



*Volume 2 Issue 12*  
*December 2000*

**Copyright © 2000, Wimborne Publishing Ltd**  
(Allen House, East Borough, Wimborne, Dorset, BH21 1PF, UK)

**and Maxfield & Montrose Interactive Inc.,**  
(PO Box 857, Madison, Alabama 35758, USA)

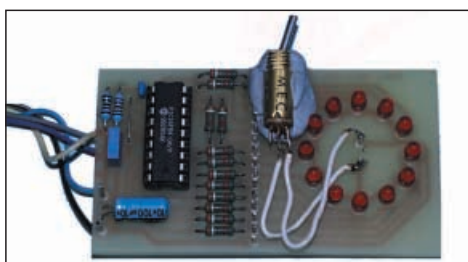
**All rights reserved.**

## ***WARNING!***

The materials and works contained within *EPE Online* — which are made available by Wimborne Publishing Ltd and Maxfield & Montrose Interactive Inc — are copyrighted. You are permitted to make a backup copy of the downloaded file and one (1) hard copy of such materials and works for your personal use. International copyright laws, however, prohibit any further copying or reproduction of such materials and works, or any republication of any kind.

Maxfield & Montrose Interactive Inc and Wimborne Publishing Ltd have used their best efforts in preparing these materials and works. However, Maxfield & Montrose Interactive Inc and Wimborne Publishing Ltd make no warranties of any kind, expressed or implied, with regard to the documentation or data contained herein, and specifically disclaim, without limitation, any implied warranties of merchantability and fitness for a particular purpose.

Because of possible variances in the quality and condition of materials and workmanship used by readers, *EPE Online*, its publishers and agents disclaim any responsibility for the safe and proper functioning of reader-constructed projects based on or from information published in these materials and works. In no event shall Maxfield & Montrose Interactive Inc or Wimborne Publishing Ltd be responsible or liable for any loss of profit or any other commercial damages, including but not limited to special, incidental, consequential, or any other damages in connection with or arising out of furnishing, performance, or use of these materials and works.



**NOTE NEW PUBLISHING DATE**  
 January issue on sale  
 Thursday December 14

© Wimborne Publishing Ltd 2000. Copyright in all drawings, photographs and articles published in EVERYDAY PRACTICAL ELECTRONICS is fully protected, and reproduction or imitations in whole or in part are expressly forbidden.

Our January 2001 issue will be published on Thursday, 14 December 2000. See page 875 for details

## Projects and Circuits

**PIC-MONITORED DUAL PSU - 1** by John Becker 884

Workshop power supply with multiple options and monitoring of voltage and current using PIC microcontroller plus I.C.D. readout

**STATIC FIELD DETECTOR** by Robert Penfold 894

An amusing "electroscope" starter project that reveals if your friends are "highly charged"!

**INGENUITY UNLIMITED** hosted by Alan Winstanley 902

Car Wash-Wipe Latch; Missed Call Indicator; Scissors, Paper, Stone

**MOTORIST'S BUZZ-BOX** by Terry de Vaux-Balbirnie 930

A multipurpose test instrument for the intrepid car owner

**CHRISTMAS SUPPLEMENT** Between pages 912 and 913

**TWINKLING STAR** by Bart Trepak 1

Twinkle twinkle little LED, brighten our festives as we're fed!

**CHRISTMAS BUBBLE** by Owen Bishop 4

Keep the party balloons intact, watch light bubbles burst instead!

**FESTIVE FADER** by Steve Dellow 7

Relax your Noelistic senses with smoothly changing lighting effects!

**PICTOGRAM** by Andy Flind 13

Become a novelty flasher at the Mad Hatter's (or other's) Xmas party!

## Series and Features

**CIRCUIT SURGERY** by Alan Winstanley and Ian Bell 908

Switched-Mode Power Supplies

**THE SCHMITT TRIGGER - 2.**

**Op.amp and comparator triggers** by Anthony H. Smith 913

A designer's guide to investigating and using Schmitt triggers

**NEW TECHNOLOGY UPDATE** by Ian Poole 924

Inkjet and optical technologies combine to provide greater comms bandwidth

**INTERFACE** by Robert Penfold 926

Extended temperature PC Interface software

**NET WORK - THE INTERNET PAGE** surfed by Alan Winstanley 929

Freeserve - and other "unmetered" servers

**QUASAR KITS REVIEW** by Robert Penfold 938

Examining the merits of a dozen electronic kits from Quasar

## Regulars and Services

**EDITORIAL** 883

**NEWS** - Barry Fox highlights technology's leading edge 892

Plus everyday news from the world of electronics

**BACK ISSUES** Did you miss these? Some now on CD-ROM! 899

**READOUT** John Becker addresses general points arising 905

**ELECTRONICS MANUALS** 922

Essential reference works for hobbyists, students and service engineers

**SHOPTALK** with David Barrington 920

The *essential* guide to component buying for *EPE* projects

**CD-ROMS FOR ELECTRONICS** 940

Electronic Projects; Filters; Digital Works 3.0; Parts Gallery + Electronic Circuits and Components; Digital Electronics; Analogue Electronics; PICtutor; Modular Circuit Design; Electronic Components Photos.

**DIRECT BOOK SERVICE** 943

A wide range of technical books available by mail order, plus more CD-ROMs

**PRINTED CIRCUIT BOARD AND SOFTWARE SERVICE** 946

PCBs for *EPE* projects. Plus *EPE* software

**ELECTRONICS VIDEOS** Our range of educational videos 949

**ANNUAL INDEX 2000** 947

**ADVERTISERS INDEX** 952

Readers Services • Editorial and Advertisement Departments 883



Visit our website  
www.distel.co.uk

# THE ORIGINAL SURPLUS WONDERLAND!

THIS MONTH'S SELECTION FROM OUR VAST EVER CHANGING STOCKS

Surplus always  
wanted for cash!

## THE AMAZING TELEBOX

Converts your colour monitor into a QUALITY COLOUR TV!!



TV SOUND &  
VIDEO TUNER  
CABLE COMPATIBLE\*

The TELEBOX is an attractive fully cased mains powered unit, containing all electronics ready to plug into a host of video monitors or AV equipment which are fitted with a composite video or SCART input. The composite video output will also plug directly into most video recorders, allowing reception of TV channels not normally receivable on most television receivers\* (TELEBOX MB). Push button controls on the front panel allow reception of 8 fully tuneable 'off air' UHF colour television channels. TELEBOX MB covers virtually all television frequencies VHF and UHF including the HYPERBAND as used by most cable TV operators. Ideal for desktop computer video systems & PIP (picture in picture) setups. For complete compatibility - even for monitors without sound - an integral 4 watt audio amplifier and low level Hi Fi audio output are provided as standard. Brand new - fully guaranteed.

TELEBOX ST for composite video input type monitors £36.95  
TELEBOX STL as ST but fitted with integral speaker £39.50  
TELEBOX MB Multiband VHF/UHF/Cable/Hyperband tuner £69.95  
For overseas PAL versions state 5.5 or 6 MHz sound specification.  
\*For cable / hyperband signal reception Telebox MB should be connected to a cable type service. Shipping on all Telebox's, code (B)

**NEW** State of the art PAL (UK spec) UHF TV tuner module with composite 1V pp video & NICAM hi fi stereo sound outputs. Micro electronics all on one small PCB only 73 x 160 x 52 mm enable full tuning control via a simple 3 wire link to an IBM pc type computer. Supplied complete with simple wiring program and documentation. Requires +12V & +5V DC to operate. **BRAND NEW - Order as MY00. Only £49.95 code (B)**  
See [www.distel.co.uk/data\\_my00.htm](http://www.distel.co.uk/data_my00.htm) for picture & full details

## FLOPPY DISK DRIVES 2 1/2" - 8"

All units (unless stated) are **BRAND NEW** or removed from often brand new equipment and are fully tested, aligned and shipped to you with a full 90 day guarantee. Call or see our web site [www.distel.co.uk](http://www.distel.co.uk) for over 2000 unlisted drives for spares or repair.

