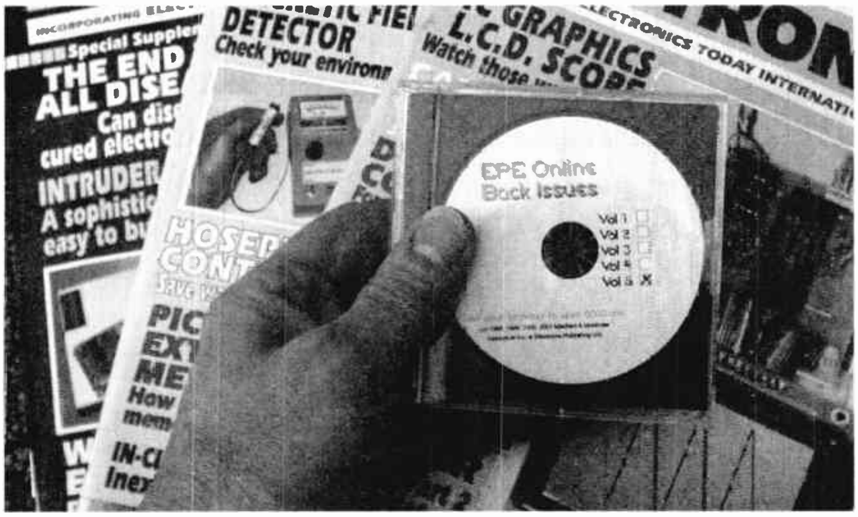
Card No. ....

Valid From .... Card Expiry Date .... Card Security Code ....
(The last 3 digits on or just under the signature strip)

SEND TO: **Everyday Practical Electronics, Wimborne Publishing Ltd., 408 Wimborne Road East, Ferndown, Dorset BH22 9ND.**
Tel: 01202 873872. Fax: 01202 874562.
E-mail: orders@epemag.wimborne.co.uk **On-line Shop:** www.epemag.wimborne.co.uk/shopdoor.htm
Payments must be in £ sterling – cheque or bank draft drawn on a UK bank. Normally supplied within seven days of receipt of order.
Send a copy of this form, or order by letter if you do not wish to cut your issue.

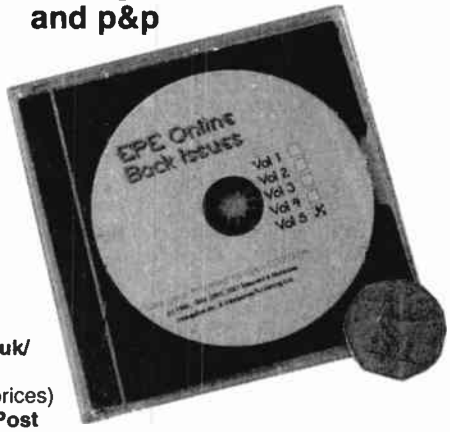
M12/04

STORE YOUR BACK ISSUES ON MINI CD-ROMS



VOL 10 NOW AVAILABLE

ONLY £14.45 each including VAT and p&p



A great way to buy *EPE* Back Issues – our mini CD-ROMs contain back issues from our *EPE Online* website plus bonus articles, all the relevant PIC software and web links. Note: no free gifts are included. All this for just £14.45 each including postage and packing.

VOL 1: BACK ISSUES – January 1999 to June 1999
Plus bonus material from November and December 1998

VOL 2: BACK ISSUES – July 1999 to December 1999

VOL 3: BACK ISSUES – January 2000 to June 2000

VOL 4: BACK ISSUES – July 2000 to December 2000

VOL 5: BACK ISSUES – January 2001 to June 2001

VOL 6: BACK ISSUES – July 2001 to December 2001

VOL 7: BACK ISSUES – January 2002 to June 2002

VOL 8: BACK ISSUES – July 2002 to December 2002

VOL 9: BACK ISSUES – January 2003 to June 2003

VOL 10: BACK ISSUES – July 2003 to December 2003

NOTE: These mini CD-ROMs are suitable for use on any PC with a CD-ROM drive. They require Adobe Acrobat Reader (available free from the Internet – **www.adobe.com/acrobat**)

WHAT IS INCLUDED

All volumes include the *EPE Online* editorial content of every listed issue, plus all the available **PIC Project Codes** for the PIC projects published in those issues.

Note: Some supplements etc. can be downloaded free from the Library on the *EPE Online* website at **www.epemag.com.**
No advertisements are included in Volumes 1 and 2; from Volume 5 onwards the available relevant software for *Interface* articles is also included.

EXTRA ARTICLES – ON ALL VOLUMES

BASIC SOLDERING GUIDE – Alan Winstanley's internationally acclaimed fully illustrated guide. **UNDERSTANDING PASSIVE COMPONENTS** – Introduction to the basic principles of passive components. **HOW TO USE INTELLIGENT L.C.Ds**, by Julyan Ilett – An utterly practical guide to interfacing and programming intelligent liquid crystal display modules. **PhyzzyB COMPUTERS BONUS ARTICLE** 1 – Signed and Unsigned Binary Numbers. By Clive "Max" Maxfield and Alvin Brown. **PhyzzyB COMPUTERS BONUS ARTICLE 2** – Creating an Event Counter. By Clive "Max" Maxfield and Alvin Brown. **INTERGRAPH COMPUTER SYSTEMS 3D GRAPHICS** – A chapter from Intergraph's book that explains computer graphics technology. **FROM RUSSIA WITH LOVE**, by Barry Fox – Russian rockets launching American Satellites. **PC ENGINES**, by Ernest Flint – The evolution of Intel's microprocessors. **THE END TO ALL DISEASE**, by Aubrey Scoon – The original work of Rife. **COLLECTING AND RESTORING VINTAGE RADIOS**, by Paul Stenning. **THE LIFE & WORKS OF KONRAD ZUSE** – a brilliant pioneer in the evolution of computers. A bonus article on his life and work written by his eldest son, including many previously unpublished photographs.

Note: Some of the **EXTRA ARTICLES** require WinZip to unzip them.

Order on-line from
www.epemag.wimborne.co.uk/shopdoor.htm
or www.epemag.com (USA $ prices)
or by phone, Fax, E-mail or Post

BACK ISSUES MINI CD-ROM ORDER FORM

Please send me .... (quantity) BACK ISSUES CD-ROM **VOL 1**
Please send me .... (quantity) BACK ISSUES CD-ROM **VOL 2**
Please send me .... (quantity) BACK ISSUES CD-ROM **VOL 3**
Please send me .... (quantity) BACK ISSUES CD-ROM **VOL 4**
Please send me .... (quantity) BACK ISSUES CD-ROM **VOL 5**
Please send me .... (quantity) BACK ISSUES CD-ROM **VOL 6**
Please send me .... (quantity) BACK ISSUES CD-ROM **VOL 7**
Please send me .... (quantity) BACK ISSUES CD-ROM **VOL 8**
Please send me .... (quantity) BACK ISSUES CD-ROM **VOL 9**
Please send me .... (quantity) BACK ISSUES CD-ROM **VOL 10**
Price £14.45 each – includes postage to anywhere in the world.

Name ....

Address ....

.... Post Code ....

☐ I enclose cheque/P.O./bank draft to the value of £ ....

☐ Please charge my Visa/Mastercard/Amex/Diners Club/Switch

£ ....

Card No. ....

Card Security Code .... (The last 3 digits on or just under the signature strip)

Valid From .... Expiry Date ....

Switch Issue No. ....

SEND TO: **Everyday Practical Electronics,**
Wimborne Publishing Ltd.,
408 Wimborne Road East, Ferndown, Dorset BH22 9ND.
Tel: 01202 873872. Fax: 01202 874562.
E-mail: orders@epemag.wimborne.co.uk

Payments must be by card or in £ Sterling – cheque or bank draft drawn on a UK bank.

Normally supplied within seven days of receipt of order.
Send a copy of this form, or order by letter if you do not wish to cut your issue.

PIC N' MIX ANDREW JARVIS

Our periodic column for your PIC programming enlightenment

More PIC Devices for TK3 : 12F629/75

It is difficult to say why exactly, but there's something about the 8-pin PICs that makes them a whole lot of fun. Of the many possible reasons, I personally think it boils down to small being beautiful. There's a certain brilliance in making something as small and as elegant as you possibly can, electronic circuits are no exception.

There are a couple of issues to sort out up front. The first is to clarify exactly which flavour of chip we mean, for they are many and varied. The second is that they kind of don't work yet with John Becker's *EPE Toolkit TK3* software.

Mid Range Only (For Now)

PICs are grouped by the size of their instruction word into Base-Line (12-bit) and Mid-Range (14-bit) devices. *TK3* is currently optimised for 14-bit instruction word devices (like the familiar 16F chips) – and changing this would impact the entire assembly process, in addition to the programming algorithms considered here. Not for the faint hearted, better to keep changes limited to new and decoupled modules that effectively "bolt on" to John's existing code.

(That said, John has exciting things in the pipeline for *TK3* that could make such changes a whole lot easier – opening the door to programming base line flash PICs like the recently announced 10F devices and presenting the opportunity for even smaller, more beautiful circuits – watch this space, as they say.)

Classic or Enhanced

So the first of the 8-pin devices to be eliminated from consideration are the 12-bit instruction word devices, which include the popular 12C508/9(A) devices and their flash relatives, 12F508/509.

Next go the OTP devices (too many to list) for the simple reason that developing with them is hard work for the hobbyist. If you make as many mistakes as I do you'll need at least one windowed version of each chip you want to use and an EEPROM eraser too. Save all that until you are ready for production!

Sticking with the remaining flash types leaves the 12F629, 12F675, 12F635 and 12F683. Microchip labels the first two as "classic" low pin count devices, and the latter "enhanced" (41223A.pdf - Low Pin Count PIC Flash Microcontrollers brochure). Let's first look at the classics, then see another time how the enhanced make a difference.

A great deal of experimentation (and coffee!) has revealed that there seem to be two different ways to program the 12F629/75. The right way, or the easy way.

The Right Way

Document 41191C.pdf (PIC12F629/75 Memory Programming Specification) clearly shows that the sequence to enter program mode is to hold the clock and data pins low while raising MCLR to high voltage before applying V_{DD}. Fig.1 shows a datasheet extract that illustrates this so called "V_{PP} first" program mode entry, where T_{PPDP} and T_{HLD0} are a minimum of $5\mu s$.

It appears that the requirement to programmatically switch V_{DD} is essential, but *TK3* was not designed to do this. Instead V_{DD} is supplied constantly with no capability to switch it so that it can be turned off prior to raising V_{PP} then back on after T_{PPDP}.

Thinking that this would have to change, an experiment was conducted with the circuit shown in Fig.2.

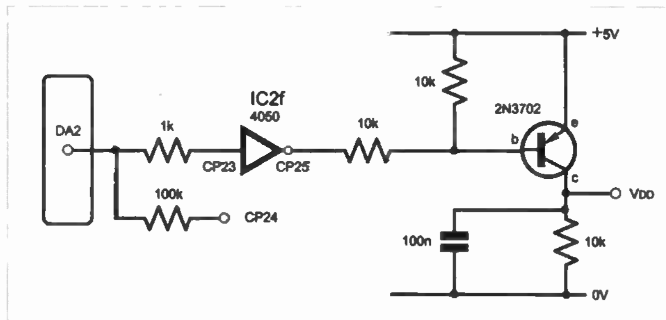


Fig.2. Switching V_{dd} from TK3

This is pretty much as David Tait suggests in his simple PIC16C84 programmer (details easily recovered with a Google search) but with use made of the spare *TK3* hex buffer IC2f, and additional ballast and pull-down resistors. Printer port line DA2 was chosen, as it is currently unused and a connection made to it using an insulated wire link on the underside of the board.

The idea was to program the PIC using the existing 6-pin programming connector which already delivers MCLR, CLK, DATA and 0V in addition to the +5V needed. V_{DD} becomes switchable from software using bit 2 of the output register and in such a way that when the port is cleared (as it is when *TK3* is initialised) the value of V_{DD} will be the expected +5V. However, when set using an instruction like **out port1,4**, V_{DD} drops to zero.

Although it was found that switching V_{DD} like this works ok, it does violate the principal of least software change advocated earlier, because each time program mode is needed for the 12F chips, the new, different, entry sequence is required. And that essentially means every time you do anything in *TK3*.

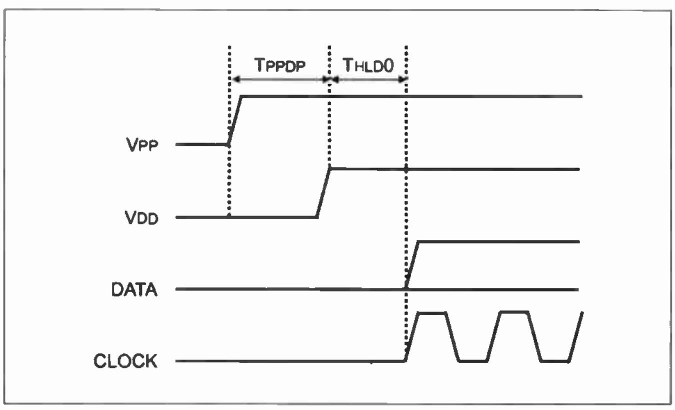


Fig.1. Entering high voltage program mode (from PIC12F629/675 programming specification).

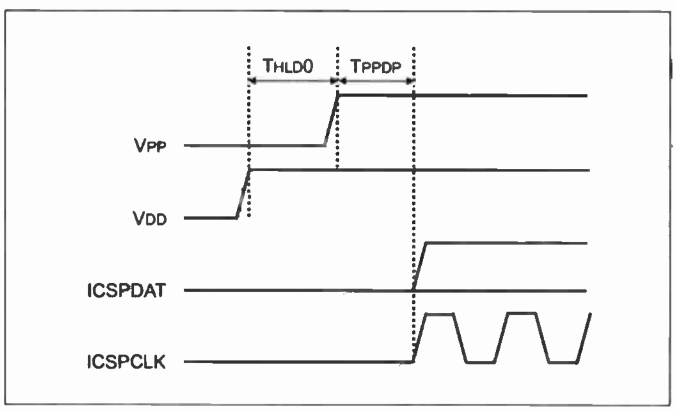


Fig.3. V_{DD} first program mode entry (from PIC12F635/683 programming specification).

Luckily, the changes never had to be made and the experimental circuit quickly dropped, because an easier way materialised.

The Easy Way

Consulting the programming spec. for the PIC16F628 one day (for an entirely different reason), it was noticed that this PIC also has an internal OSC (significance revealed shortly), a requirement for V_{PP} first program mode entry, and on further investigation a timing diagram very similar to Fig.1 was found.

Yet *TK3* programs these without any problem or modifications – I know I've used them myself and they've also appeared in published projects like John's *Wind Speed Meter* (Jan '03) and *PIC LCF Meter* (Feb '04).

So why do they work? and more to the point – will the 12F work without the need for changes?

Sure enough, even after abandoning the circuit of Fig 2, a 12F675 was successfully programmed (if only this had been tried first!). Clues as to why appear in yet another programming specification, 41204c.pdf (12F635/83) and although it doesn't purport to cover the 12F629/75, it is rather more detailed – and strangely relevant.

In addition to the "V_{PP} first" entry method, this spec goes on to suggest an alternative, "V_{DD} first" – which, as the name suggests, is to first apply V_{DD}, then hold clock and data low before raising MCLR to high voltage. This is effectively how *TK3* works and therefore implies that the 12F635/83 specification is also applicable to the 12F629/75. Fig.3 shows this method.

Microchip suggest that "V_{PP} first" (the right way) is safe for any configuration word selection and indeed must be used if internal oscillator and MCLR options are selected. This is because in raising the MCLR pin to V_{PP} before applying V_{DD}, the device is prevented from executing application code prior to entering program mode, which is apparently a bit of a problem.

V_{DD} first (the way that TK3 operates), can evidently be used for any configuration word selection except when internal oscillator and MCLR options are selected. (Internal oscillator configurations do not require any start-up time, which means the program counter could be incremented before program mode entry voltage is achieved on MCLR, resulting in some arbitrary offset being added as the code is loaded. In crystal modes the oscillator start-up timer includes a delay before code is executed.)

Problem Prevention

The simple way to avoid any of these problems is to keep the default setting for MCLRE (= 1) in the configuration word (i.e. don't make the MCLR pin digital I/O). This precaution is also suggested as the likely reason why the 16F628 has been working without problems (although with that chip the I/O pins are not likely to be in as much demand).

At the risk of confusing matters somewhat, in the last few months of experimentation and testing with a 12F675, many different configuration word settings have been tried with *TK3*. No problems have been encountered so far and the little chip continues to tick along in its small, beautiful way.

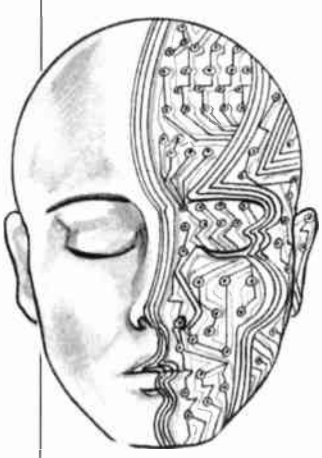
Socket Revival

If you want to use the 8-pin socket on the *TK3* p.c.b., you'll need to make a couple more alterations. IC8 pins 6 (clock) and 7 (data) are incorrectly reversed. Luckily, if you have the *EPE* board there are two convenient wire links (between the socket and the GP0-2 connection points) that make the correction job an easy one.

Magenta board users are not so lucky. The same error exists here but correcting it involves track breaks and wire links beneath the p.c.b. – much easier in this case to program the chip in-circuit or on an external breadboard. In fact doing this could be the preferred option anyway, since these low pin count PICs have their own precision internal 4MHz oscillators you'll probably want to use and free up a couple more I/O pins at the same time, which you can't do otherwise.