3 1/2" Mitsubishi MF355C-L 1.4 Meg. Laptops only £25.95(B)  
3 1/2" Mitsubishi MF355C-D 1.4 Meg. Non laptop £18.95(B)  
5 1/4" Teac FD-55GFR 1.2 Meg. (for IBM pc's) RFE £18.95(B)  
5 1/4" Teac FD-55F-03 U 720K 40/80 (for BBC's etc) RFE £29.95(B)  
5 1/4" BRAND NEW Mitsubishi MF501B 360K £22.95(B)  
Table top case with integral PSU for HH 5 1/4" Floppy / HD £29.95(B)  
8" Shugart 80/801 8" SS refurbished & tested £210.00(E)  
8" Shugart 810 8" SS HH Brand New £195.00(E)  
8" Shugart 851 8" double sided refurbished & tested £260.00(E)  
8" Mitsubishi M2894-63 double sided NEW £295.00(E)  
8" Mitsubishi M2896-63-02U DS slimline NEW £295.00(E)  
Dual 8" cased drives with integral power supply 2 Mb £499.00(E)

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

2 1/2" TOSHIBA MK1002MAV 1.1Gb laptop (12.5 mm H) New £79.95  
2 1/2" TOSHIBA MK2101MAN 2.1Gb laptop (19 mm H) New £89.50  
2 1/2" TOSHIBA MK4309MAT 4.3Gb laptop (8.2 mm H) New £105.00  
2 1/2" TOSHIBA MK6409MAV 6.1Gb laptop (12.7 mm H) New £190.00  
2 1/2" to 3 1/2" conversion kit for Pc's, complete with connectors £14.95  
3 1/2" FUJII FK-309-26 20mb MFM I/F RFE £59.95  
3 1/2" CONNER CP3024 20 mb IDE I/F (or equiv.) RFE £59.95  
3 1/2" CONNER CP3024 40 mb IDE I/F (or equiv.) RFE £69.00  
3 1/2" QUANTUM 40S Prodi 40 mb MFM I/F (or equiv.) RFE £49.00  
5 1/4" MINISCRIIBE 3425 20mb MFM I/F (or equiv.) RFE £49.95  
5 1/4" SEAGATE ST-238R 30 mb RLL I/F Return £69.95  
5 1/4" CDC 94205-51 40mb HH MFM I/F RFE tested £99.00  
5 1/4" HP 97548 850 Mb SCSI RFE tested £99.00  
5 1/4" HP C3010 2 Gbyte SCSI differential RFE tested £195.00  
8" NEC D2246 85 Mb SMD interface. New £199.00  
8" FUJITSU M2322K 160Mb SMD I/F RFE tested £195.00  
8" FUJITSU M2392K 2 Gb SMD I/F RFE tested £345.00  
Many other drives in stock - Shipping on all drives is code (C1)

## TEST EQUIPMENT & SPECIAL INTEREST ITEMS

MITTS. FA3455ETKL 14" Industrial spec SVGA monitors £245  
FARNELL 0-60V DC @ 50 Amps, bench Power Supplies £995  
FARNELL AP3080 0-30V DC @ 80 Amps, bench Supply £1850  
1kW to 400 kW - 400 Hz 3 phase power sources - ex stock EPOA  
IBM 8230 Type 1, Token ring base unit driver £760  
Wayne Kerr RA200 Audio frequency response analyser £2500  
IBM 53F5501 Token Ring ICS 20 port lobe modules £750  
IBM MAU Token ring distribution panel 8228-23-5050N £95  
AIM 501 Low distortion Oscillator 9Hz to 330KHz, IEEE £550  
ALLGON 8360 11805-1880 MHz hybrid power combiners £250  
Trend DSA 274 Data Analyser with G703(2M) 64 v/o EPOA  
Marconi 6310 Programmable 2 to 22 GHz sweep generator £6500  
Marconi 2022C 10KHz-1GHz RF signal generator £1550  
Marconi 2030 opt 03 10KHz-1.3 GHz signal generator, New £4995  
HP1650B Logic Analyser £3750  
HP3781A Pattern generator & HP3782A Error Detector EPOA  
HP6621A Dual Programmable GPIB PSU 0-7 V 160 watts £1800  
HP6254 Rack mount variable 0-20V @ 20A metered PSU £675  
HP54121A DC to 22 GHz four channel test set EPOA  
HP8130A opt 020 300 MHz pulse generator, GPIB etc £7900  
HP A1, A0 8 pen HPGL high speed drum plotters - from £550  
HP DRAFTMASTER 1 8 pen high speed plotter £750  
Eva-G Brookdale 9503SC Precision lock in amp £1800  
View Eng. Mod 1200 compensated inspection system EPOA  
Sony DXC-3000V High quality CCD colour TV camera £995  
Keithley 590 CV capacitor / voltage analyser EPOA  
Racal ICR40 dual 40 channel voice recorder system £3750  
Fiskers 45KVA 3 ph On Line UPS - New batteries £9500  
Emerson AP130 2.5KVA industrial spec UPS £2100  
Mann Tally M7645 High speed line printer £2200  
Intel SBC 486/133SE Multibus 486 system, 8Mb Ram £945  
Siemens K4400 64Kb to 140Mb demux analyser £2950

## IC's - TRANSISTORS - DIODES

OBSOLETE - SHORT SUPPLY - BULK  
10,000,000 items EX STOCK  
For MAJOR SAVINGS

CALL OR SEE OUR WEB SITE [www.distel.co.uk](http://www.distel.co.uk)

## VIDEO MONITOR SPECIALS

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

Mitsubishi FA3415ETKL 14" SVGA Multisync colour monitor with fine 0.28 dot pitch tube and resolution of 1024 x 768. A variety of inputs allows connection to a host of computers including IBM PC's in CGA, EGA, VGA & SVGA modes, BBC, COMMODORE (including Amiga 1200), ARCHIMEDES and APPLE. Many features: Etched faceplate, text switching and LOW RADIATION MPR specification. Fully guaranteed, in EXCELLENT little

used condition. Order as T11 & Swivel Base £475  
VGA cable for IBM PC included. Only £119 (E) MITS-SVGA

External cables for other types of computers available - CALL

Ex demo 17" 0.28 SVGA Mitsubishi Diamond Pro monitors, Full multisync etc.  
Full 90 day guarantee. Only £199.00 (E)

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

PHILIPS HCS35 (same style as CM8833) attractively styled 14" colour monitor with both RGB and standard composite 15.625 KHz video inputs via SCART socket and separate phono jacks. Integral audio power amp and speaker for all audio visual uses. Will connect direct to Amiga and Atari BBC computers. Ideal for all video monitoring / security applications with direct connection to most colour cameras. High quality with many features such as front concealed fan controls, VCR correction button etc. Good used condition - fully tested - guaranteed Dimensions: W14" x H1234" x 15 1/2" D. Only £99.00 (E)

PHILIPS HCS31 Ultra compact 9" colour video monitor with standard composite 15.625 KHz video input via SCART socket. Ideal for all monitoring / security applications. High quality, ex-equipment fully tested & guaranteed (possible minor screen burns). In attractive square black plastic case measuring W10" x H10" x 13 1/2" D. 240 V AC mains powered. Only £79.00 (D)

KME 10" 15M10009 high definition colour monitors with 0.28" dot pitch. Superb clarity and modern styling. Operates from any 15.625 KHz sync RGB video source, with RGB analog and composite sync such as Atari, Commodore Amiga, Acorn Archimedes & BBC. Measures only 13 1/2" x 12" x 11". Good used condition. Only £125 (E)

## 20" 22" and 26" AV SPECIALS

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

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

We probably have the largest range of video monitors in Europe. All sizes and types from 4" to 42" call for info.

## DC POWER SUPPLIES

Virtually every type of power supply you can imagine. Over 10,000 Power Supplies Ex Stock  
Call or see our web site.

HP6030A 0-200V DC @ 17 Amps bench power supply £1950  
Intel SBC 486/125C08 Enhanced Multibus (MSA) New £1150  
Nikon HFX-11 (Ephiphot) exposure control unit £1450  
PHILIPS PM5518 pro. TV signal generator £1250  
Motorola VME Bus Boards & Components List. SAE / CALL EPOA  
Frio 0-18 vdc linear, metered 30 amp bench PSU. New £550  
Tajitsu M3041R 600 LPM high speed band printer £1950  
Fujitsu M3041D 600 LPM printer with network interface £1250  
Perkin Elmer 299B Infrared spectrophotometer £3500  
Perkin Elmer 597 Infrared spectrophotometer £3500  
VG Electronics 1035 TELETEXT Decoding Margin Meter £3250  
LightBand 60 output high spec 2u rack mount video VDA's £495  
Sekonic SD 150H 18 channel digital Hybrid chart recorder £1995  
B&K 2633 Microphone pre amp £300  
Taylor Hobson Tallysur amplifier / recorder £750  
ADC S5200 Carbon dioxide gas detector / monitor £1450  
BBC AM20/3 PPM Meter (Ernest Turner) + drive electronics £75  
ANRITSU 9654A Optical DC-2.5G/b waveform monitor £5650  
ANRITSU MS9001B1 0.6-1.7 uM optical spectrum analyser EPOA  
ANRITSU ML93A optical power meter £990  
ANRITSU Fibre optic characteristic test set EPOA  
R&S FTDZ Dual sound unit £675  
R&S SBUF-E1 Vision modulator £750  
WILTRON 6630B 12.4 / 20GHz RF sweep generator £5750  
TEK 2445 150 MHz 4 trace oscilloscope £1250  
TEK 2465 300 MHz 4 trace oscilloscope rack mount £1955  
TEK TDS380 400MHz digital realtime + disk drive, FFT etc £2900  
TEK TDS224 500MHz digital realtime + colour display etc £5100  
PH3585A Opt 907 20Hz to 40 MHz spectrum analyser £3950  
HILIPS PW1730/10 60KV XRAY generator & accessories EPOA  
CLAUDE LYONS 12A 240V single phase auto. volt. regs £325  
CLAUDE LYONS 100A 240/415V 3 phase auto. volt. regs £2900

## 19" RACK CABINETS

Superb quality 6 foot 40U  
Virtually New, Ultra Smart  
Less than Half Price!