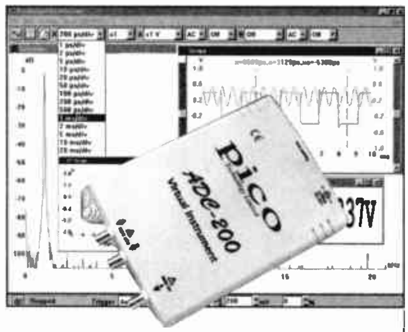
Differences

Next time, some of the differences you'll encounter when using the chips and a few more programming issues, in particular with setting the configuration word and calibrating the internal oscillator. If you want to get going in the meantime you'll need *TK3* version 2.24 or later, available to download from the usual place (access via the Downloads click-link on the main page at **www.epemag.co.uk**)



INGENUITY UNLIMITED

Our regular round-up of readers' own circuits. We pay between £10 and £50 for all material published, depending on length and technical merit. We're looking for novel applications and circuit designs, not simply mechanical, electrical or software ideas. Ideas *must be the reader's own work* and **must not have been published or submitted for publication elsewhere.** The circuits shown have NOT been proven by us. *Ingenuity Unlimited* is open to ALL abilities, but items for consideration in this column should be typed or word-processed, with a brief circuit description (between 100 and 500 words maximum) and full circuit diagram showing all component values. **Please draw all circuit schematics as clearly as possible.**
Send your circuit ideas to: *Ingenuity Unlimited,* Wimborne Publishing Ltd., 408 Wimborne Road East, Ferndown Dorset BH22 9ND. (We **do not** accept submissions for *IU* via E-mail.) Your ideas could earn you some cash **and a prize!**



WIN A PICO PC BASED OSCILLOSCOPE WORTH £586

- 100MS/s Dual Channel Storage Oscilloscope
- 50MHz Spectrum Analyser
- Multimeter • Frequency Meter
- Signal Generator

If you have a novel circuit idea which would be of use to other readers then a Pico Technology PC based oscilloscope could be yours.
Every 12 months, Pico Technology will be awarding an ADC200-100 digital storage oscilloscope for the best IU submission. In addition, a DrDAQ Data Logger/Scope worth £69 will be presented to the runner up.

Simple MW Radio – Easy Listening

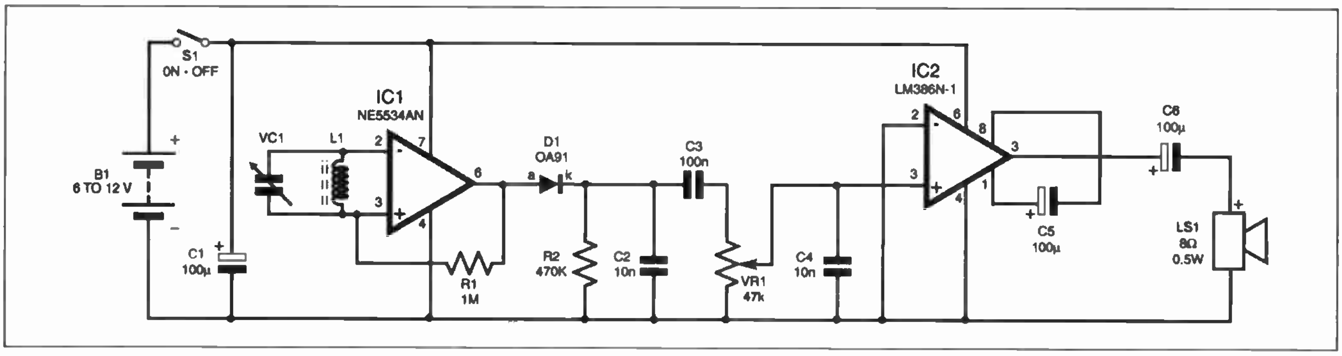


Fig.1. Complete circuit diagram for the Simple M.W. Radio

THE circuit in Fig.1 represents a cheap and simple MW Radio. It has modest selectivity, yet good power (0·5W r.m.s. into 8W), and does not require an external aerial or earth.

The heart of the circuit is around IC1. When a station is tuned in, variable capacitor VC1 and inductor L1 resonate at the tuned frequency. That is, they present a minuscule alternating voltage to the inputs of IC1, which is a low-noise, high-frequency preamplifier. IC1 is essentially wired as a comparator with a little positive feedback, so that the alternating voltage across the tuned circuit is greatly amplified at output pin 6.

A germanium diode, D1, is employed for demodulation (a silicon diode would also work here), with R1 and C2 forming the remainder of the detector circuit, which produces audio by controlling the charge and discharge paths of capacitor C2, which also doubles as a low-pass filter.

An a.c. coupling capacitor, C3, is used to couple the radio circuit to the 0·5W amplifier, IC2, and volume is controlled by potentiometer VR1. Capacitor C4 serves as a low-pass filter, to filter out radio frequencies which might slip through the detector circuit and overload IC2.

Since the output of IC1 is not very high, the gain of IC2 is increased by wiring a 10μF capacitor, C5, between pins 1 and 8. The usual Zobel network at the amplifier's output is omitted for the sake of simplicity. The small measure of protection which a Zobel network would afford IC2's internal transistors ought not to be missed here.

The most commonly available a.m. tuners typically have two separate sections or gangs, and a tuned circuit for the medium waves could use such a tuner with its two separate sections wired in parallel. Either a ready-made medium wave coil may be used for L1, or this may be wound with about 80 turns of approximately 30s.w.g. (0.315mm) enamelled copper wire, close-wound on a 10mm diameter ferrite rod.

Be sure to use screened microphone cable for connections, and do not use crocodile clips during testing, or the radio may not function properly – or in the worst case, not at all. Also be aware that the placement of the battery, speaker, and tuned circuit may cause radio frequency (r.f.) interference which could interfere with the proper functioning of the circuit.

The MW Radio's quiescent current consumption lies below 10mA, rising to more than 20mA at full volume, which would represent a few days' continuous and loud listening off an AA battery pack.

Thomas Scarborough,
Cape Town, South Africa

PC Keyboard Tester – Logic Training

IT'S John Becker to thank (blame?!) for unknowingly inspiring this idea.

His *PIC To PS/2 Mouse and Keyboard Interfacing* (Aug '04) specifies the interface to a standard keyboard, with the objective of reading the keys in PIC projects. But, I also saw how standard logic chips could display the keyboard output, enabling testing outside of any PIC project.

Each key press (and nearly all key releases) sends a train of serial data, each bit settled and available to read at the down-going clock edge. This circuit (Fig.2) takes the final character (8-bit byte) and presents it on two 7-segment l.e.d. displays as two hexadecimal nibbles. Thus, the activated key is identifiable. For example, referring to John's article, pressing (or releasing) key "B" creates a hex display of "32".

Data trains are variable length and begin with a start bit that's redundant in this circuit. It captures the very last data byte and the parity bit that follows. The stop bit is available if required.

To understand the principle of this circuit, imagine a railway train arriving at a platform. Each train varies in length but is always too long for the platform. It always stops with the guard's van just upstream of the platform and the rearmost nine passenger carriages exactly occupying the platform. All other rolling stock disappears off the downstream end of the platform and is inaccessible, regardless of how many carriages/locos there are.

When the data train arrives at the platform, made of serial-input shift registers, IC2 and IC3 in Fig.2, the guard's van stop-bit halts at the upstream end, IC2 output QA, pin 3. Walking downstream along the platform, the rearmost passenger/parity carriage halts at IC2 QB, the most significant bit of the left digit is at IC2 QC, and so-on down to IC2 QH, which carries bit C of the right digit.

But, the platform is longer than this. As each carriage/bit rolls one place down the platform, IC2 QH links to IC3 data input A pin 1 and so the train carries on down IC3 as well. Character bit 0, least significant of the right nibble, ends up at IC3 QB when the train stops. Actually, some of the many carriages further forward do appear on IC3's other outputs but are ignored.

Keyboard data bits, the arriving carriages, go onto the platform by entering IC2 data input A, pin 1. The "moving one place on" of each carriage (as the train shifts along the platform) is co-ordinated by the clock pulses received on inverter IC1a, pin 1; the shift registers move their bits on the up-going clock stroke, which is why the active down-going pulse from the keyboard needs inverting.

Once all the data from the present keystroke has been sent by the keyboard, there are no more clock pulses and the train comes to a halt. IC4 and IC5 are decoders that look at each carriage in order, via their A to D inputs. Depending on the carriage "occupancy" (binary 1 or 0) of the four carriages that stop level with each decoder, the hex value is immediately available to the common-anode l.e.d. displays, X1 and X2, with resistor networks RM1 and RM2 limiting the current.

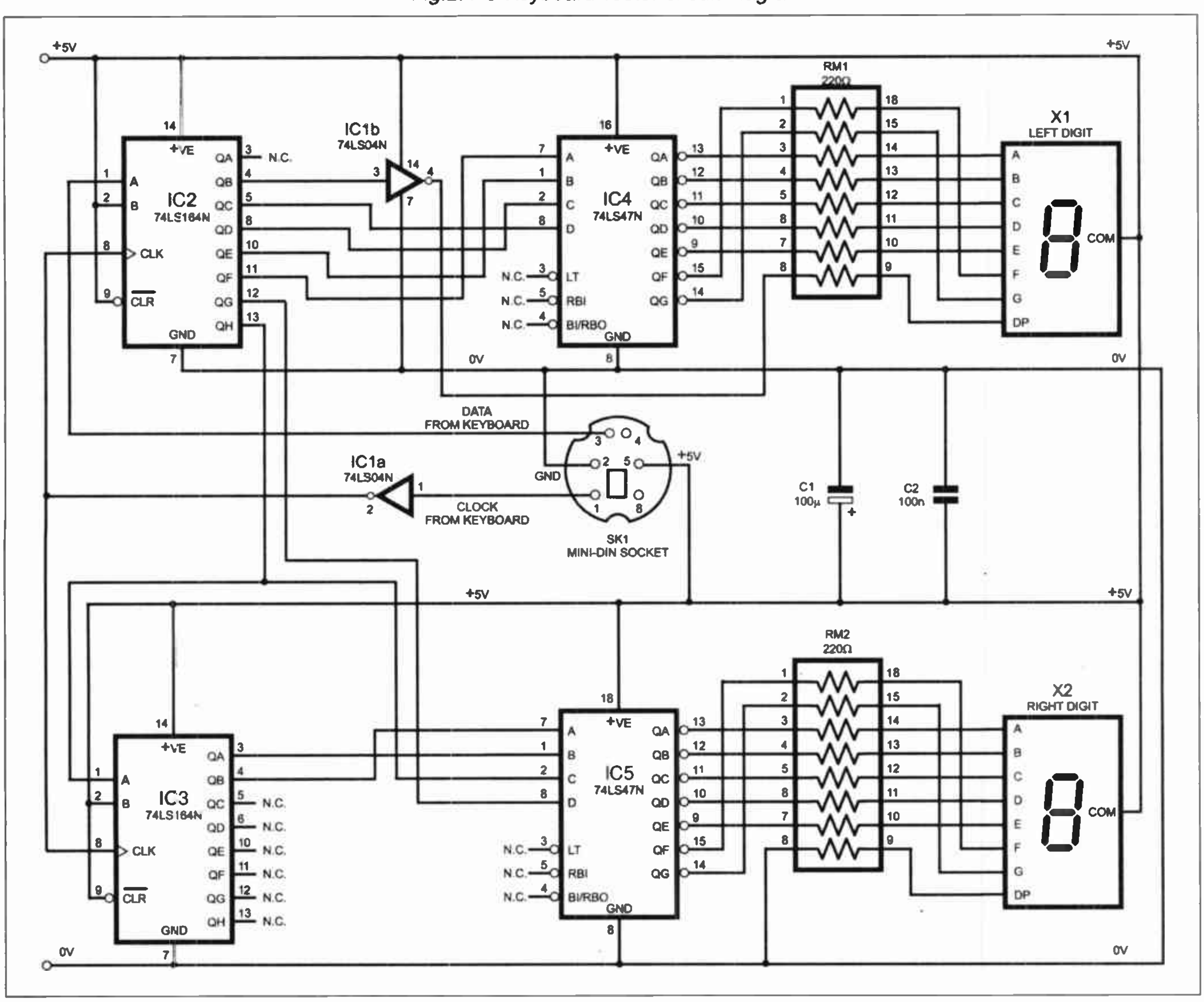
Decoder outputs are active-low and pull the l.e.d. cathodes (k) *down* to light them *up* (sounds like an aircraft checklist!). Parity arrives active-high and needs inverting by IC1b to make the leftmost decimal point light up. Including parity, there will always be an odd number of occupied carriages (bits set high).

The right-most decimal point is wired permanently on as a pilot light, to show that the circuit is powered and to act as a red signal so that the "engineer" driving the data train knows to stop at the station!

This simple decoder does not allow the display to show the full hex-digit range beyond digit 9 and letters A to F are represented by "[]Uct ", respectively.

Godfrey Manning G4GLM,

Fig.2. PC Keyboard Tester circuit diagram.



EPE IS PLEASED TO BE ABLE TO OFFER YOU THESE

ELECTRONICS CD-ROMS

ELECTRONICS PROJECTS

Logic Probe testing

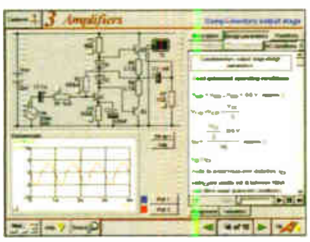
Electronic Projects is split into two main sections: **Building Electronic Projects** contains comprehensive information about the components, tools and techniques used in developing projects from initial concept through to final circuit board production. Extensive use is made of video presentations showing soldering and construction techniques. The second section contains a set of ten projects for students to build, ranging from simple sensor circuits through to power amplifiers. A shareware version of Matrix's CADPACK **schematic capture, circuit simulation** and **p.c.b. design** software is included.
The projects on the CD-ROM are: Logic Probe; Light, Heat and Moisture Sensor; NE555 Timer; Egg Timer; Dice Machine; Bike Alarm; Stereo Mixer; Power Amplifier; Sound Activated Switch; Reaction Tester. Full parts lists, schematics and p.c.b. layouts are included on the CD-ROM.

ELECTRONIC CIRCUITS & COMPONENTS V2.0

Circuit simulation screen

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. Version 2 has been considerably expanded in almost every area following a review of major syllabuses (GCSE, GNVQ, A level and HNC). It also contains both European and American circuit symbols. Sections 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* will help students to recognise common electronic components and their corresponding symbols in circuit diagrams.
Included in the Institutional Versions are multiple choice questions, exam style questions, fault finding virtual laboratories and investigations/worksheets.

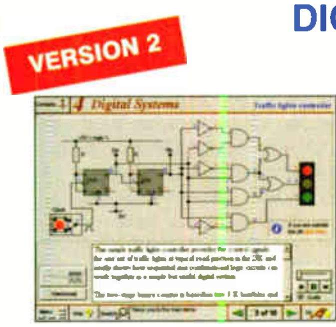
ANALOGUE ELECTRONICS



Complimentary output stage

Analogue Electronics is a complete learning resource for this most difficult branch of electronics. The CD-ROM includes a host of virtual laboratories, animations, diagrams, photographs and text as well as a SPICE electronic circuit simulator with over 50 pre-designed circuits.
Sections on the CD-ROM include: **Fundamentals** – Analogue Signals (5 sections), Transistors (4 sections), Waveshaping Circuits (6 sections). **Op.Amps** – 17 sections covering everything from Symbols and Signal Connections to Differentiators. **Amplifiers** – Single Stage Amplifiers (8 sections), Multi-stage Amplifiers (3 sections). **Filters** – Passive Filters (10 sections), Phase Shifting Networks (4 sections), Active Filters (6 sections). **Oscillators** – 6 sections from Positive Feedback to Crystal Oscillators. **Systems** – 12 sections from Audio Pre-Amplifiers to 8-Bit ADC plus a gallery showing representative p.c.b. photos.

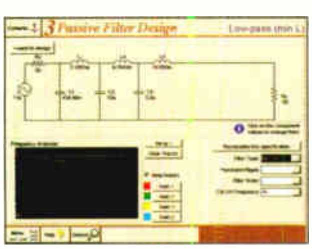
DIGITAL ELECTRONICS V2.0



Virtual laboratory – Traffic Lights

Digital Electronics builds on the knowledge of logic gates covered in *Electronic Circuits & Components* (opposite), 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.
Covers binary and hexadecimal numbering systems, ASCII, basic logic gates, monostable action and circuits, and bistables – including JK and D-type flip-flops. Multiple gate circuits, equivalent logic functions and specialised logic functions. Introduces sequential logic including clocks and clock circuitry, counters, binary coded decimal and shift registers. A/D and D/A converters, traffic light controllers, memories and microprocessors – architecture, bus systems and their arithmetic logic units. Sections on Boolean Logic and Venn diagrams, displays and chip types have been expanded in Version 2 and new sections include shift registers, digital fault finding, programmable logic controllers, and microcontrollers and microprocessors. The Institutional versions now also include several types of assessment for supervisors, including worksheets, multiple choice tests, fault finding exercises and examination questions.

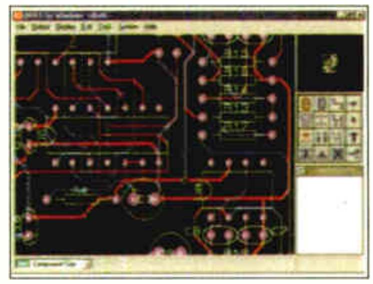
FILTERS



Filter synthesis

Filters is a complete course in designing active and passive filters that makes use of highly interactive virtual laboratories and simulations to explain how filters are designed. It is split into five chapters: **Revision** which provides underpinning knowledge required for those who need to design filters. **Filter Basics** which is a course in terminology and filter characterization, important classes of filter, filter order, filter impedance and impedance matching, and effects of different filter types. **Advanced Theory** which covers the use of filter tables, mathematics behind filter design, and an explanation of the design of active filters. **Passive Filter Design** which includes an expert system and filter synthesis tool for the design of low-pass, high-pass, band-pass, and band-stop Bessel, Butterworth and Chebyshev ladder filters. **Active Filter Design** which includes an expert system and filter synthesis tool for the design of low-pass, high-pass, band-pass, and band-stop Bessel, Butterworth and Chebyshev op.amp filters.

ELECTRONICS CAD PACK



PCB Layout

Electronics CADPACK allows users to design complex circuit schematics, to view circuit animations using a unique SPICE-based simulation tool, and to design printed circuit boards. CADPACK is made up of three separate software modules. (These are restricted versions of the full Labcenter software.) **ISIS Lite** which provides full schematic drawing features including full control of drawing appearance, automatic wire routing, and over 6,000 parts. **PROSPICE Lite** (integrated into ISIS Lite) which uses unique animation to show the operation of any circuit with mouse-operated switches, pots. etc. The animation is compiled using a full mixed mode SPICE simulator. **ARES Lite** PCB layout software allows professional quality PCBs to be designed and includes advanced features such as 16-layer boards, SMT components, and an autorouter operating on user generated Net Lists.

ROBOTICS & MECHATRONICS

Case study of the Milford Instruments Spider

Robotics and Mechatronics is designed to enable hobbyists/students with little previous experience of electronics to design and build electromechanical systems. The CD-ROM deals with all aspects of robotics from the control systems used, the transducers available, motors/actuators and the circuits to drive them. Case study material (including the NASA Mars Rover, the Milford Spider and the Furby) is used to show how practical robotic systems are designed. The result is a highly stimulating resource that will make learning, and building robotics and mechatronic systems easier. The Institutional versions have additional worksheets and multiple choice questions.

- Interactive Virtual Laboratories
- Little previous knowledge required
- Mathematics is kept to a minimum and all calculations are explained
- Clear circuit simulations

PRICES

Prices for each of the CD-ROMs above are:

(Order form on third page)

Hobbyist/Student ....£45 inc VAT
Institutional (Schools/HE/FE/Industry)..............£99 *plus* VAT
Institutional 10 user (Network Licence)..........£199 *plus* VAT
Site Licence...£499 *plus* VAT

(UK and EU customers add VAT at 17.5% to "plus VAT" prices)

PICmicro TUTORIALS AND PROGRAMMING

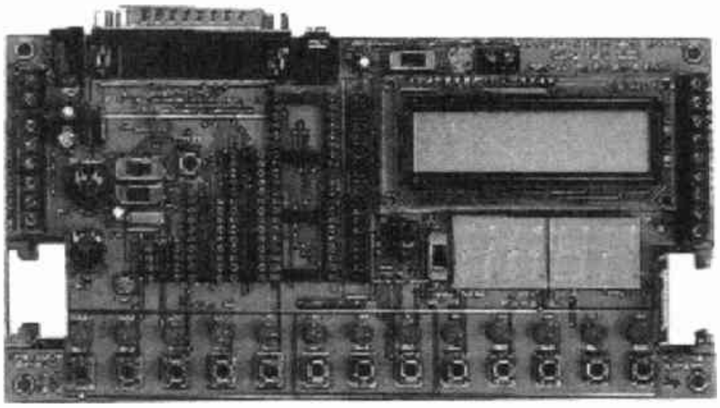
HARDWARE

VERSION 2 PICmicro MCU DEVELOPMENT BOARD

Suitable for use with the three software packages listed below.

This flexible development board allows students to learn both how to program PICmicro microcontrollers as well as program a range of 8, 18, 28 and 40-pin devices. For experienced programmers all programming software is included in the PPP utility that comes with the development board. For those who want to learn, choose one or all of the packages below to use with the Development Board.

- Makes it easier to develop PICmicro projects
- Supports low cost Flash-programmable PICmicro devices
- Fully featured integrated displays – 13 individual l.e.d.s, quad 7-segment display and alphanumeric l.c.d. display
- Supports PICmicro microcontrollers with A/D converters
- Fully protected expansion bus for project work
- All inputs and outputs available on screw terminal connectors for easy connection



£145 including VAT and postage

12V 500mA plug-top PSU (UK plug) £7

25-way 'D' type connecting cable £5

SOFTWARE

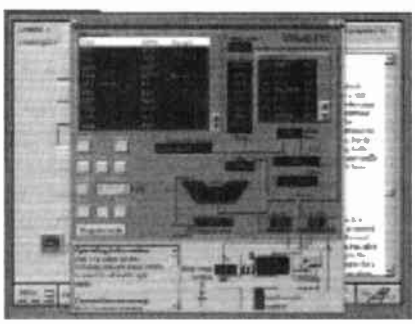
Suitable for use with the Development Board shown above.

ASSEMBLY FOR PICmicro V2

(Formerly PICtutor)

Assembly for PICmicro microcontrollers V2.0 (previously known as PICtutor) by John Becker contains a complete course in programming the PIC16F84 PICmicro microcontroller from Arizona Microchip. It starts with fundamental concepts and extends up to complex programs including watchdog timers, interrupts and sleep modes. The CD makes use of the latest simulation techniques which provide a superb tool for learning: the Virtual PICmicro microcontroller. This is a simulation tool that allows users to write and execute MPASM assembler code for the PIC16F84 microcontroller on-screen. Using this you can actually see what happens inside the PICmicro MCU as each instruction is executed which enhances understanding.

● Comprehensive instruction through 39 tutorial sections ● Includes Vlab, a Virtual PICmicro microcontroller: a fully functioning simulator ● Tests, exercises and projects covering a wide range of PICmicro MCU applications ● Includes MPLAB assembler ● Visual representation of a PICmicro showing architecture and functions ● Expert system for code entry helps first time users ● Shows data flow and fetch execute cycle and has challenges (washing machine, lift, crossroads etc.) ● Imports MPASM files.



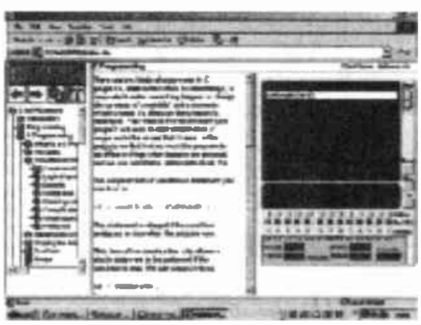
Virtual PICmicro

'C' FOR PICmicro VERSION 2

The C for PICmicro microcontrollers CD-ROM is designed for students and professionals who need to learn how to program embedded microcontrollers in C. The CD contains a course as well as all the software tools needed to create Hex code for a wide range of PICmicro devices – including a full C compiler for a wide range of PICmicro devices.

Although the course focuses on the use of the PICmicro microcontrollers, this CD-ROM will provide a good grounding in C programming for any microcontroller.

● Complete course in C as well as C programming for PICmicro microcontrollers ● Highly interactive course ● Virtual C PICmicro improves understanding ● Includes a C compiler for a wide range of PICmicro devices ● Includes full Integrated Development Environment ● Includes MPLAB software ● Compatible with most PICmicro programmers ● Includes a compiler for all the PICmicro devices.



Minimum system requirements for these items: Pentium PC running Windows 98, NT, 2000, ME, XP; CD-ROM drive; 64MB RAM; 10MB hard disk space.

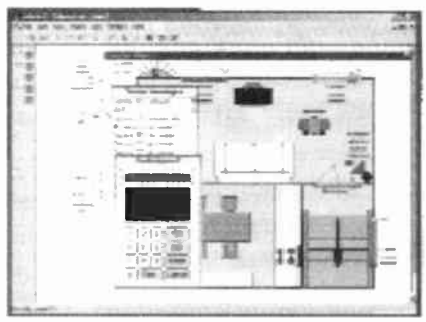
FLOWCODE FOR PICmicro V2

Flowcode is a very high level language programming system for PICmicro microcontrollers based on flowcharts. Flowcode allows you to design and simulate complex robotics and control systems in a matter of minutes.

Flowcode is a powerful language that uses macros to facilitate the control of complex devices like 7-segment displays, motor controllers and l.c.d. displays. The use of macros allows you to control these electronic devices without getting bogged down in understanding the programming involved.

Flowcode produces MPASM code which is compatible with virtually all PICmicro programmers. When used in conjunction with the Version 2 development board this provides a seamless solution that allows you to program chips in minutes.

● Requires no programming experience ● Allows complex PICmicro applications to be designed quickly ● Uses international standard flow chart symbols (ISO5807) ● Full on-screen simulation allows debugging and speeds up the development process ● Facilitates learning via a full suite of demonstration tutorials ● Produces ASM code for a range of 18, 28 and 40-pin devices ● Professional versions include virtual systems (burglar alarm, buggy and maze, plus RS232, IrDa etc.).



Burglar Alarm Simulation

PRICES

Prices for each of the CD-ROMs above are:

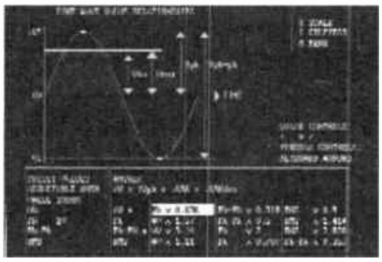
(Order form on next page)

Hobbyist/Student	£45 inc VAT
Flowcode V2 Hobbyist/Student	£57 inc VAT
Institutional (Schools/HE/FE/Industry)	£99 *plus* VAT
Flowcode Professional	£99 *plus* VAT
Institutional/Professional 10 user (Network Licence)	£249 *plus* VAT
Site Licence	£599 *plus* VAT

(UK and EU customers add VAT at 17.5% to "plus VAT" prices)

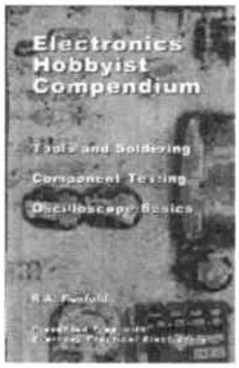
TEACH-IN 2000 – LEARN ELECTRONICS WITH EPE

EPE's own *Teach-In* CD-ROM, contains the full 12-part *Teach-In* series by John Becker in PDF form plus the *Teach-In* interactive software (Win 95, 98, ME and above) covering all aspects of the series. We have also added Alan Winstanley's highly acclaimed *Basic Soldering Guide* which is fully illustrated and which also includes *Desoldering*. The *Teach-In* series covers: Colour Codes and Resistors, Capacitors, Potentiometers, Sensor Resistors, Ohm's Law, Diodes and L.E.D.s, Waveforms, Frequency and Time, Logic Gates, Binary and Hex Logic, Op.amps, Comparators, Mixers, Audio and Sensor Amplifiers, Transistors, Transformers and Rectifiers Voltage Regulation, Integration, Differentiation, 7-segment Displays, L.C.D.s, Digital-to-Analogue. Each part has an associated practical section and the series includes a simple PC interface (Win 95, 98, ME ONLY) so you can use your PC as a basic oscilloscope with the various circuits.



Sine wave relationship values

FREE BOOK WITH TEACH-IN 2000 CD-ROM

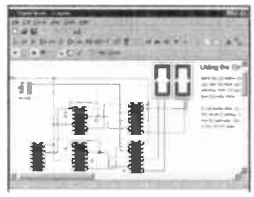


A hands-on approach to electronics with numerous breadboard circuits to try out.

£12.45 including VAT and postage. Requires Adobe Acrobat (available free from the Internet – **www.adobe.com/acrobat**).

FREE WITH EACH TEACH-IN CD-ROM – *Electronics Hobbyist Compendium* 80-page book by Robert Penfold. Covers Tools For The Job; Component Testing; Oscilloscope Basics.

DIGITAL WORKS 3.0



Counter project

Digital Works Version 3.0 is a graphical design tool that enables you to construct digital logic circuits and analyze their behaviour. It is so simple to use that it will take you less than 10 minutes to make your first digital design. It is so powerful that you will never outgrow its capability • Software for simulating digital logic circuits • Create your own macros – highly scalable • Create your own circuits, components, and i.c.s • Easy-to-use digital interface • Animation brings circuits to life • Vast library of logic macros and 74 series i.c.s with data sheets • Powerful tool for designing and learning.

Hobbyist/Student £45 inc. VAT.
Institutional £99 *plus* VAT.
Institutional 10 user £199 *plus* VAT.
Site Licence £499 *plus* VAT.

ELECTRONICS IN CONTROL

Two colourful animated courses for students on one CD-ROM. These cover Key Stage 3 and GCSE syllabuses. **Key Stage 3:** A pictorial look at the Electronics section featuring animations and video clips. Provides an ideal introduction or revision guide, including multi-choice questions with feedback. **GCSE:** Aimed at the Electronics in many Design & Technology courses, it covers many sections of GCSE Electronics. Provides an ideal revision guide with Homework Questions on each chapter. Worked answers with an access code are provided on a special website.

Single User £29 inc. VAT. Multiple User £39 plus VAT
Student copies (available only with a multiple user copy) £6 plus VAT
(UK and EU customers add VAT at 17.5% to "plus VAT" prices)

ELECTRONIC COMPONENTS PHOTOS

A high quality selection of over 200 JPG images of electronic components. This selection of high resolution photos can be used to enhance projects and presentations or to help with training and educational material. They are royalty free for use in commercial or personal printed projects, and can also be used royalty free in books, catalogues, magazine articles as well as worldwide web pages (subject to restrictions – see licence for full details).

Also contains a FREE 30-day evaluation of Paint Shop Pro 6 – Paint Shop Pro image editing tips and on-line help included!

Price £19.95 inc. VAT

MODULAR CIRCUIT DESIGN

VERSION 3

Contains 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. Version 3 includes data and circuit modules for a range of popular PICs; includes PICAXE circuits, the system which enables a PIC to be programmed without a programmer, and without removing it from the circuit. Shows where to obtain free software downloads to enable BASIC programming.

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.

Single User £19.95 inc. VAT. Multiple User £34 *plus* VAT
(UK and EU customers add VAT at 17.5% to "plus VAT" prices)

Minimum system requirements for these CD-ROMs: Pentium PC, CD-ROM drive, 32MB RAM, 10MB hard disk space. Windows 95/98/NT/2000/ME/XP, mouse, sound card, web browser.

CD-ROM ORDER FORM

Please send me:

- ☐ **Electronic Projects**
- ☐ **Electronic Circuits & Components V2.0**
- ☐ **Analogue Electronics**
- ☐ **Digital Electronics V2.0**
- ☐ **Filters**
- ☐ **Electronics CAD Pack**
- ☐ **Robotics & Mechatronics**
- ☐ **Assembly for PICmicro V2**
- ☐ **'C' for PICmicro V2**
- ☐ **Flowcode V2 for PICmicro**
- ☐ **Digital Works 3.0**

Version required:

- ☐ **Hobbyist/Student**
- ☐ **Institutional**
- ☐ **Institutional/Professional 10 user**
- ☐ **Site licence**

- ☐ **PICmicro Development Board V2 (hardware)**
- ☐ **Development Board UK plugtop power supply**
- ☐ **Development Board 25-way connecting lead**

- ☐ **Teach-In 2000 + FREE BOOK**
- ☐ **Electronic Components Photos**
- ☐ **Electronics In Control – Single User**
- ☐ **Electronics In Control – Multiple User**
- ☐ **Modular Circuit Design – Single User**
- ☐ **Modular Circuit Design – Multiple User**

Note: The software on each version is the same, only the licence for use varies.

Full name: ....

Address: ....

.............................Post code: ....Tel. No: ....

Signature: ....

☐ I enclose cheque/PO in £ sterling payable to WIMBORNE PUBLISHING LTD for £ ....

☐ Please charge my Visa/Mastercard/Amex/Diners Club/Switch: £ ....

Valid From: ....Card expiry date: ....

Card No: .... Switch Issue No. ....

Card Security Code .... (The last 3 digits on or just under the signature strip)

ORDERING

ALL PRICES INCLUDE UK POSTAGE

Student/Single User/Standard Version price includes postage to most countries in the world
EU residents outside the UK add £5 for airmail postage per order

Institutional, Multiple User and Deluxe Versions – overseas readers add £5 to the basic price of each order for airmail postage (**do not add VAT** unless you live in an EU (European Union) country, then add 17½% VAT or provide your official VAT registration number).

Send your order to:
Direct Book Service
Wimborne Publishing Ltd
408 Wimborne Road East
Ferndown, Dorset BH22 9ND

To order by phone ring
01202 873872. Fax: 01202 874562

Goods are normally sent within seven days

E-mail: orders@wimborne.co.uk

Online shop:
www.epemag.wimborne.co.uk/shopdoor.htm

Light Emitting Diodes – Operation and Applications

Anthony H. Smith, BSc. (Hons)

Part 4 - L.E.D. drivers, and unusual uses for l.e.d.s

LAST month, in the third part of this series, we looked at several l.e.d. flasher circuits, we examined "booster" circuits capable of driving l.e.d.s from very low voltages, and we discussed the characteristics of bicolour and tricolour l.e.d.s.

This month, we conclude the series by examining two rather unusual uses for an l.e.d. We begin, however, by looking at a handful of the many special-purpose integrated circuits that have been developed for l.e.d. applications.

Silicon Valley Sees the Light

During the 1970s and 1980s, as l.e.d.s became cheaper, widely available and more efficient, semiconductor manufacturers saw opportunities to exploit this new light source and soon began producing i.c.s specifically intended for driving or flashing l.e.d.s in a variety of different ways.

National Semiconductor's LM3914 and LM3915 bargraph drivers, for example, rapidly established themselves as popular i.c.s that made it easy to display an analogue input voltage as a moving dot or bar of light on a bargraph display consisting of ten or more l.e.d.s.

Another device, the LM3909 l.e.d. flasher i.c., was introduced as a single-chip solution for flashing an l.e.d. from a single cell voltage as low as 1V. Sadly, this device, like others, has long since disappeared and is no longer produced by National Semiconductor.

Even though some of the early l.e.d. driver chips may have fallen by the wayside, many others have appeared to fill their places, or to provide new functions and driver techniques that are simpler, cheaper, smaller or more efficient than earlier solutions. While researching this series, the author compiled a list of *over seventy* special-purpose l.e.d. driver chips, a list that is steadily growing as new devices are introduced on an almost monthly basis!

Here is just a small selection from that list:

- Allegro A6277 8-channel serial input constant current latched l.e.d. driver
- Fairchild FAN5611 low-dropout l.e.d. driver
- Infineon TLE4241G l.e.d. driver with adjustable current
- Micrel MIC5400 dual, 8-output, 14-bit l.e.d. video display driver
- Microsemi LX1990 dual programmable l.e.d. current sink
- Seiko S-8813 3-channel white l.e.d. driver
- Supertex CL1 constant current l.e.d. driver
- Zetex ZXSC300 single or multi-cell l.e.d. driver

The sheer number and variety of devices are perfect testimony to the fact that l.e.d.s have evolved into an invaluable and highly versatile light source that presents huge opportunities for semiconductor manufacturers. To illustrate just a handful of the wide array of devices now available, we will examine four typical i.c.s, each of which provides a slightly different way of driving one or more l.e.d.s.

Pump It Up

Last month, we showed how the *charge pump* technique can be used to "boost" a small voltage as low as 1V to a higher level sufficient to flash an l.e.d. By exploiting this technique, i.c. manufacturers have developed chips that use the charge pump method (sometimes called the "switched capacitor" technique) to drive a constant current through one or more l.e.d.s from a relatively low supply voltage.

A typical example is shown in Fig.1, where the Maxim MAX1910 provides all the charge pump circuitry needed to step up a voltage as low as 2·7V to a higher level capable of driving one or more white l.e.d.s. During the "charge" phase, internal switches connect "transfer" capacitors C1 and C2 in series across the input supply voltage, V_{IN}. Then, during the "transfer" phase, the switches change position so as to connect C1 and C2 in parallel between the IN and OUT terminals, thus transferring charge to output capacitor C_{OUT}.

This process repeats at a high frequency, typically 750kHz, and the output voltage, V_{OUT}, is regulated by controlling the rate at which the transfer capacitors are charged. The MAX1910 has an internal voltage threshold of 0·2V at the SET pin, which is used to regulate the forward current, I_{D1}, flowing through l.e.d. D1.