Top quality 19" rack cabinets made in UK by Optima Enclosures Ltd. Units feature designer, smoked acrylic lockable front door, full height lockable full louvered back door and louvered removable side panels. Fully adjustable internal fixing struts, ready punched for any configuration of equipment mounting, plus ready mounted integral 12 way 13 amp socket switched mains distribution strip make these racks some of the most versatile we have ever sold. Racks may be stacked side by side and therefore require only two side panels to stand singly or in multiple bays. Overall dimensions are: 77 1/2" H x 32 1/2" D x 22" W. Order as:

OPT Rack 1 Complete with removable side panels. £345.00 (G)  
OPT Rack 2 Rack. Less side panels. £245.00 (G)

Over 1000 racks, shelves, accessories  
19" 22" & 24" wide 3 to 46 U high.  
Available from stock !!

## 32U - High Quality - All steel RakCab

Made by Eurocraft Enclosures Ltd to the highest possible spec, rack features all steel construction with removable side, front and back doors. Front and back doors are hinged for easy access and all are lockable with five secure 5 lever barrel locks. The front door is constructed of double walled steel with a 'designer style' smoked acrylic front panel to enable status indicators to be seen through the panel, yet remain unobtrusive. Internally the rack features fully slotted reinforced vertical fixing members to take the heaviest of 19" rack equipment. The two movable vertical fixing struts (extras available) are pre punched for standard 'cage nuts'. A mains distribution panel internally mounted to the bottom rear, provides 8 x IEC 3 pin Euro sockets and 1 x 13 amp 3 pin switched utility socket. Overall ventilation is provided by fully louvered back door and double skinned top section with top and side louvers. The top panel may be removed for fitting of integral fans to the sub plate etc. Other features include: fitted castors and floor levelers, prepunched utility panel at lower rear for cable / connector access etc. Supplied in excellent, slightly used condition with keys. Colour Royal blue. External dimensions mm=1625H x 635D x 603 W. (64" H x 25" D x 23 3/4" W)

Sold at Less than a third of makers price !!

A superb buy at only £245.00 (G)

42U version of the above only £345 - CALL

## 12V BATTERY SCOOP - 60% off !!

A special bulk purchase from a cancelled export order brings you the most amazing savings on these ultra high spec 12V DC 14Ah rechargeable batteries. Made by Hawker Energy Ltd, type SBS15H featuring pure lead plates which offer a far superior shelf & guaranteed 15 year service life. Fully BT & BS6290 approved. Supplied BRAND NEW and boxed. Dimensions 200 wide, 137 high, 77 deep: M6 bolt terminals. Fully guaranteed. Current makers price over £70 each. Our Price £35 each (C), or 4 for £99 (E)

## RELAYS - 200,000 FROM STOCK

Save ££££'s by choosing your next relay from our Massive Stocks covering types such as Military, Octal, Cradle, Hermetically Sealed, Continental, Contactors, Time Delay, Relay, Mercury Wetted, Solid State, Printed Circuit Mounting etc. CALL or see our web site [www.distel.co.uk](http://www.distel.co.uk) for more information. Many obsolete types from stock. Save ££££'s

## COLOUR CCD CAMERAS

BIG £  
SAVER

Undoubtedly a miracle of modern technology & our special buying power! A quality product featuring a fully cased COLOUR CCD camera at a give away price! Unit features full autolight sensing for use in low light & high light applications. A 10 mm fixed focus wide angle lens gives excellent focus and resolution from close up to long range. The composite video output will connect to any composite monitor or TV (via SCART socket) and most video recorders. Unit runs from 12V DC so ideal for security & portable applications where mains power not available. Overall dimensions 66 mm wide x 117 deep x 43 high. Supplied BRAND NEW & fully guaranteed with user data, 100's of applications including Security, Home Video, Web TV, Web Cams etc, etc.

Web ref = LK33 ONLY £99.00 or 2 for £180.00 (B)

## SOFTWARE SPECIALS

NT4 WorkStation, complete with service pack 3 and licence - OEM packaged. ONLY £89.00 (B)  
ENCARTA 95 - CDROM, Not the latest - but at this price! £7.95  
DOS 5.0 on 3 1/2" disks with concise books c/w QBasic. £14.95  
Windows for Workgroups 3.11 + Dos 6.22 on 3.5" disks £55.00  
Wordperfect 6 for DOS supplied on 3 1/2" disks with manual. £24.95  
shipping charges for software is code B.

DISTEL on the web !! - Over 16,000,000 items from stock - [www.distel.co.uk](http://www.distel.co.uk)

DISPLAY  
-ELECTRONICS-

ALL MAIL TO  
Dept PE, 29/35 Osborne Rd  
Thornton Heath  
Surrey CR7 8PD  
Open Mon - Fri 9.00 - 5.30

LONDON SHOP  
Open Mon - Sat 9.00 - 5.30  
215 Whitehorse Lane  
South Norwood  
On 68A Bus Route  
14 Thornton Heath &  
Selhurst Park SR Rail Stations

NEW  
DISTEL ©  
Visit our web site  
[www.distel.co.uk](http://www.distel.co.uk)  
email = [admin@distel.co.uk](mailto:admin@distel.co.uk)

ALL ENQUIRIES  
0208 653 3333  
FAX 0208 653 8888

All prices for UK Mainland. UK customers add 17.5% VAT to TOTAL order amount. Minimum order £10. Bona Fide account orders accepted from Government, Schools, Universities and Local Authorities - minimum account order £50. Cheques over £100 are subject to 10 working days clearance. Carriage charges (A)=£3.00, (A1)=£4.00, (B)=£5.50, (C)=£8.50, (D)=£12.50, (E)=£15.00, (F)=£18.00, (G)=£20.00, (H)=£22.00, (I)=£24.00, (J)=£26.00, (K)=£28.00, (L)=£30.00, (M)=£32.00, (N)=£34.00, (O)=£36.00, (P)=£38.00, (Q)=£40.00, (R)=£42.00, (S)=£44.00, (T)=£46.00, (U)=£48.00, (V)=£50.00, (W)=£52.00, (X)=£54.00, (Y)=£56.00, (Z)=£58.00. All goods supplied to the standard Conditions of Sale and unless stated guaranteed for 90 days. All guarantees on a return to base basis. All rights reserved to change prices / specifications without prior notice. Orders subject to stock. Discounts for volume. Top CASH prices paid for surplus goods. All trademarks, tradenames etc acknowledged. © Display Electronics 1999. E & O E. 07/99.

SWITCH  
VISA  
EST. 26 YEARS



# NEXT MONTH

## UFO DETECTOR AND EVENT RECORDER

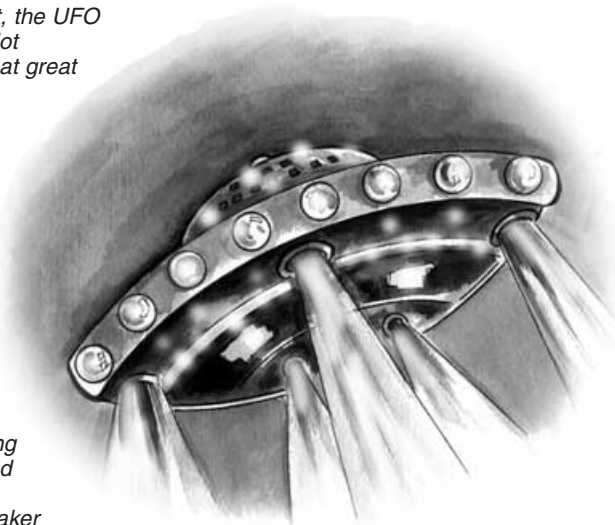
Although some ancient texts are said to contain references to spacecraft, the UFO enigma really began on the afternoon of 24 June, 1947, when aircraft pilot Kenneth Arnold reported nine crescent-shaped objects crossing the sky at great speed near Mount Rainier in the State of Washington, USA. Since then there have been countless sightings, world-wide, and private and government organisations have been set up to investigate and report on the phenomena.

And there's been no shortage of encounters to fill the researchers' files. Whilst many incidents have been shown to have a terrestrial origin, there remains a solid core of cases where inexplicable phenomena and reliable witnesses combine to challenge our disbelief.

One thing running like a thread through many of the reports is the powerful magnetic disturbance which accompanies the craft. Car and aircraft ignition systems falter or fail (presumably the ignition coil core becomes saturated), and dashboard and navigation instruments behave erratically.

As recently as 30 March this year, a family travelling along the Klondike Highway in Canada claim to have observed a saucer-shaped UFO closing in on their car. Headlights dimmed, the tape recorder stopped playing and battery operated watches malfunctioned.