A closed-loop feedback mechanism constantly compares the voltage V_{SET} appearing across resistor R_{SET} with the internal 0·2V threshold, and alters the capacitor charging rate to maintain V_{OUT} at just the right level to hold V_{SET} at 0·2V. In this way, the device behaves as a charge pump current regulator, where the current through D1 is given by the simple relationship: $I_{D1} = 0{\cdot}2/R_{SET}$ (A)

Matched Intensity

Additional l.e.d.s can be connected in parallel with D1 as shown in Fig.1. Provided l.e.d.s D2 and D3 have the same

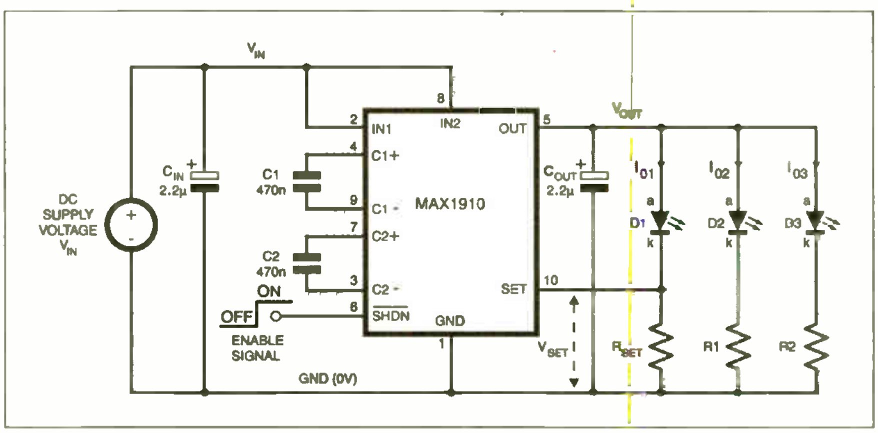


Fig.1. High-efficiency charge-pump l.e.d. driver.

forward voltage as D1, and as long as ballast resistors R1 and R2 are the same value as R_{SET}, the current flowing through each additional l.e.d. – and hence the light intensity – will be the same as that in the regulated l.e.d.

The number of l.e.d.s that can be accommodated is limited mainly by the MAX1910's 80mA maximum output current. For example, four white l.e.d.s each operating at 20mA could be supported.

Housed in the tiny 10-pin μMAX package, the MAX1910 is ideal for portable items that need to establish constant, balanced light intensity in a number of white l.e.d.s powered by a low voltage source (e.g. two alkaline cells, or one 3V Lithium battery). Typical applications are l.c.d. backlights and keypad illumination in cellular phones and PDAs.

The $\overline{SHDN}$ input at pin 6 provides a convenient, power-saving way of turning the l.e.d.s on and off by means of an active-high "enable" signal: when this signal is low, the MAX1910 shuts down and reduces its current consumption to less than 10μA.

Other charge pump l.e.d. driver i.c.s, such as Linear Technology's LTC3201 and National Semiconductor's LM2793, operate in a similar manner, but also allow control of the brightnes of the l.e.d., either by digital (LTC3201) or analogue (LM2793) means.

Energy Field

Whereas charge pump devices use capacitors to store and transfer energy, another class of voltage boosters, often referred to as switch-mode regulators or d.c.-to-d.c. converters, makes use of an inductor's magnetic field as an energy storage medium. By storing energy in an inductor on one part of a cycle and then releasing it on the next, it is possible to increase or decrease the magnitude, and/or invert the polarity, of a voltage source.

This technique is used to good effect in Linear Technology's LT1932, a constant current, d.c.-to-d.c. l.e.d. driver (see Fig.2). The device operates as a fixed frequency, step-up, d.c.-to-d.c. converter, designed to operate as a constant-current source, and is therefore ideal for driving l.e.d.s.

An internal 1·2MHz oscillator acts as a clock source that provides precise timing for each cycle of the part's operation. At the start of each cycle, an internal transistor turns on and switches the SW terminal (pin 1) to ground (GND). Current now ramps up in inductor L1, storing energy in its magnetic field. After a brief period, the switch turns off, causing the inductor to generate a *back-e.m.f.* which raises the potential at pin 1 to a level higher than the supply voltage, $+V_S$.

Schottky diode D1 now becomes forward biased, and current flows through l.e.d.s D1 to D_n as the energy stored in the inductor is released. By comparing the l.e.d. current that flows into the l.e.d. terminal at pin 3 with a reference current flowing from pin 4 through R_{SET}, the device adjusts the duty cycle of the switching waveform at pin 1 so as to maintain a constant current through the l.e.d.s.

Capacitor C2 acts as a smoothing capacitor that filters the a.c. components of the waveform at D1's cathode such that a steady d.c. voltage is available to drive the l.e.d.s. Since the value of this d.c. voltage is greater than the supply voltage, the circuit can drive several series-connected white or blue l.e.d.s, even though $+V_S$ may be as low as 1V.

Pulse Width Modulation

The relationship between the l.e.d. forward current, I_F, and the current set resistor, R_{SET}, is given by:

$$R_{SET} = 225 \times (0{\cdot}1V/I_F) \quad (\Omega)$$

An l.e.d. current of, say, 30mA would therefore require a 750Ω current set resistor. By applying an external pulse width modulated (PWM) signal to pin 4 via resistor R1, the l.e.d.s' brightness may be controlled simply by adjusting the duty cycle of the PWM signal. The principles of the PWM technique were discussed in Part Two, where we examined two circuits that used the PWM method to vary an l.e.d.'s intensity.

Like the MAX1910 discussed above, the LT1932 features a $\overline{SHDN}$ input that can be used to turn off the l.e.d.s and reduce current drain to less than 1μA. The circuit's supply voltage, $+V_S$, can range from 1V to 10V. With $+V_S$ = 1V, the LT1932 can support two series-connected white l.e.d.s; at $+V_S$ = 3V, the device can drive as many as eight white l.e.d.s.

Effectively, the LT1932 functions as a refined and enhanced version of the inductor-based voltage booster circuits reviewed in Part Three. Housed in a 6-lead SOT-23 package, and requiring only a tiny inductor, the device is a good choice for miniature, battery-powered products. The Zetex ZXLD1100, also housed in a tiny 6-pin package, is another example of an inductive boost converter that can drive up to eight white l.e.d.s from a 5V supply.

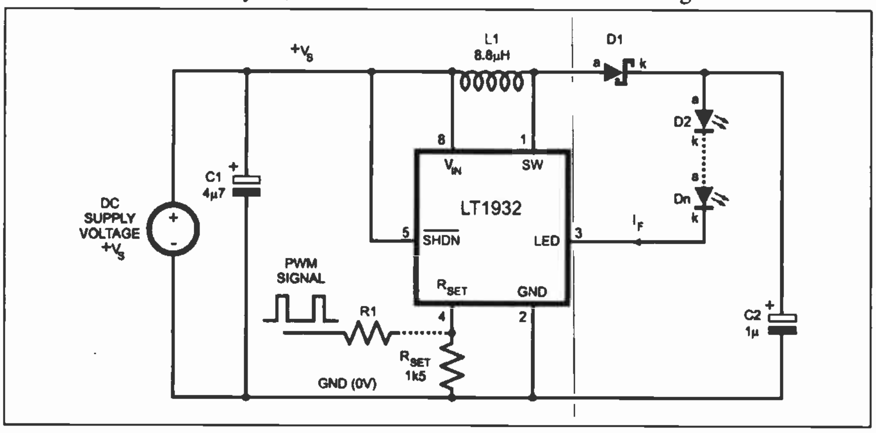


Fig.2. Switchmode voltage booster drives multiple l.e.d.s

Precision Control

We showed in Part One how a series-connected ballast resistor can be used to set the current level in an l.e.d. Although this simple approach is often adequate for most applications, it suffers from two significant drawbacks. First, the technique requires a well-regulated supply voltage, otherwise the l.e.d.'s forward current will vary, causing changes in light intensity. Second, the series resistor offers no way to adjust the l.e.d. current electronically. For applications requiring precise, variable control of the forward current, some other approach is needed.

Until recently, miniature cold cathode fluorescent light (CCFL) tubes and electroluminescent (EL) lights were a common choice when designing backlights for liquid crystal displays in mobile phones, alarm clocks, and similar products requiring display illumination. The advent of white l.e.d.'s, however, has seen a shift away from traditional backlighting techniques, and towards l.e.d.-based solutions that are efficient, relatively cheap and often easier to drive.

The key to the success of l.e.d. backlighting, though, is the ability to provide a uniform light source whose intensity can be adjusted to suit the prevailing ambient light conditions.

White In Triplicate

The circuit in Fig.3 illustrates an l.e.d. driver chip specifically intended for l.c.d. backlighting, keyboard illumination and similar applications. The MAX1916, a triple l.e.d. driver, provides a versatile alternative to resistor biasing techniques by replacing the ballast resistors with three constant-current sinks, each precisely matched to ensure uniform brightness in three similar l.e.d.s.

A control current, I_{SET}, is used to "program" the forward current flowing in each of the l.e.d.s. The individual l.e.d. currents, I_{LED}, track each other to within ±0.3%. The magnitude of I_{LED} is related to I_{SET} by the equation:

$$I_{LED} = 230 \times I_{SET} \quad (A)$$

The control current, I_{SET}, can be derived from a constant current source, or by means of a resistor R_{SET} and control voltage V_{CTRL}, in which case:

$$I_{LED} = 230 \times (V_{CTRL} - V_{SET})/R_{SET} \quad (A)$$

where V_{SET}, typically 1·215V, is the voltage at the SET terminal (pin 3). Rearranging the equation gives a suitable expression for R_{SET}:

$$R_{SET} = 230 \times (V_{CTRL} - 1{\cdot}215)/I_{LED} \quad (\Omega)$$

So, for example, a value of R_{SET} = 18k would allow a control voltage of 2V to 5V

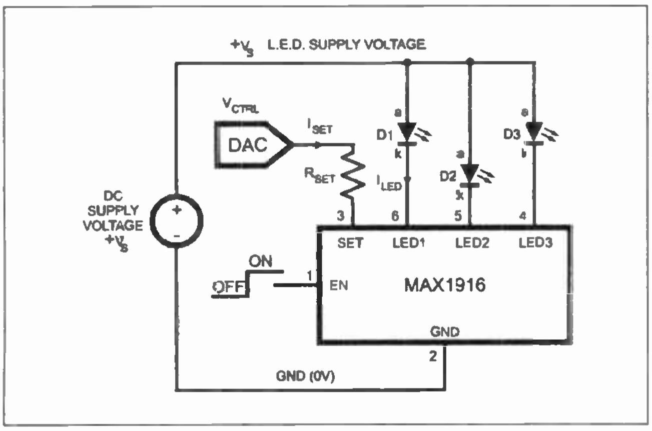


Fig.3. A single chip provides constant current bias for three white l.e.d.s.

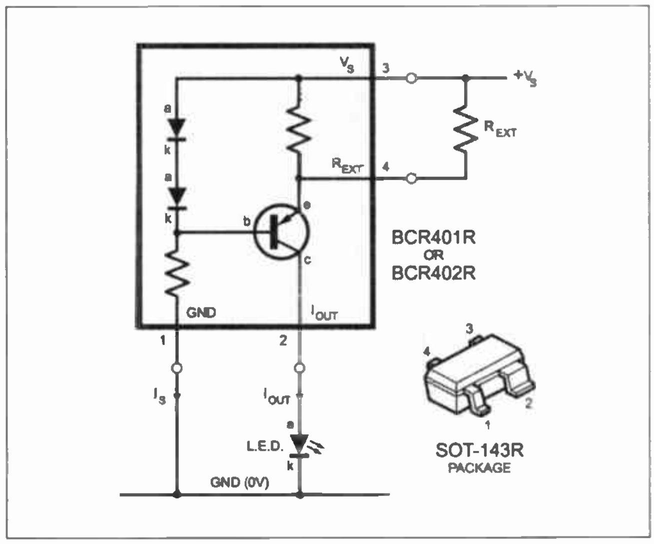


Fig.4. L.E.D. biasing using a single chip current source.

(perhaps derived from a digital-to-analogue converter, or DAC, as shown) to vary the l.e.d. current from around 10mA to 48mA.

You may be wondering by now where the MAX1916 derives its power from, since the device has no positive supply terminal! In fact, the chip gets its power from the "enable" signal applied to pin 1. When this signal is low (at GND potential), the l.e.d.s are off and the chip is disabled, consuming less than $1\mu A$. Taking pin 1 to a voltage in the range 2·5V to 5·5V, however, enables the chip and turns on the l.e.d.s; the i.c. now draws a miserly $40\mu A$ from the enable signal, making it well-suited to battery-powered applications.

Similar micropower l.e.d. drivers are available from other manufacturers. Fairchild Semiconductor's FAN5613 and National Semiconductor's LM3595, for instance, can each drive up to four l.e.d.s. Like the MAX1916, they require no ballast resistors, and the matched l.e.d. currents are set by means of a programmable reference current.

Current Source

Whereas the MAX1916, FAN5613 and LM3595 operate by sinking current through the l.e.d.s, another l.e.d. driver, the Infineon BCR401R, acts as a single-chip current source, specifically intended for biasing one or more series-connected l.e.d.s (see Fig.4). You will probably observe that this figure is similar to one shown in Part Two. Compare the BCR401R in Fig.4 with the current sink shown in Fig.2 of Part Two and the similarities will be apparent.

The BCR401R circuit is effectively an "inverted", or "complementary", version of the circuit in Part Two. By replacing the *npn* transistor with a *pnp* type, and by connecting the two voltage reference diodes to the positive supply rail, $+V_S$, the current sink is transformed into a current source.

Despite these differences, the two circuits operate in exactly the same way. The two diodes establish a stable reference voltage between $+V_S$ and the *pnp* transistor's base. This generates a fixed voltage, typically 0·75V, across the internal emitter resistor, resulting in a constant current, I_{OUT}, flowing through the transistor and out to the l.e.d.

Shunt Resistor

The typical value of I_{OUT} is 10mA. Infineon also produce the BCR402R, which is identical to the BCR401R but has greater output current, typically 20mA. For both parts, I_{OUT} can be increased by connecting an external resistor, R_{EXT}, between pins 3 and 4. This resistor shunts the internal emitter resistor and can be used to increase I_{OUT} to around 50mA.

Although Fig.4 shows only a single l.e.d., it is possible to drive two or more connected in series. The maximum number that can be accommodated depends on their forward voltage drops, and on the magnitude of $+V_S$. With a maximum supply voltage of 18V, and a typical voltage drop of 1·4V across the device (from pin 3 to pin 2), the BCR401R can support a total l.e.d. voltage of around 16·6V, equivalent to four or five white l.e.d.s, or as many as ten red l.e.d.s.

By replacing five components with a single, diminutive SOT-143R surface mount package, the BCR401R and BCR402R provide a space-saving alternative to the circuit reviewed in Part Two. Although these devices are not intended as precision current sources, their performance is, nonetheless, quite good. Temperature stability, for example, is typically −0·3%/°C, and the output current typically varies by just ±2%/V with changes in supply voltage.

Hidden Mystery

Many years ago, while servicing an oscilloscope, the author was intrigued to find several l.e.d.s mounted *inside* the unit on the main circuit board. Considering that they would be completely invisible to anyone using the instrument, it was not clear what purpose they served. Were they intended to indicate a fault condition, or to act as some kind of visual troubleshooting aid?

A closer look at the circuit diagram quickly resolved the mystery, where it became clear that the l.e.d.s were being used as *voltage references*! Specifically, each one acted as a reference in a current sink as shown in Fig.5. This circuit is essentially identical to the current sink illustrated in Fig.2 of Part Two, but instead of signal diodes it uses l.e.d. D1 to provide a stable reference voltage at the transistor's base.

The merits of using an l.e.d. to act as a voltage reference can be appreciated by referring again to the l.e.d. characteristics discussed in Part One, where Fig.2 showed how the forward voltage, V_F, across an l.e.d. varies with its forward current, I_F.

If we re-examine the characteristic of the 3mm red l.e.d., we see that V_F remains very stable at around 1·6V as I_F varies from 5mA to over 30mA. The forward voltage of the 5mm green l.e.d., on the other hand, varies from about 2·5V at I_F = 5mA, to around 3·6V at I_F = 30mA.

Clearly, the red l.e.d. would make a good voltage reference because for I_F > 5mA its forward voltage remains virtually constant with changes in current – an essential feature of any voltage reference.

Band Gap

Voltage reference i.c.s like the LM385 range that use the "band gap" principle are able to provide an accurate, stable output voltage even with a supply current as low as $10\mu A$, or less. In this respect, such devices are vastly superior to an l.e.d.

Nevertheless, for applications where precision and micropower operation are not essential, an l.e.d. like the 3mm red part discussed above can provide acceptable performance at a fraction of the cost of a voltage reference i.c. Furthermore, when used in a circuit like the current sink of Fig.5, the l.e.d.'s 1·6V forward voltage often makes it a better choice than using signal diodes or a Zener diode.

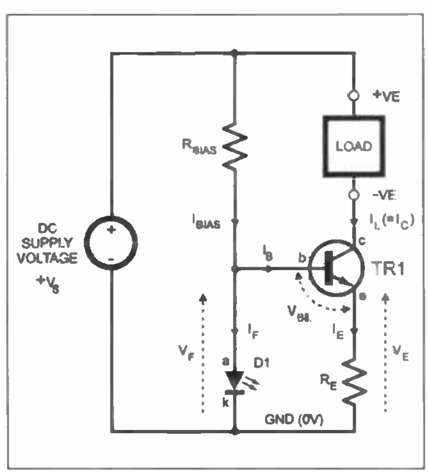


Fig.5. Current sink using an l.e.d. as a voltage reference.

Analysis of the circuit in Fig.5 is exactly the same as that of the current sink examined in Part Two. Transistor TR1's emitter voltage, V_E, is given by $V_E = V_F - V_{BE}$, and since the emitter current, I_E, is given by: $I_E = V_E/R_E$, it follows that $I_E = V_F - V_{BE})/R_E$.

Provided TR1 has good current gain, we can assume that its collector current, I_C, is roughly equal to I_E, and so the current flowing in the load is simply: $I_L \cong V_F - V_{BE})/R_E$. The l.e.d.'s bias resistor, R_{BIAS}, is chosen to ensure adequate forward current in diode D1 when the supply voltage, $+V_S$, is at a minimum, as shown in the following worked example.

Let's assume we need to set a load current of I_L = 25mA, and that $+V_S$ is an unregulated d.c. supply that can vary from as little as 8V to as much as 15V. If we use the 3mm red l.e.d. we should ensure a minimum forward current of 5mA. Now, $R_{BIAS} = (V_S - V_F)/(I_{BIAS}) = (V_S - V_F)/(I_F + I_B)$, where I_B is TR1's base current.

Therefore, allowing a generous 1mA for I_B, and using the minimum value for $+V_S$, we find that R_{BIAS} = (8V − 1.6V)/(5mA + 1mA) = 1066Ω, and so we would use the nearest lower preferred value, namely 1kΩ. Rearranging the expression for I_L given above, we see that: $R_E = (V_F - V_{BE})/I_L$. Taking a typical value of 0.7V for V_{BE}, we find that: R_E = (1.6V − 0.7V)/25mA = 0.9V/25mA = 36Ω.

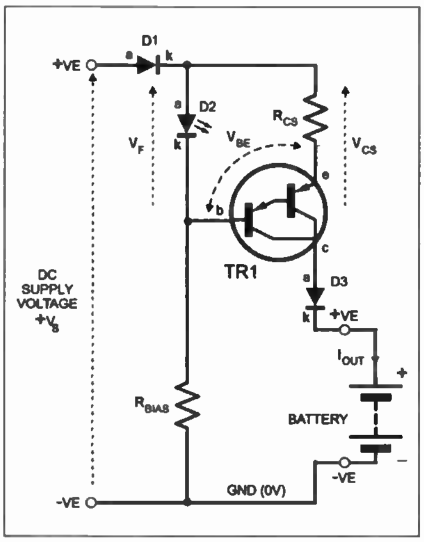


Fig.6. Simple constant-current battery charger.

Battery Charger

A practical example of an l.e.d.-based constant-current supply is shown in Fig.6. Here, the l.e.d., D2, is used with a *pnp* Darlington transistor, TR1, to form a simple current-source battery charger. The use of a Darlington transistor provides much greater current gain than a standard *pnp*, and allows for relatively high output current, I_{OUT}, without needing a large base current.

However, there is a penalty in using a Darlington in that its base-emitter voltage, V_{BE}, is roughly twice that of a standard transistor, so it is necessary to select an l.e.d. with relatively large V_F in order to generate adequate voltage, V_{CS}, across current sense resistor, R_{CS}. The output current is: $I_{OUT} = V_{CS}/R_{CS} = (V_F - V_{BE})/R_{CS}$.

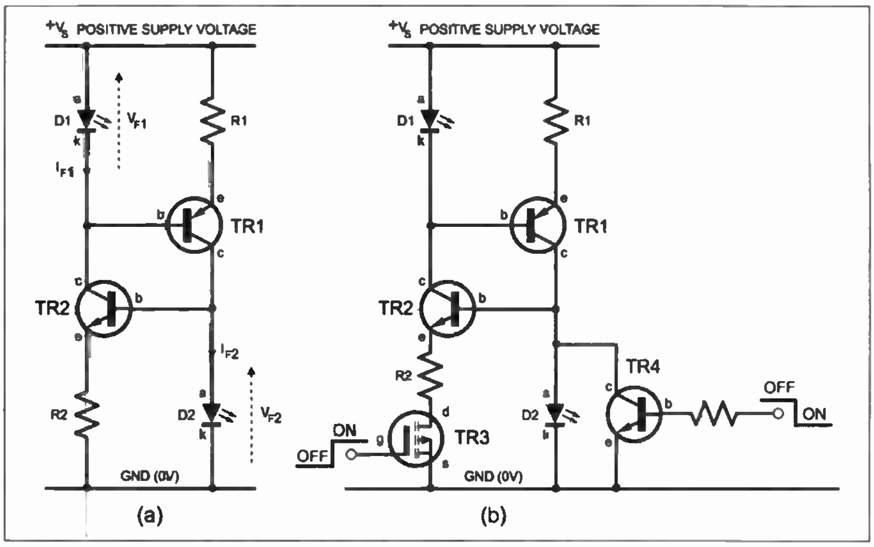


Fig.7. Constant-current dual l.e.d. drivers.

Therefore, taking $V_{BE} \cong 1{\cdot}3$V, and using an l.e.d. with V_F = 1·8V, a current sense resistor of 5·1Ω would produce an output current of around 100mA.

Diodes D1 and D3 are protection components that prevent potentially damaging current flow should the d.c. supply voltage or the battery be connected with reverse polarity. Given that I_{OUT} can be fairly large, transistor TR1 would normally be a power device, and would probably be mounted on a heatsink to handle the large power dissipation that would occur in the event of a short-circuit across the output terminals.

Dual Purpose

As well as acting as a voltage reference, the l.e.d. also doubles as a convenient "charging" indicator, since it will only illuminate if current is flowing into the battery. If I_{OUT} falls to zero – either because the battery has been removed or because of an open-circuit fault – TR1 stops behaving as a transistor (because its collector current is zero) and instead acts as a low-impedance shunt across the l.e.d. Consequently, practically all of the bias current flowing through R_{BIAS} is diverted into the base of TR1, starving D2 of forward current, thereby extinguishing the l.e.d.

Note that this kind of rudimentary charger is only suitable for batteries that require constant-current charging, and is not suitable for all battery chemistries. Nevertheless, despite its simplicity, it was widely used during the 1990s as a charger for cellular phone batteries.

Dual L.E.D. Driver

The circuit in Fig.7a shows how two l.e.d.s can be used as both light emitters *and* voltage references to produce a current-regulated, dual l.e.d. driver.

In this highly symmetrical circuit, the l.e.d.s operate in a complementary manner. l.e.d. D1 provides a stable reference voltage for the R1-TR1 current source which generates a steady forward current, I_{F2}, for l.e.d. D2. In turn, l.e.d. D2 acts as a reference for the R2-TR2 current sink that generates a stable forward current, I_{F1}, for l.e.d. D1. In this way, the l.e.d.s' forward current – and hence their brightness – remains virtually constant despite large changes in supply voltage, $+V_S$.

The circuit's minimum supply voltage is given by: $+V_{S(min)} = V_{F1} + V_{F2} + V_{CE(min)}$, where $V_{CE(min)}$ (typically around 1V) is the minimum collector-emitter voltage required to ensure TR1 and TR2 do not saturate. Therefore, if V_{F1} and V_{F2} are each around 2V, the circuit will operate properly down to about 5V.

The maximum supply voltage is dictated by the maximum collector-emitter voltage, $V_{CEO(max)}$ (sometimes called "collector-emitter breakdown voltage", denoted $V_{(BR)CEO}$), and by the maximum power rating, $P_{D(max)}$, of the devices used for TR1 and TR2. For example, with I_{F1} and I_{F2} each set to around 12mA, the use of small-signal transistors having a maximum power rating of 500mW would allow the circuit to operate with adequate safety margin up to 40V at room temperature, provided the transistors were rated to $V_{CEO(max)} \geq 45$V.

Test Results

A test circuit built with R1 = R2 = 150Ω, TR1 = BC557, TR2 = BC547, and using two yellow l.e.d.s each having V_F = 1·92V, produced impressive results. At $+V_S$ = 10V, the forward currents were fairly well matched at I_{F1} = 8·37mA and I_{F2} = 8·56mA. The current regulation (i.e., the change in current with supply voltage) was a mere 33μA/V over a 5V to 25V supply range.

The l.e.d.s can easily be turned on and off by, say, a TTL or CMOS logic signal with the addition of either TR3 or TR4, as shown in Fig.7b. If TR3 is used, the circuit can be turned on with an *active-high* signal applied to the *n*-channel MOSFET's gate. The device chosen should have low "on" resistance: for moderate current levels, a 2N7000, or similar, should suffice. Alternatively, an *npn* bipolar transistor with low collector-emitter saturation voltage, $V_{CE(sat)}$, could be used instead.

The alternative *active-low* approach uses a transistor, TR4, to clamp the base of TR2 to 0V when the signal is high, thus disabling both TR2 and TR1 and extinguishing the l.e.d.s.

When the signal goes low, TR4 turns off, releasing TR2's base, and the circuit functions normally. Although an *npn* bipolar transistor is shown for TR4, an *n*-channel MOSFET could also be used. Note that either TR3 or TR4 could be replaced by an open-collector or open-drain output of the

Table 1: Voltage Measurements on Different L.E.D. Samples

Manufacturer & Part Number	Description	Measured Photovoltage vs. Light Source		
		Darkened Room	Overcast Sky	10cm from 60W Bulb
Unknown	5mm green; lens:clear, tinted	1mV	1·27V	1·53V
Unknown	5mm red; les. diffused, tinted	3mV	3mV	3mV
Agilent HLMP-D155	5mm red lens:clear, untinted	7mV	1·19V	1·43V
Agilent HLMP-K150	3mm red; lens:difused, tinted	10mV	0·98V	1·32V
Kingbright L54PWC	5mm white; lens: clear, untinted	0	10mV	36mV

type found on some logic gates, voltage comparators, microcontrollers, and so on.

Multiple L.E.D.s

A final variation on the theme, shown in Fig.8, is a circuit for driving large arrays of l.e.d.s, where the two l.e.d.s, D1 and D2, are again used as light emitters and voltage references. However, provided the supply voltage, $+V_S$, is great enough, any number of additional l.e.d.s may be connected in the two series strings as shown.

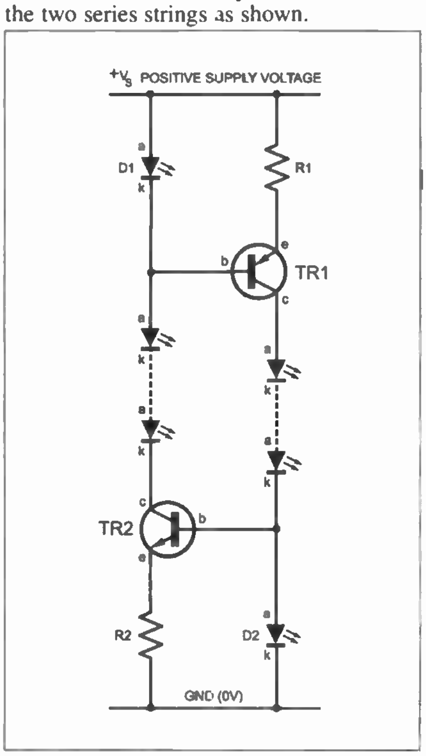


Fig.8. Constant-current multiple l.e.d. driver.

The circuit functions in exactly the same way as the dual l.e.d. driver, with D1 and R1 responsible for the current sourced through TR1 in the right half of the circuit, and D2 and R2 responsible for the current sunk through TR2 in the left half.

When driving more than, say, a dozen l.e.d.s, this complementary series technique can be simpler and more effective than parallel drivers. However, the circuit does require a relatively large d.c. supply, and since the l.e.d.s in each string share the same current, they must be well matched to ensure uniform brightness.

Turning the Tables

If you have a selection of l.e.d.s and a digital multimeter handy, try the following simple experiment. Set the multimeter to Volts mode and connect the test leads to the l.e.d.'s terminals: positive to anode, negative to cathode. Now, expose the l.e.d. to bright light and note the meter's reading. Next, cover the l.e.d. to shield it from the light – the reading should fall drastically.

Here, we meet a *fourth* use for the l.e.d. – as a light sensor! Normally, we apply electrical energy to an l.e.d. to produce light output, but by "turning the tables" we can use light as the *input* energy in order to generate an electrical output.

Note, however, that not all l.e.d.s are good at generating an electrical output. The results shown in Table 1 were obtained from measurements on several different l.e.d.s found in the author's junkbox. In each case, the *photovoltage* was measured using a digital voltmeter with 10MΩ input impedance.

The second sample in the table, even though perfectly good at emitting light when driven in the normal way, refused to generate more than a few millivolts of photovoltage, even when located just 10cm from the 60W filament bulb. The white l.e.d. also produced poor results, presumably because the internal phosphor layer prevents most of the light reaching the semiconductor junction.

On the other hand, the best samples tested produced over 1.5V in bright light – as much as an alkaline cell! But what kind of mechanism is responsible for turning light into electrical energy?

Light Fantastic?

Effectively, when exposed to light, the l.e.d. exhibits a *photodiode* response (see Photodiode Basics panel), and in particular is acting as a *photovoltaic* source when operated open-circuit (or when connected to a high impedance, such as a 10MΩ digital voltmeter).

Although an output voltage of 1.5V may seem impressive, the output *power* is actually very low, typically just a few microwatts. Sadly, therefore, l.e.d.s can't be used to replace batteries or solar cells as a useful power source!

The effect of "loading" can be investigated using the circuit shown in Fig.9, where D1 is the l.e.d. test sample, and R_L is the load impedance. Resistor R_F and capacitor C_F form a low-pass filter that minimises the effects of interference and pickup (important if D1 is connected to the circuit via long flying leads), and also attenuates any a.c. component in the measured voltage that can be introduced by mains-powered lighting.

Op.amp IC1 acts as a unity-gain buffer that allows the photovoltaic voltage, V_P, to be measured by any kind of voltmeter, even a low-impedance moving-coil type, without affecting the results. One half of the dual TLC27L2 is a convenient choice for the op amp: this is a single-rail, CMOS device with very low input bias current (I_B is typically just 0.6pA at room temperature) which introduces negligible loading to the l.e.d. and filter.

Furthermore, the TLC27L2 has reasonably low input offset voltage (typically 1.1mV), such that the output voltage, V_O, can be considered equal to V_P for all voltages above 50mV, or so.

CMOS Op.Amps

The supply voltage is not critical – any well-regulated d.c. voltage in the range 5V to 12V will suffice, so a 9V battery should be ideal. If you wish to use an alternative op.amp, single-rail CMOS types are the best choice due to their inherently high input impedance, but take care not to exceed the supply voltage rating for the particular device used.

The circuit can be used to assess the performance of different l.e.d. samples, or to see how a given l.e.d. type responds to varying light conditions.

To see how loading affects the photovoltage, locate D1 in a fixed light source and measure V_O for different values of load resistor, R_L. A mains-powered light bulb can be used as a reasonably constant light source, **but beware – the bulb gets very hot and should be used with caution!**

The graph shown in Fig.10 shows the effect of varying the load resistance on an Agilent HLMP-D155 sample located 10cm away from a 60W bulb. The response (plotted on log-log axes) exhibits a straight-line increase in output voltage, V_O, as R_L is increased from 1kΩ to around 100kΩ. At that point, the characteristic levels off: the l.e.d.'s photovoltage is now approaching its maximum value, and further increases in R_L have negligible effect.

Although an l.e.d. used in photovoltaic mode can serve as a rudimentary light sensor, its response tends to be very non-linear, and much better performance can be obtained if it is used in photodiode mode (see panel). Nevertheless, as we see in next month's *Light Detector* project, an l.e.d. can provide an inexpensive yet effective way of sensing a change in light levels.

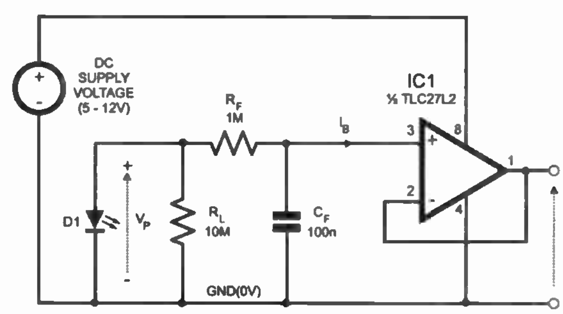


Fig.9. Simple buffer circuit for photovoltaic experiment.

Photodiode Basics

Whereas l.e.d.s are specifically designed to emit light in the visible, infrared and even ultraviolet regions of the spectrum, there are also optoelectronic devices that are optimised to be sensitive to electromagnetic radiation in these regions.

It was shown in Part One that in any forward-biased *pn* junction, a recombination of holes and electrons takes place, where the energy possessed by each unbound electron is transferred to another state. In all semiconductor *pn* junctions, some of this energy is given off as heat, and some in the form of photons, or light energy, where the light wavelength is characteristic of the particular semiconductor material.

However, the converse is also true, in that light energy falling on a semiconductor junction will cause a change in energy states that generates either a current or a voltage, depending on how the device is used. When a semiconductor junction is irradiated by light, its intrinsic conductivity increases (its resistance falls). The light dependent resistor (LDR) is a common device that exploits this effect.

Photoconductor devices such as the photodiode, and its counterpart the phototransistor, also exhibit light-dependent behaviour. The mechanism responsible for the photoconductive process is too complex to describe in detail here. In simple terms, though, the increase in conductivity is due to the radiant energy being absorbed by the atomic structure, causing spontaneous generation of electron-hole pairs. In photoconductivity, the primary mechanism is due to the excitation of an electron from the valence band to the conduction band.

Wavelength

For a particular semiconductor material, the photoconductive response is highly dependent on the wavelength of the light. The wavelength, denoted λ, is usually measured in angstrom units (Å) or micrometres (μm), where 1Å = 10^{-10}m, and 1μm = 10^{-6}m. Silicon, for example, has a spectral response ranging from around 4000Å (roughly equivalent to violet in the visible range), through infrared, and out to around 12,000Å. Germanium, on the other hand, has a broader response ranging from less than 3000Å to over 17,000Å.

Symbols

Single photodiodes are packaged in a housing not unlike that of an l.e.d., sometimes inside a small metal can with a transparent lens cover, or contained inside an entirely plastic package with a domed lens to focus the incident light. Two common symbols for the device are shown in Fig.11a, where the sensitivity to light is denoted either by incoming arrows, or by the λ wavelength symbol.

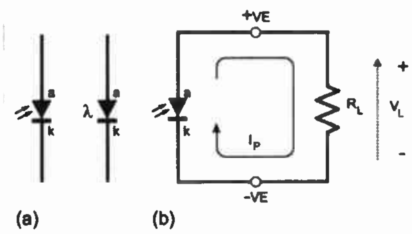


Fig.11. Photodiode symbols and the photovoltaic mode.

The behaviour of the photodiode depends on the "mode" in which it is used. Connecting the device to a load as shown in Fig.11b and exposing it to light will generate a voltage across the load. This mode, known as the *photovoltaic* mode, produces a relatively weak amount of electrical energy, and the relationship between the input light intensity and the output photovoltage tends to be highly non-linear.

Photodiode Amplifier

For light measurement applications requiring high linearity, the device is usually operated in *photodiode* mode with zero or reverse bias applied. This mode produces an output photocurrent, I_P, which varies in a linear manner with applied light intensity. One example of a zero-bias photodiode amplifier is shown in Fig.12, in which the op.amp maintains zero electrical potential across the photodiode, D1, and also converts the photocurrent into a proportional output voltage, V_O.