The equipment to be described next month will detect and record far weaker magnetic perturbations than these. Stand-by current is extremely low, and the battery powered units can be operated economically in remote locations. Go out and find your alien!



## A TWO-WAY INTERCOM

Intercom projects used to be part of the staple diet of electronic construction enthusiasts with at least one appearing somewhere every year. Over time they seem to have become less common, perhaps because they can be bought quite cheaply nowadays, so when a reader asked if EPE had recently published one, editorial eyebrows rose at the discovery that some eight years had passed since the last appeared. It seemed timely, therefore, to present a new intercom design.

It might be asked why anyone would build an intercom when they can be bought quite cheaply. In fact there are several reasons. A home-built design can be customised, built into other projects, modified and used in ways its original design never intended. Parts of the circuit might be adapted for use in other projects. The constructor can easily repair it if it goes wrong and an intercom is a good starter project for those seeking electronic experience. Last, but by no means least, constructors with children will probably find that an intercom's entertainment potential will earn them lots of brownie points with the kids! Given all this, a new design seems well worthwhile.

## VERSATILE OPTICAL TRIGGER

This is a circuit that is flexible enough to cater for many different applications. In its basic form, the Versatile Optical Trigger switches a load on or off, depending on the amount of light falling on its sensor. It can be set to respond in reasonably bright conditions or in dim light. It can be adapted to work either way round, switching on when the light gets brighter, or when it becomes dimmer. Applications for the basic circuit include switching on a porch lamp at dusk, briefly sounding a buzzer when someone's shadow falls on the sensor (or when the cat leaves the house by the cat door), or to switch on a lamp in a cupboard when the door is opened. We leave it to the imagination of the reader to find other interesting things to do with this circuit.

**PLUS ALL THE REGULAR FEATURES**

**NO ONE DOES IT BETTER**



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

**Demand is bound to be high**

**JANUARY 2001 ISSUE ON SALE THURSDAY, DECEMBER 14**

# KITMASTER EDUCATIONAL KITS FROM GREENWELD

RADIO CLUBS – NOVICES – COLLEGES – SCHOOLS

www.greenweld.co.uk

## SOLID STATE KITS

ALL KITS BUILT ON TRIPAD PCB BUILD AS YOU SEE SYSTEM	FULL KIT & INSTRUCTIONS	PERFECT FOR NOVICE FIRST TIME BUILDERS IN ELECTRONICS
KMX1 2-IC MK484 MW RADIO	£11.50	KMB43 AUDIO NOISE GENERATOR £11.50
KMX3 1-IC + TRAN MW RADIO	£11.50	KMB45 GENERAL 3 TRANSISTOR AMP £6.75
KMX5 MK484 + 2030 MW RADIO	£21.95	KMB46 LM386 AMPLIFIER GENERAL £6.75
KMX7 MK484 TUNER MW, NO AMP	£7.50	KMB48 COMMON PRE-AMP RADIO £6.75
KMB2 BASIC CRYSTAL SET AMPLIFIED	£11.50	KMB49 PEST SCARER HIGH PITCH £14.99
KMB4 WORKSHOP AMPLIFIER	£11.50	KMB50 VARIABLE FREQ. OSCILLATOR £6.75
KMX11 S. METER	£11.95	KMB51 AUTOMATIC NIGHT LIGHT £6.75
KMB44 SIMPLE HF MW ATU	£9.25	KMB52 FROST ALARM £6.99
KMB8 SW TUNER GENERAL	£11.50	KMB53 PRESSURE MAT & ALARM £16.50
KMC1 BASIC CRYSTAL SET MW	£7.95	KMB54 GUITAR TUNER £11.50
KMB61 MW SIGNAL BOOSTER	£14.99	KMB55 TOUCH ALARM £6.99
KMB9 FAKE CAR ALARM FLASHER	£6.30	KMB56 SIMPLE LIGHT METER £16.50
KMB10 2 L.E.D. FLASHER	£5.95	KMB57 L.E.D. CONTINUITY METER £5.50
KMB11 LOW VOLTS L.E.D. ALARM 9-12V	£6.30	KMB58 SOUND-OPERATED SWITCH £7.95
KMB12 LIE DETECTOR WITH METER	£11.50	KMB58A 8 FLASHING L.E.D.s £8.25
KMB13 TOY ORGAN	£7.95	KMB59 TBA 820M AUDIO AMP £12.75
KMB14 METRONOME IC CONTROL	£6.30	KMB60 TDA 2030 AUDIO AMP £11.50
KMB15 TOUCH SWITCH	£6.30	KMB62 ELECTRONIC DICE GAME £10.30
KMB16 HEADS OR TAILS GAME	£6.30	KMB63 ADVANCED THERAMIN-MUSIC £12.75
KMB17 SIREN	£5.95	KMB64 TOUCH DELAY LAMP £7.95
KMB18 RAIN DETECTOR	£5.95	KMB65 FISHERMAN'S ROD BITE ALARM £5.99
KMB19 CONTINUITY TESTER	£5.50	KMB66 BEAM BREAK DETECTOR ALARM £9.75
KMB20 FORSE CODE OSCILLATOR	£5.95	KMB67 LATCHING BURGLAR ALARM £9.25
KMB21 BURGLAR ALARM L.E.D. & SPEAKER	£6.30	KMB68 LIGHT-OPERATED RELAY £9.25
KMB22 LOOP SECURITY ALARM	£6.30	KMB69 MICROPHONE PRE-AMP £9.25
KMB23 VIBRATION ALARM	£5.95	KMB70 MAGNETIC ALARM-MODELS £9.25
KMB25 HAND TREMOR GAME	£5.95	KMB72 BATH OR WATER BUTT ALARM £8.25
KMB26 RAIN SYNTHESIZER - NOISE	£11.95	KMB73 0-18 VOLT POWER SUPPLY UNIT £8.25
KMB27 AUTO LIGHT DARK INDICATOR	£5.95	KMB74 FM BUG POWER SUPPLY 0-9V £7.99
KMB28 ADJ LOW LIGHT INDICATOR	£5.95	KMB75 1 TRANSISTOR FM BUG £7.95
KMB29 DARK ACTIVATED L.E.D. FLASHER	£5.95	KMB76 2 TRANSISTOR FM BUG £8.95
KMB30 LIGHT ACTIVATED TONE ALARM	£5.95	KMB77 CHIRP GENERATOR £8.25
KMB31 CAR EE ELECTRIC PROBE	£5.75	KMB78 TONE BURST GENERATOR £8.25
KMB32 SIGNAL INJECTOR	£5.75	KMB79 SOUND EFFECTS GENERATOR £11.95
KMB33 MOISTURE METER - L.E.D.	£5.95	KMB80 LIGHT METER - PHOTOGRAPHY £11.95
KMB34 L.E.D. TRANSISTOR TESTER NPN	£5.75	KMB81 LIGHT OSCILLATOR - PHOTOGRAPHY £11.50
KMB35 DIODE TESTER - L.E.D.	£5.75	KMB82 LIGHT-ACTIVATED RELAY £11.50
KMB36 L.E.D. TRANSISTOR TESTER PNP	£5.75	KMB83 DARK-ACTIVATED RELAY £11.50
KMB37 IC 555 TESTER - L.E.D.	£6.75	KMB84 SOUND SIREN + LOUD AMPLIFIER £13.95
KMB38 0-18 MIN TIMER L.E.D. & SPEAKER	£6.75	KMX12 AUDIO PROBE £11.95
KMB39 TOY THERAMIN MUSIC	£8.25	KMX14 CHILD SPEAK LAMP £8.25
KMB40 AMPLIFIED RF PROBE + METER	£11.95	KMZ1 SW GEN RECEIVER £16.50
KMB41 TRANSMITTER RF INDICATOR L.E.D.	£5.95	

ALL KITMASTER KITS DESIGNED



BY DAVID JOHNS



### FREE CATALOGUE

GREENWELD OFFERS A MASSIVE RANGE OF LOW COST ELECTRONIC COMPONENTS, NEW AND SURPLUS. WHETHER YOUR INTEREST IS IN ELECTRONICS, MODEL ENGINEERING, AUDIO, COMPUTERS OR ROBOTS, WE HAVE SOMETHING FOR YOU.

**LOOK! NEW BATTERY VALVE KITS**  
YES, THEY'RE HERE. IF YOU'RE LIKE US AND DON'T WANT TO BOTHER WITH BATTERIES, WE SUGGEST YOU BUILD T1 BATTERY ELIMINATOR FIRST THEN YOU CAN CHOOSE WHICH RADIO TO START ON. WE WILL ADD THAT T2 IS AN EXCELLENT LITTLE MEDIUM WAVE SET, IT'S WORTH CONSIDERING AND IT'S GOT GOOD VOLUME, EASY TO BUILD.