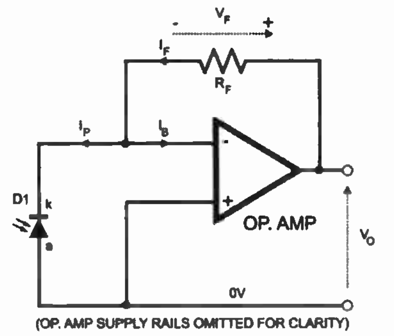


Fig.12. Converting light to voltage with a photodiode amplifier.

Since the op.amp's non-inverting input terminal is connected to 0V, this forces a "virtual earth" to appear at the inverting input terminal, i.e., there is zero potential at the inverting input, and hence zero bias across the photodiode. The presence of the virtual earth also means that the output voltage is equal to the voltage V_F across feedback resistor R_F, where $V_F = I_F \times R_F$; therefore: $V_O = I_F \times R_F$.

Provided the op.amp's inverting input has very high input impedance (easily achieved using CMOS and JFET type op.amps), we can assume the input bias current, I_B, is zero such that $I_P = I_F$. Consequently, $V_O = I_P \times R_F$, and we see that the output voltage is directly proportional to the photocurrent, and therefore linearly proportional to the light intensity falling on D1.

The photodiode finds many applications, not just as a light measurement device, but also as a detector in products like barcode scanners and fibre optic links. When combined with a light emitter such as an l.e.d., the photodiode (or phototransistor) forms one half of an optocoupler (or optoisolator), a device that provides optical transmission of an electrical signal across a galvanically isolated barrier (see next month's *Light Detector* project for a practical application of an optocoupler).

The Future

There can be little doubt that from humble beginnings as a rather feeble light source considered by some to be a mere curiosity, the light emitting diode has progressed enormously in the past thirty years. Take a look at all the electronic products around you: there's a good chance that most of them will make use of one or more l.e.d.'s..

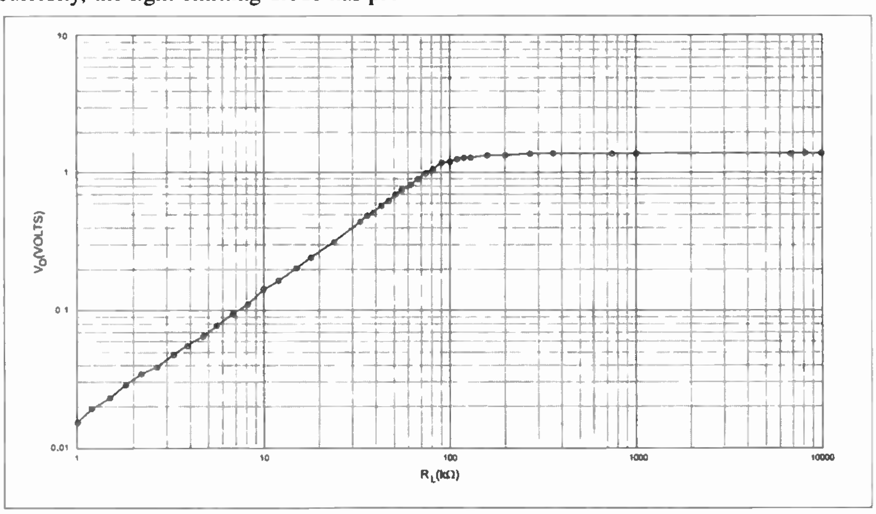


Fig.10. Effects of load resistance on l.e.d. prototype.

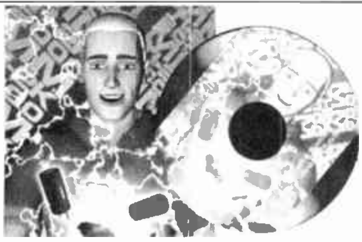
In this series, we have shown how the l.e.d.'s behaviour as a diode allows it to be used in applications that simply would not be possible with an incandescent filament bulb. We have also seen how certain types of l.e.d. can be used as voltage references and even as rudimentary light sensors. Remarkably, the author has also heard of an l.e.d. being used as a *temperature sensor* by exploiting the temperature-dependent change in forward voltage that is a characteristic of all semiconductor *pn* junctions!

Notwithstanding these secondary functions, it is, of course, the l.e.d.'s highly efficient ability to emit light in a range of different colours that makes it such an attractive and invaluable component in today's products. From the early days when l.e.d.s were available only in red or infrared, we can now choose from green, yellow, cyan, amber, blue, white and even ultraviolet! Indeed, to paraphrase a familiar slogan, it seems that in the world of l.e.d.s, "the future's bright, the future's ... *any colour you want!*" □

DIRECT BOOK SERVICE

NOTE: ALL PRICES INCLUDE UK POSTAGE

FREE *Electronics Hobbyist Compendium* book with Teach-In 2000 CD-ROM



EPE TEACH-IN 2000 CD-ROM

The whole of the 12-part *Teach-In 2000* series by John Becker (published in *EPE* Nov '99 to Oct 2000) is now available on CD-ROM. Plus the *Teach-In 2000* interactive software (Win 95, 98, ME and above) covering all aspects of the series and Alan Winstanley's *Basic Soldering Guide* (including illustrations and Desoldering).

Teach-In 2000 covers all the basic principles of electronics from Ohm's Law to Displays, including Op.Amps, Logic Gates etc. Each part has its own section on the interactive software where you can also change component values in the various on-screen demonstration circuits.

The series gives a hands-on approach to electronics with numerous breadboard circuits to try out, plus a simple computer interface (Win 95, 98, ME only) which allows a PC to be used as a basic oscilloscope.

ONLY **£12.45** including VAT and p&p

Order code Teach-In CD-ROM

Circuits and Design

PREAMPLIFIER AND FILTER CIRCUITS
R. A. Penfold

Provides circuits and background information for a range of preamplifiers, plus tone controls, filters, mixers, etc. The use of modern low noise operational amplifiers and a specialist high performance audio preamplifier i.c. results in circuits that have excellent performance, but which are still quite simple. All the circuits featured can be built at quite low cost. The preamplifier circuits featured include: Microphone preamplifiers (low impedance, high impedance, and crystal). Magnetic cartridge pick-up preamplifiers with R.I.A.A. equalisation. Crystal/ceramic pick-up preamplifier. Guitar pick-up preamplifier. Tape head preamplifier.

Other circuits include: Audio limiter. Passive tone controls. Active tone controls. PA filters (highpass and lowpass). Scratch and rumble filters. Loudness filter. Mixers. Volume and balance controls.

92 pages **Order code BP309** **£4.49**

DOMESTIC SECURITY SYSTEMS
A. L. Brown

This book shows you how, with common sense and basic do-it-yourself skills, you can protect your home. It also gives tips and ideas which will help you to maintain and improve your home security, even if you already have an alarm. Every circuit in this book is clearly described and illustrated, and contains components that are easy to source. Advice and guidance are based on the real experience of the author who is an alarm installer, and the designs themselves have been rigorously put to use on some of the most crime-ridden streets in the world.

The designs include all elements, including sensors, detectors, alarms, controls, lights, video and door entry systems. Chapters cover installation, testing, maintenance and upgrading.

192 pages **Order code NE25** **£20.99**

MICROCONTROLLER COOKBOOK
Mike James

The practical solutions to real problems shown in this cookbook provide the basis to make PIC and 8051 devices really work. Capabilities of the variants are examined, and ways to enhance these are shown. A survey of common interface devices, and a description of programming models, lead on to a section on development techniques. The cookbook offers an introduction that will allow any user, novice or experienced, to make the most of microcontrollers.

240 pages **Order code NE26** **£23.99**

A BEGINNER'S GUIDE TO TTL DIGITAL ICs
R. A. Penfold

This book first covers the basics of simple logic circuits in general, and then progresses to specific TTL logic integrated circuits. The devices covered include gates, oscillators, timers, flip/flops, dividers, and decoder circuits. Some practical circuits are used to illustrate the use of TTL devices in the "real world".

142 pages **Order code BP332** **£5.45**

PRACTICAL ELECTRONICS CALCULATIONS AND FORMULAE
F. A. Wilson, C.G.I.A., C.Eng., F.I.E.E., F.I.E.R.E., F.B.I.M.

Bridges the gap between complicated technical theory, and "cut-and-tried" methods which may bring success in design but leave the experimenter unfulfilled. A strong practical bias – tedious and higher mathematics have been avoided where possible and many tables have been included.

The book is divided into six basic sections: Units and Constants, Direct-Current Circuits, Passive Components, Alternating-Current Circuits, Networks and Theorems, Measurements.

256 pages **Order code BP53** **£5.49**

Computing & Robotics

WINDOWS XP EXPLAINED
N. Kantaris and P. R. M. Oliver

If you want to know what to do next when confronted with Microsoft's Windows XP screen, then this book is for you. It applies to both the Professional and Home editions.

The book was written with the non-expert, busy person in mind. It explains what hardware requirements you need in order to run Windows XP successfully, and gives an overview of the Windows XP environment.

The book explains: How to manipulate Windows, and how to use the Control Panel to add or change your printer, and control your display; How to control information using WordPad, Notepad and Paint, and how to use the Clipboard facility to transfer information between Windows applications; How to be in control of your filing system using Windows Explorer and My Computer; How to control printers, fonts, characters, multimedia and images, and how to add hardware and software to your system; How to configure your system to communicate with the outside world, and use Outlook Express for all your email requirements; How to use the Windows Media Player 8 to play your CDs, burn CDs with your favourite tracks, use the Radio Tuner, transfer your videos to your PC, and how to use the Sound Recorder and Movie Maker; How to use the System Tools to restore your system to a previously working state, using Microsoft's Website to update your Windows set-up how to clean up, defragment and scan your hard disk, and how to backup and restore your data; How to successfully transfer text from those old but cherished MS-DOS programs.

268 pages **Order code BP514** **£7.99**

INTRODUCING ROBOTICS WITH LEGO MINDSTORMS
Robert Penfold

Shows the reader how to build a variety of increasingly sophisticated computer controlled robots using the brilliant Lego Mindstorms Robotic Invention System (RIS). Initially covers fundamental building techniques and mechanics needed to construct strong and efficient robots using the various "click-together" components supplied in the basic RIS kit. Explains in simple terms how the "brain" of the robot may be programmed on screen using a PC and "zapped" to the robot over an infra-red link. Also, shows how a more sophisticated Windows programming language such as Visual BASIC may be used to control the robots.

Detailed building and programming instructions provided, including numerous step-by-step photographs.

288 pages – large format **Order code BP901** **£14.99**

MORE ADVANCED ROBOTICS WITH LEGO MINDSTORMS – Robert Penfold

Covers the Vision Command System

Shows the reader how to extend the capabilities of the brilliant Lego Mindstorms Robotic Invention System (RIS) by using Lego's own accessories and some simple home constructed units. You will be able to build robots that can provide you with 'waiter service' when you clap your hands, perform tricks, 'see' and avoid objects by using 'bats radar', or accurately follow a line marked on the floor. Learn to use additional types of sensors including rotation, light, temperature, sound and ultrasonic and also explore the possibilities provided by using an additional (third) motor. For the less experienced, RCX code programs accompany most of the featured robots. However, the more adventurous reader is also shown how to write programs using Microsoft's VisualBASIC running with the ActiveX control (Spirit.OCX) that is provided with the RIS kit.

Detailed building instructions are provided for the featured robots, including numerous step-by-step photographs. The designs include rover vehicles, a virtual pet, a robot arm, an 'intelligent' sweet dispenser and a colour conscious robot that will try to grab objects of a specific colour.

298 pages **Order code BP902** **£14.99**

PIC YOUR PERSONAL INTRODUCTORY COURSE SECOND EDITION John Morton

Discover the potential of the PIC microcontroller through graded projects – this book could revolutionise your electronics construction work!

A uniquely concise and practical guide to getting up and running with the PIC Microcontroller. The PIC is one of the most popular of the microcontrollers that are transforming electronic project work and product design.

Assuming no prior knowledge of microcontrollers and introducing the PICs capabilities through simple projects, this book is ideal for use in schools and colleges. It is the ideal introduction for students, teachers, technicians and electronics enthusiasts. The step-by-step explanations make it ideal for self-study too: this is not a reference book – you start work with the PIC straight away.

The revised second edition covers the popular reprogrammable EEPROM PICs: P16C84/16F84 as well as the P54 and P71 families.

270 pages **Order code NE36** **£15.99**

INTRODUCTION TO MICROPROCESSORS
John Crisp

If you are, or soon will be, involved in the use of microprocessors, this practical introduction is essential reading. This book provides a thoroughly readable introduction to microprocessors. assuming no previous knowledge of the subject, nor a technical or mathematical background. It is suitable for students, technicians, engineers and hobbyists, and covers the full range of modern microprocessors.

After a thorough introduction to the subject, ideas are developed progressively in a well-structured format. All technical terms are carefully introduced and subjects which have proved difficult, for example 2's complement, are clearly explained. John Crisp covers the complete range of microprocessors from the popular 4-bit and 8 bit designs to today's super-fast 32-bit and 64-bit versions that power PCs and engine management systems etc.

222 pages **Order code NE31** **£21.99**

The books listed have been selected by *Everyday Practical Electronics* editorial staff as being of special interest to everyone involved in electronics and computing. They are supplied by mail order direct to your door. Full ordering details are given on the last book page.

FOR A FURTHER SELECTION OF BOOKS SEE THE NEXT TWO ISSUES OF *EPE*

All prices include UK postage

NEWNES INTERFACING COMPANION
Tony Fischer-Cripps

A uniquely concise and practical guide to the hardware, applications and design issues involved in computer interfacing and the use of transducers and instrumentation.

Newnes Interfacing Companion presents the essential information needed to design a PC-based interfacing system from the selection of suitable transducers, to collection of data, and the appropriate signal processing and conditioning.

Contents: Part 1 – Transducers; Measurement systems; Temperature; Light; Position and motion; Force, pressure and flow. Part 2 – Interfacing; Number systems; Computer architecture; Assembly language; Interfacing; A to D and D to A conversions; Data communications; Programmable logic controllers; Data acquisition project. Part 3 – Signal processing; Transfer function; Active filters; Instrumentation amplifier; Noise; Digital signal processing.

320 pages **Order code NE38** **£26.99**

Testing, Theory and Reference

THE AMATEUR SCIENTIST CD-ROM

The complete collection of The Amateur Scientist articles from *Scientific American* magazine. Over 1,000 classic science projects from a renowned source of winning projects. All projects are rated for cost, difficulty and possible hazards.
Plus over 1,000 pages of helpful science techniques that never appeared in *Scientific American.*
Exciting science projects in: Astronomy; Earth Science; Biology; Physics; Chemistry; Weather . . . and much more! The most complete resource ever assembled for hobbyists, and professionals looking for novel solutions to research problems.
Includes extensive Science Software Library with even more science tools.
Suitable for Mac, Windows, Linux or UNIX. 32MB RAM minimum, Netscape 4.0 or higher or Internet Explorer 4.0 or higher.
Over 1,000 projects **Order code AS1 CD-ROM** **£19.95**

BEBOP BYTES BACK (and the Beboputer Computer Simulator) CD-ROM
Clive (Max) Maxfield and Alvin Brown

This follow-on to *Bebop to the Boolean Boogie* is a multimedia extravaganza of information about how computers work. It picks up where "Bebop I" left off, guiding you through the fascinating world of computer design . . . and you'll have a few chuckles, if not belly laughs, along the way. In addition to over 200 megabytes of mega-cool multimedia, the CD-ROM contains a virtual microcomputer, simulating the motherboard and standard computer peripherals in an extremely realistic manner. In addition to a wealth of technical information, myriad nuggets of trivia, and hundreds of carefully drawn illustrations, the CD-ROM contains a set of lab experiments for the virtual microcomputer that let you recreate the experiences of early computer pioneers. If you're the slightest bit interested in the inner workings of computers, then don't dare to miss this!
Over 800 pages in Adobe Acrobat format **Order code BEB2 CD-ROM** **£21.95**

DIGITAL ELECTRONICS – A PRACTICAL APPROACH
With FREE Software: Number One Systems – EASY-PC Professional XM and Pulsar (Limited Functionality)
Richard Monk

FREE SOFTWARE

Covers binary arithmetic, Boolean algebra and logic gates, combination logic, sequential logic including the design and construction of asynchronous and synchronous circuits and register circuits. Together with a considerable practical content plus the additional attraction of its close association with computer-aided design including the FREE software.
There is a 'blow-by-blow' guide to the use of EASY-PC Professional XM (a schematic drawing and printed circuit board design computer package). The guide also conducts the reader through logic circuit simulation using Pulsar software. Chapters on p.c.b. physics and p.c.b. production techniques make the book unique, and with its host of project ideas make it an ideal companion for the integrative assignment and common skills components required by BTEC and the key skills demanded by GNVQ. The principal aim of the book is to provide a straightforward approach to the understanding of digital electronics.
Those who prefer the 'Teach-In' approach or would rather experiment with some simple circuits should find the book's final chapters on printed circuit board production and project ideas especially useful.
250 pages **Temporarily out of print**

OSCILLOSCOPES – FIFTH EDITION
Ian Hickman

Oscilloscopes are essential tools for checking circuit operation and diagnosing faults, and an enormous range of models are available.
This handy guide to oscilloscopes is essential reading for anyone who has to use a 'scope for their work or hobby; electronics designers, technicians, anyone in industry involved in test and measurement, electronics enthusiasts . . . Ian Hickman's review of all the latest types of 'scope currently available will prove especially useful for anyone planning to buy – or even build – an oscilloscope.
The contents include a description of the basic oscillscope; Advanced real-time oscilloscope; Accessories; Using oscilloscopes; Sampling oscilloscopes; Digital storage oscilloscopes; Oscilloscopes for special purposes; How oscillocopes work (1): the CRT; How oscilloscopes work (2): circuitry; How oscilloscopes work (3): storage CRTs; plus a listing of Oscilloscope manufacturers and suppliers.
288 pages **Order code NE37** **£22.99**

SCROGGIE'S FOUNDATIONS OF WIRELESS AND ELECTRONICS – ELEVENTH EDITION
S. W. Amos and Roger Amos

Scroggie's Foundations is a classic text for anyone working with electronics, who needs to know the art and craft of the subject. It covers both the theory and practical aspects of a huge range of topics from valve and tube technology, and the application of cathode ray tubes to radar, to digital tape systems and optical recording techniques.
Since *Foundations of Wireless* was first published over 60 years ago, it has helped many thousands of readers to become familiar with the principles of radio and electronics. The original author Sowerby was succeeded by Scroggie in the 1940s, whose name became synonymous with this classic primer for practitioners and students alike. Stan Amos, one of the fathers of modern electronics and the author of many well-known books in the area, took over the revision of this book in the 1980s and it is he, with his son, who have produced this latest version.

400 pages **Temporarily out of print**

PRACTICAL ELECTRONIC FAULT FINDING AND TROUBLESHOOTING
Robin Pain

To be a real fault finder, you must be able to get a feel for what is going on in the circuit you are examining. In this book Robin Pain explains the basic techniques needed to be a fault finder.
Simple circuit examples are used to illustrate principles and concepts fundamental to the process of fault finding. This is not a book of theory, it is a book of practical tips, hints and rules of thumb, all of which will equip the reader to tackle any job. You may be an engineer or technician in search of information and guidance, a college student, a hobbyist building a project from a magazine, or simply a keen self-taught amateur who is interested in electronic fault finding but finds books on the subject too mathematical or specialised.
The fundamental principles of analogue and digital fault finding are described (although, of course, there is no such thing as a "digital fault" – all faults are by nature analogue). This book is written entirely for a fault finder using only the basic fault-finding equipment: a digital multimeter and an oscilloscope. The treatment is non-mathematical (apart from Ohm's law) and all jargon is strictly avoided.
274 pages **Order code NE22** **£25.99**

ELECTRONIC TEST EQUIPMENT HANDBOOK
Steve Money

In most applications of electronics, test instruments are essential for checking the performance of a system or for diagnosing faults in operation, and so it is important for engineers, technicians, students and hobbyists to understand how the basic test instruments work and how they can be used.
The principles of operation of the various types of test instrument are explained in simple terms with a minimum of mathematical analysis. The book covers analogue and digital meters, bridges, oscilloscopes, signal generators, counters, timers and frequency measurement. The practical uses of these instruments are also examined.
206 pages **Order code PC109** **£9.95**

DIGITAL GATES AND FLIP-FLOPS
Ian R. Sinclair

This book, intended for enthusiasts, students and technicians, seeks to establish a firm foundation in digital electronics by treating the topics of gates and flip-flops thoroughly and from the beginning.
Topics such as Boolean algebra and Karnaugh mapping are explainend, demonstrated and used extensively, and more attention is paid to the subject of synchronous counters than to the simple but less important ripple counters.
No background other than a basic knowledge of electronics is assumed, and the more theoretical topics are explained from the beginning, as also are many working practices. The book concludes with an explanation of microprocessor techniques as applied to digital logic.
200 pages **Order code PC106** **£9.95**

UNDERSTANDING ELECTRONIC CONTROL SYSTEMS
Owen Bishop

Owen Bishop has produced a concise, readable text to introduce a wide range of students, technicians and professionals to an important area of electronics. Control is a highly mathematical subject, but here maths is kept to a minimum, with flow charts to illustrate principles and techniques instead of equations.
Cutting edge topics such as microcontrollers, neural networks and fuzzy control are all here, making this an ideal refresher course for those working in Industry. Basic principles, control algorithms and hardwired control systems are also fully covered so the resulting book is a comprehensive text and well suited to college courses or background reading for university students.
The text is supported by questions under the headings Keeping Up and Test Your Knowledge so that the reader can develop a sound understanding and the ability to apply the techniques they are learning.
228 pages **Order code NE35** **£20.99**

HOW ELECTRONIC THINGS WORK – AND WHAT TO DO WHEN THEY DON'T
Robert Goodman

You never again have to be flummoxed, flustered or taken for a ride by a piece of electronics equipment. With this fully illustrated, simple-to-use guide, you will get a grasp on the workings of the electronic world that surrounds you – and even learn to make your own repairs.
You don't need any technical experience. This book gives you: Clear explanations of how things work, written in everyday language. Easy-to-follow, illustrated instructions on using test equipment to diagnose problems. Guidelines to help you decide for or against professional repair. Tips on protecting your expensive equipment from lightning and other electrical damage. Lubrication and maintenance suggestions.
Covers: colour TVs, VCRs, radios, PCs, CD players, printers, telephones, monitors, camcorders, satellite dishes, and much more!
394 pages **Order code MGH3** **£21.99**

VINTAGE RADIOS – COLLECTING ● SERVICING ● RESTORING
Tony Thompson

The essential guide to collecting, repairing and restoring vintage valve radios. These receivers are becoming ever more popular as collectibles, this is a good thing because it means that a very large piece of technological history is being reclaimed when at one time many thought it lost forever. If you look around, you will find plenty of valve radio sets just waiting for a loving restoration. They may not yet be the most highly prized, and they are unlikely to be in top condition, but they can be yours and, if you develop the skills outlined in this book, you will possess radio receivers to be proud of.
The book covers radio history, styling, faultfinding, chassis and cabinet restoration, types of set.
124 pages spiral bound **Order code TT1** **£12.95**

All prices include UK P&P

Project Building

ELECTRONIC PROJECT BUILDING FOR BEGINNERS
R. A. Penfold

This book is for complete beginners to electronic project building. It provides a complete introduction to the practical side of this fascinating hobby, including the following topics:

Component identification, and buying the right parts; resistor colour codes, capacitor value markings, etc; advice on buying the right tools for the job; soldering; making easy work of the hard wiring; construction methods, including stripboard, custom printed circuit boards, plain matrix boards, surface mount boards and wire-wrapping; finishing off, and adding panel labels; getting "problem" projects to work, including simple methods of fault-finding.

In fact everything you need to know in order to get started in this absorbing and creative hobby.

135 pages **Order code BP392** **£5.49**

NEW

BUILDING VALVE AMPLIFIERS
Morgan Jones

The practical guide to building, modifying, fault-finding and repairing valve amplifiers. A hands-on approach to valve electronics – classic and modern – with a minimum of theory. Planning, fault-finding, and testing are each illustrated by step-by-step examples.

A unique hands-on guide for anyone working with valve (*tube* in USA) audio equipment – as an electronics experimenter, audiophile or audio engineer.

Particular attention has been paid to answering questions commonly asked by newcomers to the world of the vacuum tube, whether audio enthusiasts tackling their first build, or more experienced amplifier designers seeking to learn the ropes of working with valves. The practical side of this book is reinforced by numerous clear illustrations throughout.

368 pages **Order code NE40** **£21.99**

ELECTRONIC PROJECTS FOR EXPERIMENTERS
R. A. Penfold

Many electronic hobbyists who have been pursuing their hobby for a number of years seem to suffer from the dreaded "seen it all before" syndrome. This book is fairly and squarely aimed at sufferers of this complaint, plus any other electronics enthusiasts who yearn to try something a bit different.

The subjects covered include:- Magnetic field detector, Basic Hall effect compass, Hall effect audio isolator, Voice scrambler/descrambler, Bat detector, Bat style echo location, Noise cancelling, LED stroboscope, Infra-red "torch", Electronic breeze detector, Class D power amplifier, Strain gauge amplifier, Super hearing aid.

138 pages **Order code BP371** **£5.45**

PRACTICAL FIBRE-OPTIC PROJECTS
R. A. Penfold

While fibre-optic cables may have potential advantages over ordinary electric cables, for the electronics enthusiast it is probably their novelty value that makes them worthy of exploration. Fibre-optic cables provide an innovative interesting alternative to electric cables, but in most cases they also represent a practical approach to the problem. This book provides a number of tried and tested circuits for projects that utilize fibre-optic cables.

The projects include:- Simple audio links, F.M. audio link, P.W.M. audio links, Simple d.c. links, P.W.M. d.c. link, P.W.M. motor speed control, RS232C data links, MIDI link, Loop alarms, R.P.M. meter.

All the components used in these designs are readily available, none of them require the constructor to take out a second mortgage.

132 pages **Order code BP374** **£5.45**

ELECTRONIC MUSIC AND MIDI PROJECTS
R. A. Penfold

Whether you wish to save money, boldly go where no musician has gone before, rekindle the pioneering spirit, or simply have fun building some electronic music gadgets, the designs featured in this book should suit your needs. The projects are all easy to build, and some are so simple that even complete beginners at electronic project construction can tackle them with ease. Stripboard layouts are provided for every project, together with a wiring diagram. The mechanical side of construction has largely been left to the individual constructors to sort out, simply because the vast majority of project builders prefer to do their own thing.

None of the designs requires the use of any test equipment in order to get them set up properly. Where any setting up is required, the procedures are very straightforward, and they are described in detail.

Projects covered: Simple MIDI tester, Message grabber, Byte grabber, THRU box, MIDI auto switcher, Auto/manual switcher, Manual switcher, MIDI patchbay, MIDI controlled switcher, MIDI lead tester, Program change pedal, Improved program change pedal, Basic mixer, Stereo mixer, Electronic swell pedal, Metronome, Analogue echo unit.

138 pages **Order code PC116** **£5.45**

VIDEO PROJECTS FOR THE ELECTRONICS CONSTRUCTOR
R. A. Penfold

Written by highly respected author R. A. Penfold, this book contains a collection of electronic projects specially designed for video enthusiasts. All the projects can be simply constructed, and most are suitable for the newcomer to project construction, as they are assembled on stripboard.

There are faders, wipers and effects units which will add sparkle and originality to your video recordings, an audio mixer and noise reducer to enhance your soundtracks and a basic computer control interface. Also, there's a useful selection on basic video production techniques to get you started.

Circuits include: video enhancer, improved video enhancer, video fader, horizontal wiper, improved video wiper, negative video unit, fade to grey unit, black and white keyer, vertical wiper, audio mixer, stereo headphone amplifier, dynamic noise reducer, automatic fader, pushbutton fader, computer control interface, 12 volt mains power supply.

124 pages **Order code PC115** **£5.45**

Theory and Reference

ELECTRONICS MADE SIMPLE
Ian Sinclair

Assuming no prior knowledge, *Electronics Made Simple* presents an outline of modern electronics with an emphasis on understanding how systems work rather than on details of circuit diagrams and calculations. It is ideal for students on a range of courses in electronics, including GCSE, C&G and GNVQ, and for students of other subjects who will be using electronic instruments and methods.

Contents: waves and pulses, passive components, active components and ICs, linear circuits, block and circuit diagrams, how radio works, disc and tape recording, elements of TV and radar, digital signals, gating and logic circuits, counting and correcting, microprocessors, calculators and computers, miscellaneous systems.

199 pages **Order code NE23** **£13.99**

GETTING THE MOST FROM YOUR MULTIMETER
R. A. Penfold

This book is primarily aimed at beginners and those of limited experience of electronics. Chapter 1 covers the basics of analogue and digital multimeters, discussing the relative merits and the limitations of the two types. In Chapter 2 various methods of component checking are described, including tests for transistors, thyristors, resistors, capacitors and diodes. Circuit testing is covered in Chapter 3, with subjects such as voltage, current and continuity checks being discussed.

In the main little or no previous knowledge or experience is assumed. Using these simple component and circuit testing techniques the reader should be able to confidently tackle servicing of most electronic projects.

96 pages **Order code BP239** **£5.49**

PRACTICAL ELECTRONIC FILTERS
Owen Bishop

This book deals with the subject in a non-mathematical way. It reviews the main types of filter, explaining in simple terms how each type works and how it is used.

The book also presents a dozen filter-based projects with applications in and around the home or in the constructor's workshop. These include a number of audio projects such as a rythm secuencer and a multi-voiced electronic organ.

Concluding the book is a practical step-by-step guide to designing simple filters for a wide range of purposes, with circuit diagrams and worked examples.

188 pages **Order code BP299** **£5.49**

BOOK ORDERING DETAILS

All prices include UK postage. For postage to Europe (air) and the rest of the world (surface) please add £2 per book. For the rest of the world airmail add £3 per book. CD-ROM prices include VAT and/or postage to anywhere in the world. Send a PO, cheque, international money order (£ sterling only) made payable to **Direct Book Service** or card details, Visa, Mastercard, Amex, Diners Club or Maestro to:

DIRECT BOOK SERVICE, WIMBORNE PUBLISHING LTD., 408 WIMBORNE ROAD EAST, FERNDOWN, DORSET BH22 9ND.

Books are normally sent within seven days of receipt of order, but please allow 28 days for delivery – more for overseas orders. *Please check price and availability (see latest issue of* Everyday Practical Electronics*) before ordering from old lists.*

For a further selection of books see the next two issues of *EPE*.

Tel 01202 873872 Fax 01202 874562. Email: dbs@wimborne.co.uk

Order from our online shop at: www.epemag.co.uk

BOOK ORDER FORM

Full name: ....

Address: ....

....

....

.... Post code: .... Telephone No: ....

Signature: ....

☐ I enclose cheque/PO payable to DIRECT BOOK SERVICE for £ ....

☐ Please charge my card £ .... Card expiry date....................

Card Number .... Switch/Maestro Issue No....................

Card Security Code .... (the last three digits on or just under the signature strip)

Please send book order codes: ....

....

Please continue on separate sheet of paper if necessary
If you do not wish to cut your magazine, send a letter or copy of this form

PCB SERVICE

Printed circuit boards for most recent *EPE* constructional projects are available from the PCB Service, see list. These are fabricated in glass fibre, and are fully drilled and roller tinned. All prices include VAT and postage and packing. Add £1 per board for *airmail* outside of Europe. Remittances should be sent to **The PCB Service, *Everyday Practical Electronics*, Wimborne Publishing Ltd., 408 Wimborne Road East, Ferndown, Dorset BH22 9ND. Tel: 01202 873872; Fax 01202 874562; Email: orders@epemag.wimborne.co.uk. On-line Shop: www.epemag.wimborne.co.uk/shopdoor.htm.** Cheques should be crossed and made payable to *Everyday Practical Electronics* **(Payment in £ sterling only).**

NOTE: While 95% of our boards are held in stock and are dispatched within seven days of receipt of order, please allow a maximum of 28 days for delivery – overseas readers allow extra if ordered by surface mail.

Back numbers or photostats of articles are available if required – see the *Back Issues* page for details. We do not supply kits or components for our projects.

Please check price and availability in the latest issue.

A large number of older boards are listed on our website.

Boards can only be supplied on a payment with order basis.

PROJECT TITLE		Order Code	Cost
Radio Circuits–1 MK484 TRF Receiver	JUNE '03	392	£4.44
Headphone Amp.		393	£4.28
★Fido Pedometer		394	£4.91
★PICronos L.E.D. Wall Clock		395	£14.65
EPE Mini Metal Detector	JULY '03	396	£4.28
Radio Circuits – 2 Q-Multiplier		397	£4.28
MW Reflex Radio		398	£4.60
Wave Trap		399	£4.28
Speaker Amplifier		400	£4.44
Ohmmeter Adaptor MkII		401	£4.60
Ultimate Egg Timer (Top Tenner)		403	£4.91
★EPE PIC Met Office	AUG '03	402	£10.46
Alarm System Fault Finder		404	£4.44
Radio Circuits–3 Regen. Radio		405	£5.07
Tuning Capacitor Board		406	£4.28
Master/Slave Intercom (Top Tenner)		407	£4.75
Two-Up (Top Tenner)		408	£4.91
Priority Referee (Top Tenner)	SEPT '03	410	£5.07
Vibration Alarm (Top Tenner)		411	£5.39
Radio Circuits–4 Varicap Tuner		412	£4.44
Coil Pack – General Coverage		413	£5.07
Coil Pack – Amateur Bands		414	£4.75
★PIC-A-Colour – **Software only**		–	–
Spooky Bug (Top Tenner)	OCT '03	409	£5.07
Radio Circuits–5 Crystal Marker		415	£4.44
Super Regen. Receiver		419	£5.07
Buffer Amplifier		420	£4.44
★★Serial Interface for PICs and VB6		416	£5.23
★PIC Breakpoint – **Software only**		–	–
Anyone At Home – Logic Board	NOV '03	421 } Pair	£6.35
– Relay Board		422 }	
Radio Circuits–6 Direct Conversion SW Receiver		423	£6.02
★PIC Random L.E.D. Flasher		424	£4.60
★PIC Virus Zapper Mk2	DEC '03	425	£5.72
Radio Circuits–7 SW Superhet Tuner/Mixer		426	£5.70
Christmas Cheeks (double-sided)		427	£4.44
★PIC Nim Machine – **Software only**		–	–
Bedside Nightlight (Top Tenner)	JAN '04		
Sound Trigger		417	£4.44
Timing/Lamp		418	£4.60
Radio Circuits–8 Dual Conversion SW Rec. – I.F. Amp		428	£5.71
– Signal-Strength Meter		429	£4.45
– B.F.O./Prod. Detector		430	£4.75
★Car Computer (double-sided)		431	£7.61
★PIC Watering Timer – **Software only**		–	–
★GPS to PIC and PC Interface – **Software only**		–	–
Jazzy Necklace	FEB '04	432 pair	£5.40
Sonic Ice Warning		433	£5.39
★LCF Meter		434	£5.00
★PIC Tug-of-War		435	£5.00
Bat-Band Convertor	MAR '04	436	£4.76
★MIDI Health Check – Transmitter/Receiver		437 pair	£7.61
Emergency Stand-by Light		438	£5.55
★PIC Mixer for RC Planes – **Software only**		–	–
★Teach-In '04 Part 5 – **Software only**		–	–
Infra-Guard	APR '04	439	£5.07
★Moon Clock		442	£5.71
★Teach-In '04 Part 6 – **Software only**		–	–
★EPE Seismograph Logger	APR '04		
Control Board		440 } pair	£6.50
Sensor Amp. Board		441 }	
In-Car Lap-Top PSU	MAY '04	443	£4.60
Beat Balance Metal Detector		444	£4.60
Teach-In '04 Part 7 – Transmitter		445	£4.91
Receiver		446	£4.75
Moisture		447	£4.44
★PIC Quickstep	JUNE '04	448	£5.71
Body Detector MkII		449	£4.91
★Teach-In '04 Part 8 – **Software only**		–	–
★MIDI Synchronome – **Software only**		–	–
Hard Drive Warbler	JULY '04	450	£4.60
★Bongo Box		451	£6.02
Portable Mini Alarm – Sensor		452	£5.23
– Counter		453	£5.07
★Teach-In '04 Part 9			
PIC Combination Lock Alarm Monitor		454	£5.07
★EPE Magnetometry Logger		455	£5.71
Keyring L.E.D. Torch	AUG '04	456	£4.12
★Teach-In '04 Part 10 – PIC Curtain or Blind Winder		457	£5.39
Simple F.M. Radio – F.M. Tuner		458	£5.07
– Tone Control		459	£4.75
– Audio Power Amp (TDA2003)		347	£4.60
– Power Supply		460	£5.39
★EPE Scorer – Control Board		461	£6.66
– Display Board		462	£7.93
– Slave Board		463	£5.55
★PIC to Mouse/Keyboard – **Software only**		–	–
EPE Wart Zapper	SEPT '04	464	£4.60
★Radio Control Failsafe		465	£4.76
★AlphaMouse Game		466	£4.60
★Rainbow Lighting Controller – **Software only**		–	–
★Moon and Tide Clock Calendar	OCT '04	467	£5.55
Volts Checker		468	£4.20
★Smart Karts – **Software only**		–	–
Logic Probe	NOV '04	469	£4.76
Thunderstorm Monitor		470	£5.39
MW Amplitude Modulator			
– V.F.O./Buffer		471	£4.76
– Modulator/PA		472	£5.07
– Power Supply		473	£4.76
Super Vibration Switch	DEC '04	474	£4.75
★Wind Direction Indicator		475	£6.18
★PIC Flasher Mk2			
– Control Board		476	£4.75
– Transmitter		477	£4.44
– Multipurpose Board		478	£4.75
– Simple Cycler		479	£4.44
– Luxeon V Controller		480	£4.44

EPE SOFTWARE

Software programs for *EPE* projects marked with a single asterisk ★ are available on 3·5 inch PC-compatible disks or *free* from our Internet site. The following disks are available: **PIC Tutorial V2** (Apr-June '03); ***EPE* Disk 3** (2000); ***EPE* Disk 4** (2001 – excl. PIC Toolkit TK3); ***EPE* Disk 5** (2002); ***EPE* Disk 6** (2003 – excl. Earth Resistivity and Met Office); ***EPE* Disk 7** (Jan 2004 to current cover date); ***EPE* Earth Resistivity Logger** (Apr-May '03); ***EPE* PIC Met Office** (Aug-Sept '03); ***EPE* Seismograph** (Apr-May '04); ***EPE* Magnetometry Logger** (July-Aug '04); ***EPE* Teach-In 2000; *EPE* Spectrum; *EPE* Interface Disk 1** (October '00 issue to current cover date). **EPE Toolkit TK3** software is available on the *EPE* PIC Resources CD-ROM, £14.45. Its p.c.b. is order code 319, £8.24. ★★The software for these projects is on its own CD-ROM. The 3·5 inch disks are £3.00 each (UK), the CD-ROMs are £6.95 (UK). Add 50p each for overseas surface mail, and £1 each for airmail. All are available from the *EPE PCB Service*. All files can be downloaded *free* from our Internet FTP site, accessible via our home page at: **www.epemag.co.uk.**

EPE PRINTED CIRCUIT BOARD SERVICE

Order Code Project Quantity Price

....