Send now for our comprehensive  
FREE catalogue



WE ACCEPT PAYMENT BY  
CHEQUE, POSTAL ORDER  
AND CREDIT CARD



UNIT 24, WEST HORNDON  
INDUSTRIAL PARK  
WEST HORNDON, BRENTWOOD,  
ESSEX CM13 3XD



TEL: 01277 811042  
FAX: 01277 812419

## NEW RADIO VALVE KITS

### LOW PRICED ECONOMY RANGE

ALL ESSENTIAL PARTS SUPPLIED – VALVES –  
TRANSFORMERS – SPEAKERS – TAGSTRIP –  
POTENTIOMETERS – KNOBS – TUNING CAPACITORS –  
AERIAL FORMERS – VALVE HOLDERS – RADIO CHASSIS –  
CAPACITORS – RESISTORS – SOLDER – WIRE – PLUS FULL  
INSTRUCTIONS

PLEASE NOTE: CASES ARE NOT INCLUDED

KMK1	VALVE RADIO POWER SUPPLY UNIT, IDEAL FOR MOST OF OUR KITS. HT 210 VOLTS D.C. AND LT 6-3 VOLTS A.C. ....	£26.00
KMK2	VALVE PSU HIGHER OUTPUT, OK FOR MOST OF OUR KITS. HT 250 VOLTS D.C. AND LT 6-3 VOLTS A.C. BOTH PSUs HAVE 100 mA TRANSFORMERS ....	£28.00
KMK3	TWO VALVE REGEN RADIO, WORKS ON MW OR SW INTERCHANGEABLE AERIAL COIL FORMER. COMES WITH SPEAKER – OUR BEST SELLER ....	£31.50
KMK4	ONE VALVE AMPLIFIER USES THE EL84 VALVE STILL MADE TODAY. IDEAL SHACK PROJECT. EASY TO BUILD, GOOD SPEAKER VOLUME ....	£16.50
KMK6	ONE VALVE REGEN RADIO. THIS KIT COMES WITH GOOD QUALITY EARPIECE. CAN BE USED EITHER MW OR SW. GIVES GOOD RESULTS ....	£18.50
KMK7	THIS VERY GOOD AMPLIFIER USES THE EL84 AND ECL83 VALVES. A VERY VALUABLE TWO VALVE AMP IN THE SHACK. GOOD SPEAKER VOLUME ....	£23.00
KMK8	ONE VALVE EXPERIMENTAL CRYSTAL SET WITH SOLID STATE INCORPORATED. IDEAL FOR HAM EXPERIMENTS. GOOD SPEAKER VOLUME ....	£22.00
KMK9	ONE VALVE MW RADIO THIS ONE IS NOT REGEN. INSTEAD IT HAS SOLID STATE AS WELL. GOOD SPEAKER VOLUME, EASY TO BUILD ....	£26.00
KMK10	MODERN TWO VALVE MW RADIO WITH SOLID STATE. USES TWO VALVES MADE TODAY. NO COILS TO WIND, GOOD SPEAKER VOLUME ....	£31.50
KMK11	ANOTHER TYPE OF DESIGN TWO VALVE SW RADIO. OPERATES APPROX. 6MHz TO 14MHz. IDEAL GENERAL SW SET, GOOD SPEAKER VOLUME ....	£33.50
KMK12	TWO VALVE AMPLIFIED CRYSTAL SET, MW OR SW. IDEAL HAM KIT INCORPORATES OA90 DIODE WITH EL84 AND ECC83 VALVES, LOUDSPEAKER ....	£31.50
KMK13	TRY BUILDING THIS TWO VALVE REGEN RADIO. USES THE EF91 AND ECL80 VALVES, GOOD SPEAKER VOLUME, REGEN MW OR SW ....	£31.50
KMK14	LOOK AT THIS ONE, IT'S A THREE VALVE MW OR SW REGEN SET WITH RF STAGE, GOOD SELECTIVITY, GOOD SPEAKER VOLUME ....	£39.95
KMK15	MW OR SW THREE VALVE REGEN RADIO USING A DIFFERENT SYSTEM, THIS USES EF91, EF80, EL84, VERY LOUD SPEAKER ....	£39.95
KMK16	FOUR VALVE MW OR SW TOP OF THE RANGE, DESIGNED FOR EASY BUILDING NOVICES, GOOD SELECTIVITY, GOOD SPEAKER VOLUME ....	£49.95

### LOOK! NEW BATTERY VALVE KITS – RADIOS – AMPLIFIERS ALL THESE BATTERY KITS WORK AT JUST 90 VOLTS D.C.

KMT1	BATTERY ELIMINATOR – DON'T WANT TO USE A BATTERY? USE OUR PSU, GIVES 90 VOLTS D.C. AND 1.5 VOLTS D.C. FOR ALL BATTERY KITS ....	£27.95
KMT2	BATTERY MW THREE VALVER AND A GOOD ONE, USES TWO IT4 VALVES WITH A DL96, VERY LOUD SPEAKER, GOOD PROJECT ....	£39.95
KMT3	SHORT WAVE BATTERY THREE VALVER, COMES WITH THREE AERIAL FORMERS, IDEAL HAM PROJECT, GOOD SPEAKER VOLUME ....	£44.99
KMT4	WANT A BATTERY VALVE AMPLIFIER? TRY THIS TWO VALVE AMPLIFIER, IDEAL FOR THE SHACK, MANY USES, VERY LOUD SPEAKER ....	£26.50
KMT5	BATTERY TWO VALVE MW CRYSTAL SET, STRICTLY FOR THE HAM EXPERIMENTER. USES IT4 AND DL96 WITH OA90. GOOD SPEAKER VOLUME ....	£33.95
KMT6	BATTERY TWO VALVE MW RADIO INCORPORATING SOLID STATE, NO OUTSIDE AERIAL NEEDED, GOOD SPEAKER VOLUME, GOOD PROJECT ....	£39.99
KMT7	BATTERY TWO VALVE GENERAL SW RADIO, 6MHz TO 14MHz APPROX. NO REGEN, VERY LOUD SPEAKER, EASY TO BUILD ....	£39.95

ALL RADIO CHASSIS PRE-DRILLED AND VALVE BASES FITTED READY  
FOR QUICK ASSEMBLY

Visit our new web site: <http://www.kit-master.co.uk>

<http://www.greenweld.co.uk>

For our FREE catalogue E-mail: [service@greenweld.co.uk](mailto:service@greenweld.co.uk)

P&P £3.00  
£10 OVERSEAS AND NEXT DAY

MAIL ORDER ONLY  
PLEASE ALLOW UP TO  
28 DAYS FOR DELIVERY

## MERRY CHRISTMAS TO



ALL OUR  
CUSTOMERS



# PIC LOGICATOR™

The fully graphical environment for designing control systems for PICmicros

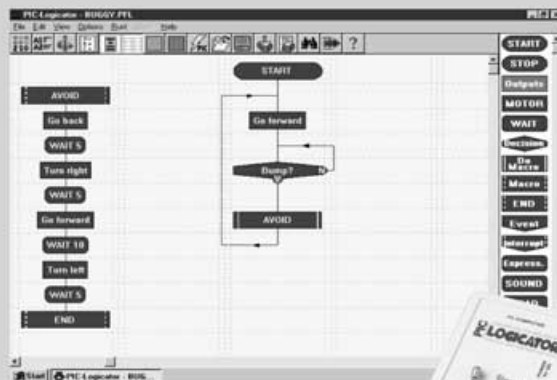
Draw the system as an on-screen flowchart, test it in the software, and download it directly to the PICmicro.

- Fast and easy
- Ideal for new PICmicro users
- Great for robotics and animatronics projects

Primarily designed for use with FLASH reprogrammable microcontrollers (e.g. PIC16F84 and PIC16F873). Also supports OTP devices. A separate software application is provided to allow the Programmer to download hex files generated from assembler code or C.



**PIC-Logicator Emulator**  
Allows in-circuit emulation of the PICmicro, either in real time or responding directly to an on-screen simulation.  
**PIC-EM £119.95**



**PIC-Logicator Pack**  
PIC-Logicator Software for PCs running Windows 95/98, and Programmer complete with serial lead, power supply and user manual.  
**PIC-L £149.95**



**www.pic-logicator.com**

• Interactive software demo • Direct purchase

Prices include UK carriage and VAT.

PIC-Logicator, Economatronics(Education)Ltd, Epic House,Darnall Rd,Sheffield S95AA UK.  
Tel 0114 281 3311. Email: education@economatronics.co.uk

# SQUIRES

## MODEL & CRAFT TOOLS

A COMPREHENSIVE RANGE OF MINIATURE HAND AND POWER TOOLS AND AN EXTENSIVE RANGE OF

### ELECTRONIC COMPONENTS

FEATURED IN A FULLY ILLUSTRATED

**432-PAGE MAIL ORDER CATALOGUE**

## 2001 ISSUE

**SAME DAY DESPATCH  
FREE POST AND PACKAGING**

Catalogues: FREE OF CHARGE to addressed in the UK.  
Overseas: CATALOGUE FREE, postage at cost charged to credit card

**Squires, 100 London Road,  
Bognor Regis, West Sussex, PO21 1DD**

**TEL: 01243 842424**

**FAX: 01243 842525**

**SHOP NOW OPEN**



Bell College  
Almada Street  
Hamilton  
Scotland ML3 0JB  
Tel: 01698 283100  
Fax: 01698 282131



## Make your Expertise pay!

In today's world you need qualifications to obtain and keep employment. Our open learning courses make obtaining those qualifications as convenient as possible.