Name ....

Address ....

....

Tel. No. ....

I enclose payment of £................ (cheque/PO in **£ sterling only**) to:

Everyday Practical Electronics

MasterCard, Amex, Diners Club, Visa or Switch/Maestro

Card No. ....

Valid From .... Expiry Date ....

Card Security Code .... Switch/Maestro Issue No ....
(The last 3 digits on or just under the signature strip)

Signature ....

NOTE: You can also order p.c.b.s by phone, Fax, Email or via our Internet site on a secure server:

http://www.epemag.wimborne.co.uk/shopdoor.htm

EVERYDAY PRACTICAL ELECTRONICS

The No 1 Magazine for Electronics & Computer Projects

VOLUME 33 INDEX

JANUARY 2004 TO DECEMBER 2004

Pages	Issue	Pages	Issue
1-80	January	437-516	July
81-152	February	517-596	August
153-224	March	597-668	September
225-292	April	669-748	October
293-364	May	749-827	November
365-436	June	829-908	December

CONSTRUCTIONAL PROJECTS

GENERAL FEATURES

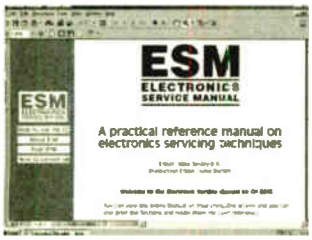
SPECIAL SERIES

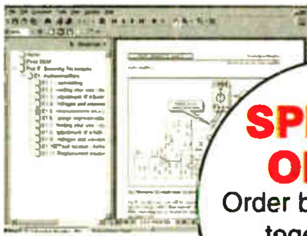
REGULAR FEATURES

SPECIAL OFFERS AND SERVICES

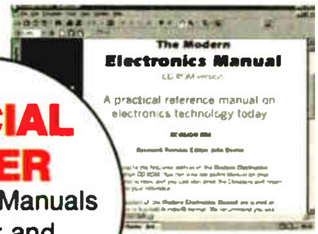
ELECTRONICS MANUALS ON CD-ROM £29.95 EACH

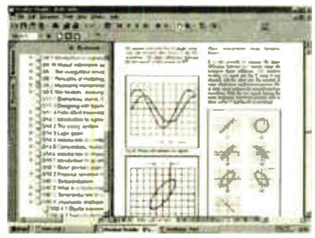
ELECTRONICS SERVICE MANUAL





THE MODERN ELECTRONICS MANUAL





SPECIAL OFFER
Order both Manuals together and
SAVE £10

Everything you need to know to get started in repairing electronic equipment

• Around 900 pages • Fundamental principles • Troubleshooting techniques • Servicing techniques • Choosing and using test equipment • Reference data • Manufacturers' web links • Easy-to-use Adobe Acrobat format • Clear and simple layout • Vital safety precautions • Professionally written • Supplements

SAFETY: Safety Regulations, Electrical Safety and First Aid. **UNDERPINNING KNOWLEDGE:** Electrical and Electronic Principles, Active and Passive Components, Circuit Diagrams, Circuit Measurements, Radio, Computers, Valves and Manufacturers' Data, etc. **PRACTICAL SKILLS:** Learn how to identify Electronic Components, Avoid Static Hazards, Carry Out Soldering and Wiring, Remove and Replace Components. **TEST EQUIPMENT:** How to Choose and Use Test Equipment, Assemble a Toolkit, Set Up a Workshop, and Get the Most from Your Multimeter and Oscilloscope, etc. **SERVICING TECHNIQUES:** The Manual includes vital guidelines on how to Service Audio Amplifiers. The Supplements include similar guidelines for Radio Receivers, TV Receivers, Cassette Recorders, Video Recorders, Personal Computers, etc. **TECHNICAL NOTES:** Commencing with the IBM PC, this section and the Supplements deal with a very wide range of specific types of equipment – radios, TVs, cassette recorders, amplifiers, video recorders etc. **REFERENCE DATA:** Diodes, Small-Signal Transistors, Power Transistors, Thyristors, Triacs and Field Effect Transistors. Supplements include Operational Amplifiers, Logic Circuits, Optoelectronic Devices, etc.

The essential reference work for everyone studying electronics

• Over 800 pages • In-depth theory • Projects to build • Detailed assembly instructions • Full components checklists • Extensive data tables • Manufacturers' web links • Easy-to-use Adobe Acrobat format • Clear and simple layout • Comprehensive subject range • Professionally written • Supplements

BASIC PRINCIPLES: Electronic Components and their Characteristics); Circuits Using Passive Components; Power Supplies; The Amateur Electronics Workshop; The Uses of Semiconductors; Digital Electronics; Operational Amplifiers; Introduction to Physics, including practical experiments; Semiconductors and Digital Instruments. **CIRCUITS TO BUILD:** The Base Manual describes 12 projects including a Theremin and a Simple TENS Unit. **ESSENTIAL DATA:** Extensive tables on diodes, transistors, thyristors and triacs, digital and linear i.c.s. **EXTENSIVE GLOSSARY:** Should you come across a technical word, phrase or abbreviation you're not familiar with, simply look up the glossary and you'll find a comprehensive definition in plain English.
The Manual also covers **Safety** and provides web links to component and equipment **Manufacturers and Suppliers.**

Full contents list available online at: www.epemag.wimborne.co.uk

Supplements: Additional CD-ROMs each containing approximately 500 pages of additional information on specific areas of electronics are available for £19.95 each. Information on the availability and content of each Supplement CD-ROM will be sent to you.
Presentation: CD-ROM suitable for any modern PC. Requires Adobe Acrobat Reader which is included on the CD-ROM.

Wimborne Publishing Ltd., Dept Y12, 408 Wimborne Road East, Ferndown, Dorset BH22 9ND. Tel: 01202 873872. Fax: 01202 874562.

PLEASE send me

☐ THE MODERN ELECTRONICS MANUAL CD-ROM
☐ ELECTRONICS SERVICE MANUAL CD-ROM

I enclose payment of £29.95 (for one Manual) or £49.90 for both Manuals (saving £10 by ordering both together).

FULL NAME ....
(PLEASE PRINT)
ADDRESS ....
....
....POSTCODE ....
SIGNATURE ....

☐ I enclose cheque/PO in UK pounds payable to Wimborne Publishing Ltd.
☐ Please charge my Visa/Mastercard/Amex/Diners Club/Switch/Maestro

Card No .... Switch/Maestro Issue No ......
Valid From .... Expiry Date ....
Card Security Code .... (The last 3 digits on or just under the signature strip)

ORDER FORM

Simply complete and return the order form with your payment to the following address:

**Wimborne Publishing Ltd,
Dept. Y12,
408 Wimborne Road East, Ferndown,
Dorset BH22 9ND**

Price includes postage to anywhere in the World

We will happily exchange any *faulty* CD-ROMs but since the content can be printed out we do not offer a refund on these items.

Your CD-ROM(s) will be posted to you by first class mail or airmail, normally within four working days of receipt of your order

EVERYDAY PRACTICAL ELECTRONICS CLASSIFIED

Everyday Practical Electronics reaches twice as many UK readers as any other UK monthly hobby electronics magazine, our sales figures prove it. We have been the leading monthly magazine in this market for the last nineteen years.

If you want your advertisements to be seen by the largest readership at the most economical price our classified and semi-display pages offer the best value. The prepaid rate for semi-display space is £10 (+VAT) per single column centimetre (minimum 2·5cm). The prepaid rate for classified adverts is 40p (+VAT) per word (minimum 12 words).

All cheques, postal orders, etc., to be made payable to Everyday Practical Electronics. **VAT must be added.** Advertisements, together with remittance, should be sent to Everyday Practical Electronics Advertisements, Mill Lodge, Mill Lane, Thorpe-le-Soken, Essex CO16 0ED. Phone/Fax (01255) 861161.

For rates and information on display and classified advertising please contact our Advertisement Manager, Peter Mew as above.

BOWOOD ELECTRONICS LTD
Suppliers of Electronic Components
Place a secure order on our website or call our sales line
All major credit cards accepted
Web: www.bowood-electronics.co.uk
Unit 1, McGregor's Way, Turnoaks Business Park, Chesterfield, S40 2WB. Sales: 01246 200222
Send 60p stamp for catalogue

The Versatile, Programmable On Screen Display System
www.STV5730A.co.uk

- Fully programmable
- PIC 16F628 microcontroller
- Demo software code available
- OSD IC 28 by 11 screen
- I/O lines free to connect sensors or buttons
- Serial or PC keyboard interface versions

X-10® Home Automation
We put *you* in control™

Why tolerate when you can automate?
An extensive range of 230V X-10 products and starter kits available. Uses proven Power Line Carrier technology, no wires required.
Products Catalogue available Online.
Worldwide delivery.

Laser Business Systems Ltd.
E-Mail: info@laser.com
http://www.laser.com
Tel: (020) 8441 9788
Fax: (020) 8449 0430

VVT TRANSFORMERS
Transformers and Chokes for all types of circuits including specialist valve units
Custom design or standard range
High and low voltage
Variable Voltage Technology Ltd
Unit 3, Sheat Manor Farm, Chillerton, Newport, Isle of Wight, PO30 3HP
Tel: 0870 243 0414 Fax: 01983 721572
email: sales@vvt-cowes.freeserve.co.uk
www.vvttransformers.co.uk

TOTALROBOTS
ROBOTICS, CONTROL & ELECTRONICS TECHNOLOGY
High quality robot kits and components
UK distributor of the OOPic microcontroller
Secure on-line ordering
Rapid delivery
Highly competitive prices
Visit **www.totalrobots.com**
Tel: 0208 823 9220

Component Kits!

Mail order P&P: £2.50 (Free P&P orders over £20)
www.fastcomponents.co.uk
Tel: 0870 750 4468 Fax: 0870 137 6005
Winchester House, Winchester Rd, Walton-on-Thames, Surrey. KT12 2RH

TRANSFORMERS
- Custom Wound
- 1 Phase to 50kVA
- 3 Phase to 100kVA
- A.C. and D.C. Chokes
- H.T. up to 5kV
- Transformer Kits
- Coils up to 1m Dia.
- Transformer Rectifiers
- Toroidals
- Motor Generators

Visit www.jemelec.com for details or request our free leaflet
Jemelec, Unit 16, Vanguard Trading Estate, Storforth Lane, Chesterfield, S40 2TZ
Tel: 0870 787 1769

BTEC ELECTRONICS TECHNICIAN TRAINING
VCE ADVANCED ENGINEERING ELECTRONICS AND ICT
HNC AND HND ELECTRONICS
NVQ ENGINEERING AND IT
PLEASE APPLY TO COLLEGE FOR NEXT COURSE DATE
FULL PROSPECTUS FROM
LONDON ELECTRONICS COLLEGE (Dept EPE) 20 PENYWERN ROAD EARLS COURT, LONDON SW5 9SU TEL: (020) 7373 8721

PC Oscilloscope & Signal Generator

3-in-1 Digital Oscilloscope + Signal Generator + Spectrum Analyser. Samples at 20 or 30 Msps. Programmable signal generator with built in sine, triangular, saw and square waves in normal & sweep modes. Plugs into printer port.
Prices from £119 – CL SYSTEM
Visit *www.clsystem.co.uk* or call 07986 860815

Miscellaneous

FREE! PROTOTYPE PRINTED CIRCUIT BOARDS! Free prototype p.c.b. with quantity orders. Call Patrick on 028 9073 8897 for details. Agar Circuits, Unit 5, East Belfast Enterprise Park, 308 Albertbridge Road, Belfast BT5 4GX.

PRINTED CIRCUIT BOARDS – QUICK SERVICE. Prototype and production artwork raised from magazines or draft designs at low cost. PCBs designed from schematics. Production assembly, wiring and software programming. For details contact Patrick at Agar Circuits, Unit 5, East Belfast Enterprise Park, 308 Albertbridge Road, Belfast, BT5 4GX. Phone 028 9073 8897, Fax 028 9073 1802, Email agar@argonet.co.uk.

VALVES AND ALLIED COMPONENTS IN STOCK. Phone for free list. Valves, books and magazines wanted. Geoff Davies (Radio), tel. 01788 574774.

KITS, TOOLS, COMPONENTS. S.a.e. catalogue: Sir-Kit Electronics, 52 Severn Road, Clacton, CO15 3RB. **www.geocities.com/sirkituk.**

Computer Software

FREE DOWNLOADABLE SOFTWARE: Electronics, Electrical and Computing V8.2. Computer Science V8.2 and GCSE Maths V8.2. Still selling at £120 each on CDROM is now available to download and fully install to your hard drive COMPLETELY FREE OF CHARGE. Latest update includes the new Web Links feature. Visit www.eptsoft.com for details.

YOU CAN ADVERTISE IN THIS SPACE FOR JUST
£50.00 + VAT
CONTACT PETER MEW ON
01255 861161

ADVERTISERS INDEX

ADVERTISEMENT MANAGER: PETER J. MEW
ADVERTISEMENT OFFICES:
EVERYDAY PRACTICAL ELECTRONICS, ADVERTISEMENTS, MILL LODGE, MILL LANE, THORPE-LE-SOKEN, ESSEX CO16 0ED. Phone/Fax: (01255) 861161
For Editorial address and phone numbers see page 839

EPE SUBSCRIPTIONS

Subscriptions for delivery direct to any address in the UK: 6 months £16.50, 12 months £31, two years £57; Overseas: 6 months £19.50 standard air service or £28.50 express airmail, 12 months £37 standard air service or £55 express airmail, 24 months £69 standard air service or £105 express airmail. Cheques or bank drafts (in **£ sterling only**) payable to *Everyday Practical Electronics* and sent to *EPE* Subs. Dept., Wimborne Publishing Ltd., 408 Wimborne Road East, Ferndown, Dorset BH22 9ND. Tel: 01202 873872. Fax: 01202 874562. **Email**: subs@epemag.wimborne.co.uk. Also via the **Web** at **http://www.epemag.wimborne.co.uk**. Subscriptions start with the next available issue. We accept MasterCard, Amex, Diners Club, Switch or Visa. (For past issues see the Back Issues page.)

ONLINE SUBSCRIPTIONS

Online subscriptions, for downloading the magazine via the Internet, $10.99US (approx. £7) for one year available from **www.epemag.com**.

USA/CANADA SUBSCRIPTIONS

To subscribe to *EPE* from the USA or Canada please telephone Express Mag toll free on 1877 363-1310 and have your credit card details ready. Or fax (514) 355 3332 or write to Express Mag, PO Box 2769, Plattsburgh, NY 12901-0239 or Express Mag, 8155 Larney Street, Anjou, Quebec, H1J 2L5.
Email address: expsmag@expressmag.com.
Web site: **www.expressmag.com.**
USA price $60(US) per annum, Canada price $97(Can) per annum – 12 issues per year.

Everyday Practical Electronics, periodicals pending, ISSN 0262 3617 is published twelve times a year by Wimborne Publishing Ltd., USA agent USACAN at 1320 Route 9, Champlain, NY 12919. Subscription price in US $60(US) per annum. Periodicals postage paid at Champlain NY and at additional mailing offices. POSTMASTER: Send USA and Canada address changes to Everyday Practical Electronics, c/o Express Mag., PO Box 2769, Plattsburgh, NY, USA 12901-0239.

Published on approximately the second Thursday of each month by Wimborne Publishing Ltd., 408 Wimborne Road East, Ferndown, Dorset BH22 9ND. Printed in England by Apple Web Offset Ltd., Warrington, WA1 4RW. Distributed by COMAG Magazine Marketing, Tavistock Rd., West Drayton, UB7 7QE. **Subscriptions** INLAND: £16.50 (6 months); £31 (12 months); £57 (2 years). OVERSEAS: Standard air service, £19.50 (6 months); £37 (12 months); £69 (2 years). Express airmail, £28.50 (6 months); £55 (12 months); £105 (2 years). Payments payable to "Everyday Practical Electronics", Subs Dept, Wimborne Publishing Ltd. Email: subs@epemag.wimborne.co.uk. EVERYDAY PRACTICAL ELECTRONICS is sold subject to the following conditions, namely that it shall not, without the written consent of the Publishers first having been given, be lent, resold, hired out or otherwise disposed of by way of Trade at more than the recommended selling price shown on the cover, and that it shall not be lent, resold, hired out or otherwise disposed of in a mutilated condition or in any unauthorised cover by way of Trade or affixed to or as part of any publication or advertising, literary or pictorial matter whatsoever.