Choose from our dozens of SQA accredited units, either singly to **update your skills** or as a group to obtain a **Higher National Certificate**.

- **Learn at your own pace in your own home**
- **Support from professional engineers via phone, FAX and the Internet**
- **Courses from Introductory Bridging Modules to HNC Electronics**
- **Units from Programmable Logic Controllers to Engineering Computing**

**DONT DELAY** – we are waiting to hear from you.

**Contact** Laura Murdoch, Open Learning Co-ordinator  
**Tel** 01698 283100 Ext. 214.  
**E-mail** l.murdoch@bell.ac.uk  
**Web:** <http://floti.bell.ac.uk/openlearning>

Member of the British Association for Open Learning  
Preview Centre for FT Knowledge



Bell College of Technology  
is a registered charity No. Sc 021179,  
providing quality Higher Education and  
Training opportunities for all.







**8 CAVANS WAY,  
BINLEY INDUSTRIAL  
ESTATE,  
COVENTRY CV3 2SF  
Tel: 01203 650702  
Fax: 01203 650773  
Mobile: 0860 400683**

(Premises situated close to Eastern-by-pass in Coventry with easy access to M1, M6, M40, M45 and M69)

### OSCILLOSCOPES

Beckman 9020 - 20MHz - Dual Channel.....	£180
Gould GS 245A/250/255/300/300S/335/4000.....	from £125
Howlett Packard 180A/180C/181A/182C.....	from £150
Howlett Packard 1740A, 1741A, 1744A 100MHz Dual Channel.....	from £300
Howlett Packard 54100D - 1 GHz Digitizing.....	£1250
Howlett Packard 54200A - 50 MHz Digitizing.....	£500
Howlett Packard 54201A - 300MHz Digitizing.....	£1450
Howlett Packard 54512B - 300MHz - 1GS/s 4-Channel.....	£2250
Howlett Packard 54501A - 100MHz - 100Ms/s 4-Channel.....	£1250
Hitaichi V152F/V302B/V302F/V353F/V508B/V508F.....	from £105
Hitaichi V650F - 60MHz Dual Channel.....	£200
Hitaichi V1100A - 100MHz 4-Channel.....	£300
Intron 8020 - 20MHz Digital Storage (NEW).....	£450
Iwatsu S55710/S55702 - 20MHz.....	from £125
Meguro - M80 1270A - 20 MHz Digital Storage (NEW).....	£450
Lecroy 9304 AM - 200MHz - 100 Ms/s 4-Channel.....	£3000
Lecroy 9450A - 300MHz/400 Ms/s D.S.O. 2-Channel.....	£2250
Philips PM 3055 - 50MHz Dual Timebase.....	£450
Philips PM 3211/PM 3212/PM 3214/PM 3217/PM 3234/PM3240/PM 3243/PM 3244/PM 3261/PM 3262/PM 3263/PM 3540.....	from £125
Philips PM 3255A - 400MHz Dual Channel.....	£1600
Philips PM 3335 - 50MHz/20 Ms/s D.S.O. 2-Channel.....	£200
Tektronix 455 - 50MHz Dual Channel.....	£200
Tektronix 464/466 - 100MHz Analogue Storage.....	from £300
Tektronix 465/466B - 100MHz Dual Channel.....	from £300
Tektronix 468 - 100MHz D.S.O.....	£300
Tektronix TAS 475 - 100MHz - 4-Channel.....	£395
Tektronix 475/475A - 200MHz/250MHz Dual Channel.....	from £400
Tektronix 485 - 350MHz - 2-Channel.....	£200
Tektronix 2211 - Digital Storage - 50MHz.....	£200
Tektronix 2213 - 60MHz Dual Channel.....	£350
Tektronix 2215 - 60MHz Dual Trace.....	£375
Tektronix 2218 - 60MHz Dual Trace.....	£350
Tektronix 2220 - 60MHz Dual Channel D.S.O.....	£350
Tektronix 2221 - 60MHz Digital Storage 2-Channel.....	£350
Tektronix 2225 - 50MHz Dual Channel.....	£350
Tektronix 2235 - 100MHz Dual trace.....	£300
Tektronix 2235 - Dual Trace 100MHz (portable).....	£2500
Tektronix 2440 - 300MHz/500 Ms/s D.S.O. 2-Channel.....	£300
Tektronix 2445 - 100MHz - 4-Channel DMM.....	£300
Tektronix 2445A - 100MHz - 4-Channel.....	£2500
Tektronix 2475B - 400MHz - 4-Channel.....	from £150
Tektronix 5403 - 60MHz - 2 or 4-Channel.....	from £225
Tektronix 7313, 7505, 7623, 7633 - 100MHz 4-Channel.....	from £350
Tektronix 7704 - 250MHz 4-Channel.....	£400
Tektronix 7904 - 50MHz.....	£125
Trio CS-1022 - 20MHz - Dual Channel.....	£125

Other scopes available too

### SPECIAL OFFER

HITACHI V212 - 20MHz DUAL TRACE.....	£160
HITACHI V222 - 20MHz DUAL TRACE+ALTERNATE MAGNIFY.....	£180

### SPECTRUM ANALYSERS

Ando AC8211 - Spectrum Analyser 1-7GHz.....	£1995
Anritsu MS622B - 10kHz-1700MHz.....	£1995
Anritsu MS3401A+MS3401B - (10Hz-30MHz).....	£3500+£3995
Anritsu MS910B - 10kHz-2GHz - (Mint).....	£4500
Anritsu MS710F - 100kHz-23GHz Spectrum Analyser.....	£5500
Avcom PSA455 - 1000MHz - portable.....	£250
Hameg 8028/8038 - Spectrum Analyser/Tracking Gen+100MHz Oscilloscope.....	£1000
Howlett Packard 182R with 8559A (10MHz-21GHz).....	£2750
Howlett Packard 182T-8559B - 0-1 to 1500MHz.....	£1250
Howlett Packard 3552A - 8559B - 0-1 to 1500MHz.....	£2250
Howlett Packard 3552A - Dual Channel Dynamic Sig. Analyser.....	£2750
Howlett Packard 3550A - 5Hz-50kHz.....	£200
Howlett Packard 3552A - 0-02Hz-25.6kHz (Dual Channel).....	£2500
Howlett Packard 3552A - 20Hz-40MHz.....	£2000
Howlett Packard 8559B - (0-01 to 22GHz).....	£2250
Howlett Packard 85046A - 'S' Parameter Test Set.....	£2500
Howlett Packard 6753A - Network Analyser.....	from £3000
Howlett Packard 6753B - Network Analyser.....	from £4500
IFR 7700 - 1kHz.....	£2000
Meguro MSA 4901 - 1-300GHz (AS NEW).....	£750
Meguro MSA 4912 - 1-1GHz (AS NEW).....	£1000
Rohde & Schwarz - SWOB 5 Polyskop 0-1-1300MHz.....	£1500
Tekoda Rillon 4132 - 1-0GHz Spectrum Analyser.....	£2100
Tektronix 7L18 with mainframe (15-60GHz with external mixers).....	£2000
Tektronix 495P - 100Hz-1.8GHz programmable.....	£4500
Tektronix 495P - 1kHz-1.8GHz Spectrum Analyser.....	£2450

### MISCELLANEOUS

Adret 740A - 100kHz-1120MHz Synthesised Signal Generator.....	£200
Anritsu MG 3901A Signal Generator 0-1-1040MHz.....	£1250
Anritsu ME 4623 DP/3 Transmission Analyser.....	£2500
Anritsu MG 645B Signal Generator 0-05-1050MHz.....	£750
Boonton 92C R/F Millivoltmeter.....	£195
Boonton 93A True RMS Voltmeter.....	£195
Drantz 628 - AC/DC - Multifunction Analyser.....	£200
EIP 331 - Frequency Counter 18GHz.....	£450
EIP 545 - Frequency Counter 18GHz.....	£1250
EIP 575 - Frequency Counter 18GHz.....	£1450
Etek SMP8 - Power Supply 60V-30V.....	£350
Farnell TSV-70 MKII Power Supply (70V - 5A or 35V - 10A).....	£200
Farnell DSG-1 Synthesised Signal Generator.....	£125
Farnell AP 30250A Power Supply 3V - 250A.....	£1750
Feedback PFG 605 Power Function Generator.....	£150
Fluke F100A - Calibrator.....	£1950
GN ELMI EPR31 PCM Signalling Recorder.....	£2500
Guildline 9152 - T12 Battery Standard Cell.....	£550
Howlett Packard 16300 - Logic Analyser (43 Channels).....	£500
Howlett Packard 16500A/B and C - Fitted with 16510A/1651A/161530A/16531A - Logic Analyser.....	from £2000
Howlett Packard 331A - Distortion Analyser.....	£300
Howlett Packard 333A - Distortion Analyser.....	£300
Howlett Packard 334A - Distortion Analyser.....	£300
Howlett Packard 335A - 21MHz Synthesiser/Function Generator.....	£300
Howlett Packard 3335A - Synthesised Signal Generator (200Hz-81MHz).....	£2750
Howlett Packard 3336C - Synthesised Signal Generator (10Hz-21MHz).....	£300
Howlett Packard 3455A - 6 1/2 Digit Multimeter (Autocal).....	£500
Howlett Packard 3455A - Digital Multimeter.....	£500
Howlett Packard 3455A - HP - 1B Switch Control Unit (various Plug-ins available).....	£350
Howlett Packard 35500A - Dual Channel Dynamic Signal Analyser.....	£2750
Howlett Packard 3556A - Selective Level Meter.....	£200
Howlett Packard 3711A/3712A/3791B/3793B - Microwave Link Analyser.....	£1500
Howlett Packard 3746A - Selective Measuring Set.....	£250
Howlett Packard 3776A - PCM Terminal Test Set.....	£1000
Howlett Packard 3779A/3779C - Primary Mux Analyser.....	from £400

Howlett Packard 3794A - Digital Transmission Analyser.....	£5000
Howlett Packard 3795A - Jitter Generator+Receiver.....	£1250
Howlett Packard 37900D - Signalling Test Set (No. 7 and ISDN).....	£4250
Howlett Packard P362A - Variable Attenuator.....	£250
Howlett Packard 4182A - LF Impedance Analyser.....	£5500
Howlett Packard 432A - Digital LCR Meter.....	£200
Howlett Packard 4342A - 'Q' Meter.....	£300
Howlett Packard 438A or B Power Meter (with 8481A/8484A).....	from £400
Howlett Packard 438A and 437B - Power Meter and Sensor.....	from £300
Howlett Packard 4910S - Transmission Impairment M/Set.....	£1500
Howlett Packard 4972A - Lan Protocol Analyser.....	£1250
Howlett Packard 5183 - Waveform Recorder.....	£1250
Howlett Packard 6238A - Frequency Counter 100MHz.....	£250
Howlett Packard 6314A - (NEW) 100MHz Universal Counter.....	£250
Howlett Packard 6321A - Universal Counter (IEEE).....	£400
Howlett Packard 6335A - 200MHz High Performance Systems Counter.....	£300
Howlett Packard 6324A - Microwave Frequency Counter (500MHz-18GHz) Opts 1+3.....	£300
Howlett Packard 6358A - High Resolution Time Synthesiser.....	£2550
Howlett Packard 6910B - Diode Mux Analyser.....	£2000
Howlett Packard 6384A - 225MHz Frequency Counter.....	£500
Howlett Packard 6385A - Frequency Counter - 1GHz - (HP1B) with OPTS 001/003/004/005.....	£750
Howlett Packard 6033A - Power Supply Autoranging (20V - 30A).....	£750
Howlett Packard 6253A - Power Supply - 3A Twin.....	£200
Howlett Packard 6255A - Power Supply 40V - 15A Twin.....	£200

### HEWLETT PACKARD 6261B Power Supply 20V - 50A £350 Discount for Quantities

Howlett Packard 6264B - Power Supply (0-20V, 0-25A).....	£300
Howlett Packard 6265B - Power Supply 40V - 5A.....	£220
Howlett Packard 6271B - Power Supply 30V - 3A.....	£225
Howlett Packard 6524A - Quad Power Supply.....	£2000
Howlett Packard 6632A - Power Supply (20V - 5A).....	£300
Howlett Packard 6652A - 20V - 25A System P.S.U.....	£750
Howlett Packard 7476A - 6 Pin Plotter.....	£250
Howlett Packard 7550A - 8 Pin Plotter.....	£250
Howlett Packard 778D - Coax Dual Directional Coupler.....	£300
Howlett Packard 8015A - 50MHz Pulse Generator.....	£200
Howlett Packard 8165A - 50MHz Programmable Signal Source.....	£1250
Howlett Packard 8100A - Data Generator.....	£350
Howlett Packard 8182A - Data Analyser.....	£1500
Howlett Packard 8350B - Sweep Oscillator Mainframe (various plug-in options available).....	£2500
Howlett Packard 8355A - Wave Source Module 26-5 to 40GHz.....	£2500
Howlett Packard 8355A - Millimeter Wave Source Module 33-50GHz.....	£2500
Howlett Packard 8404A - Vector Voltmeter.....	£1500
Howlett Packard 8620C - Sweep Oscillator Mainframe.....	from £250
Howlett Packard 8640B - Signal Generator (512MHz+1024MHz).....	from £250
Howlett Packard 8642A - Signal Generator (0-01 to 1050MHz) High Performance Synthesiser.....	£5500
Howlett Packard 8654A - Synthesised Signal Generator (900MHz).....	£350
Howlett Packard 8656B - Synthesised Signal Generator.....	£1450
Howlett Packard 8657A - Signal Generator (100kHz-1040MHz).....	£1900
Howlett Packard 8660D - Synthesised Signal Generator (10kHz-2600MHz).....	£2250
Howlett Packard 8750A - Storage Normaliser.....	£200
Howlett Packard 8755A - Scalar Network Analyser.....	£1500
Howlett Packard 8757A - Scalar Network Analyser.....	£2250
Howlett Packard 8901A - Modulation Analyser.....	£1000
Howlett Packard 8901B - Modulation Analyser.....	£2000
Howlett Packard 8903B - Distortion Analyser.....	£300
Howlett Packard 8903B - Distortion Analyser (Mint).....	£1500
Howlett Packard 8920A - R/F Comms Test Set.....	£2500
Howlett Packard 8922B/G/H - Radio Comms Test Sets (G.S.M.).....	from £5000
Howlett Packard 8955A - Cellular Radio Interface.....	£1500
Keytek MZ-15/EC - Minizap 15KV Hand-Held ESD Simulator.....	£1750
Krohn-Hite 2200 - Lin/Log Sweep Generator.....	£395
Krohn-Hite 4024A - Oscillator.....	£250
Krohn-Hite 5200 - Sweep Function Generator.....	£350
Krohn-Hite 6800 - Phase Meter.....	£250
Leader LDM-170 - Distortion Meter.....	£350
Leader 3216 - Signal Generator (100kHz-140kHz) AM/FM/CW with built-in FM stereo modulator (mint).....	£395
Marconi 1065B - Demultiplexer and Frame Alignment Monitor (new).....	£200
Marconi 2019 - 80kHz-1040MHz Synthesised Signal Generator.....	£750
Marconi 2019A - 80kHz-1040MHz Synthesised Signal Generator.....	£1000
Marconi 2111 - UHF Synthesiser (new).....	£200
Marconi 2185 - 1-50GHz Programmable Attenuator (new).....	£200
Marconi 2305 - Modulation Meter.....	£1750
Marconi 2337A - Automatic Distortion Meter.....	£150
Marconi 2610 - True RMS Voltmeter.....	£700
Marconi 2671 - Data Comms Analyser.....	£500
Marconi 2952 - Radio Comms Test Set.....	£2500
Marconi 6310 - Sweep Generator - Programmable - new (2-20GHz).....	£3500
Marconi 6950/6960 - Power Meter & Sensor.....	from £500
Marconi 6960 - Power Meter & Sensor.....	from £350
Marconi 693 - A/F Power Meter.....	£200
Philips PM5167 MHz Function Generator.....	£400
Philips 5190 - L.F. Synthesiser (G.P.I.B.).....	£200
Philips 5518 - Synthesised Function Generator.....	£1500
Philips PM5518 - TV Pattern Generator.....	£350
Pipe P4716 - 50MHz Pulse Generator.....	£250
Preme 4000 - 6 Digit Multimeter (NEW).....	£350
Quartstock 2A - Off-Air Frequency Standard.....	£200
Racal 1992 - 1-3GHz Frequency Counter.....	£700
Racal 111/1618 - GSM Radio Comms Test Set.....	£250
Racal Dana 9061/9062 - Synthesised Signal Generator 520MHz.....	from £400
Racal Dana 9084 - Synthesised Signal Generator 104MHz.....	£450
Racal 9301A - True RMS R/F Multivoltmeter.....	£300
Racal Dana 9302A - R/F Multivoltmeter (new version).....	£275
Racal Dana 9303 - R/F Level Meter & Head.....	£250
Racal Dana 9917 - UHF Frequency Meter 560MHz.....	£175
Rohde & Schwarz LFM2 - 60MHz Group Delay Sweep Generator.....	£250
Rohde & Schwarz CMTA 94 - GSM Radio Comms Analyser.....	£595
Schaefer NSG 202A - Line Voltage Variation Simulator.....	£750
Schaefer NSG 222A - Interference Simulator.....	£700
Schaefer NSG 223 - Interference Generator.....	£700
Schlumberger 2720 - 1250MHz Frequency Counter.....	£400
Schlumberger 4051 - 1GHz Radio Comms Test Set.....	£400
Schlumberger Stablock 4040 - Radio Comms Test Set.....	£185
Schlumberger 7050/7055/7075 - Multimeters.....	from £350
Stanford Research DS 340 - 15MHz Synthesised Function (NEW) and Arbitrary Waveform Generator.....	£1200
Syston Donner 609 - Microwave Frequency Counter (26-5GHz).....	£1595
Tektronix AM503+TM501+P6302 - Current Probe Amplifier.....	£395
Tektronix PG506+TG501+SG503+TM503 - Oscilloscope Calibrator.....	£1995
Tektronix 677 - Curve Tracer.....	£1150
Tektronix 1240 - Logic Analyser.....	£300
Tektronix 141A - PAL Test Signal Generator.....	£250
Tektronix AA501+TM5005 M/F - Programmable Distortion Analyser.....	£1995
Tektronix TM5003+AFG 5101 - Arbitrary Function Generator.....	£1500
Tektronix - Plug-ins - many available such as SC504, SW503, SG502, PG508, FG503, TG501, TR503+many more.....	£2000
Time 9611 - Programmable Resistance.....	£400
Time 9614 - Voltage Calibrator.....	£550
Valhalla Scientific - 2724 Programmable Resistance Standard.....	£200
Wandel & Göttermann PF-L-3 - Error/Jitter Test Set.....	£1500
Wandel & Göttermann PCM4 (+options).....	£995
Wandel & Göttermann MU30 - Test Point Scanner.....	£1500
Wayne Kerr 4225 - LCR Bridge.....	£500
Wavetek 171 - Synthesised Function Generator.....	£250
Wavetek 172B - Programmable Signal Source (0-0001Hz-13MHz).....	£200
Wavetek 184 - Sweep Generator - 5MHz.....	£250
Wavetek 3010 - 1-1GHz Signal Generator.....	£1250
Wiltron 6408 - RF Analysers (1MHz-2GHz).....	£200
Wiltron 6505 - Programmable Sweep Generator (3-6GHz-6.5GHz).....	£250
Wiltron 6747-20 - Swept Frequency Synthesiser (10MHz-20GHz).....	£350
Yokogawa 3555 - Analysing Recorder.....	£200

MANY MORE ITEMS AVAILABLE  
SEND LARGE SAE FOR LIST OF EQUIPMENT

ALL EQUIPMENT IS USED  
WITH 30 DAYS GUARANTEE.

PLEASE CHECK FOR AVAILABILITY BEFORE ORDERING  
CARRIAGE & VAT TO BE ADDED TO ALL GOODS



## MAIL ORDER ONLY • CALLERS BY APPOINTMENT

### EPE MICROCONTROLLER P.I. TREASURE HUNTER

The latest MAGENTA DESIGN – highly stable & sensitive – with I.C. control of all timing functions and advanced pulse separation techniques.

- High stability drift cancelling
- Easy to build & use
- No ground effect, works in seawater



- Detects gold, silver, ferrous & non-ferrous metals

- Efficient quartz controlled microcontroller pulse generation.
- Full kit with headphones & all hardware

**KIT 847 ..... £63.95**

### PORTABLE ULTRASONIC Pest SCARER

A powerful 23kHz ultrasound generator in a compact hand-held case. MOSFET output drives a special sealed transducer with intense pulses via a special tuned transformer. Sweeping frequency output is designed to give maximum output without any special setting up.

**KIT 842.....£22.56**

### 68000 DEVELOPMENT TRAINING KIT

- NEW PCB DESIGN
- 8MHz 68000 16-BIT BUS
- MANUAL AND SOFTWARE
- 2 SERIAL PORTS
- PIT AND I/O PORT OPTIONS
- 12C PORT OPTIONS



**KIT 621**

**£99.95**

- ON BOARD 5V REGULATOR
- PSU £6.99
- SERIAL LEAD £3.99

### Stepping Motors

MD38...Mini 48 step...£8.65

MD35...Std 48 step...£9.99

MD200...200 step...£12.99

MD24...Large 200 step...£22.95



### PIC PIPE DESCALER

- SIMPLE TO BUILD
- HIGH POWER OUTPUT
- AUDIO & VISUAL MONITORING
- SWEPT FREQUENCY

An affordable circuit which sweeps the incoming water supply with variable frequency electromagnetic signals. May reduce scale formation, dissolve existing scale and improve lathering ability by altering the way salts in the water behave. Kit includes case, P.C.B., coupling coil and all components. High coil current ensures maximum effect. L.E.D. monitor.



**KIT 868 ..... £22.95**

**POWER UNIT.....£3.99**

### MICRO Pest SCARER

Our latest design – The ultimate scarer for the garden. Uses special microchip to give random delay and pulse time. Easy to build reliable circuit. Keeps pets/pests away from newly sown areas, play areas, etc. uses power source from 9 to 24 volts.

- RANDOM PULSES
- HIGH POWER
- DUAL OPTION



Plug-in power supply £4.99

**KIT 867.....£19.99**

**KIT + SLAVE UNIT.....£32.50**

### WINDICATOR

A novel wind speed indicator with LED readout. Kit comes complete with sensor cups, and weatherproof sensing head. Mains power unit £5.99 extra.

**KIT 856.....£28.00**

## ★ TENS UNIT ★

### DUAL OUTPUT TENS UNIT

As featured in March '97 issue.

Magenta have prepared a FULL KIT for this excellent new project. All components, PCB, hardware and electrodes are included. Designed for simple assembly and testing and providing high level dual output drive.

**KIT 866. . Full kit including four electrodes £32.90**

Set of  
4 spare  
electrodes  
£6.50

### 1000V & 500V INSULATION TESTER



Superb new design. Regulated output, efficient circuit. Dual-scale meter, compact case. Reads up to 200 Megohms.

Kit includes wound coil, cut-out case, meter scale, PCB & ALL components.

**KIT 848..... £32.95**

## EPE TEACH-IN 2000

Full set of top quality NEW components for this educational series. All parts as specified by EPE. Kit includes breadboard, wire, croc clips, pins and all components for experiments, as listed in introduction to Part 1.

\*Batteries and tools not included.

### TEACH-IN 2000 -

**KIT 879 £44.95**

**MULTIMETER £14.45**

### SPACEWRITER

An innovative and exciting project. Wave the wand through the air and your message appears. Programmable to hold any message up to 16 digits long. Comes pre-loaded with "MERRY XMAS". Kit includes PCB, all components & tube plus instructions for message loading.

**KIT 849 .....£16.99**



### 12V EPROM ERASER

A safe low cost eraser for up to 4 EPROMs at a time in less than 20 minutes. Operates from a 12V supply (400mA). Used extensively for mobile work - updating equipment in the field etc. Also in educational situations where mains supplies are not allowed. Safety interlock prevents contact with UV.

**KIT 790 .....£29.90**

### SUPER BAT DETECTOR

1 WATT O/P, BUILT IN  
SPEAKER, COMPACT CASE  
20kHz-140kHz  
NEW DESIGN WITH 40kHz MIC.

A new circuit using a 'full-bridge' audio amplifier i.c., internal speaker, and headphone/tape socket. The latest sensitive transducer, and 'double balanced mixer' give a stable, high performance superheterodyne design.

**KIT 861 ..... £24.99**

ALSO AVAILABLE Built & Tested. . . £39.99



### MOSFET MkII VARIABLE BENCH POWER SUPPLY 0-25V 2.5A

Based on our Mk1 design and preserving all the features, but now with switching pre-regulator for much higher efficiency. Panel meters indicate Volts and Amps. Fully variable down to zero. Toroidal mains transformer. Kit includes punched and printed case and all parts. As featured in April 1994 EPE. An essential piece of equipment.



Kit No. 845 .....£64.95

### EPE PROJECT PICS

Programmed PICs for all\* EPE Projects  
16C84/18F84/16C71  
All **£5.90 each**

**PIC16F877 now in stock  
£10 inc. VAT & postage**  
(\*some projects are copyright)

### ULTRASONIC Pest SCARER

Keep pets/pests away from newly sown areas, fruit, vegetable and flower beds, children's play areas, patios etc. This project produces intense pulses of ultrasound which deter visiting animals.

- KIT INCLUDES ALL COMPONENTS, PCB & CASE
- EFFICIENT 100V TRANSDUCER OUTPUT
- COMPLETELY INAUDIBLE TO HUMANS

**KIT 812..... £15.00**



- UP TO 4 METRES RANGE
- LOW CURRENT DRAIN

## SIMPLE PIC PROGRAMMER

INCREDIBLE LOW PRICE! Kit 857 **£12.99**

INCLUDES 1-PIC16F84 CHIP  
SOFTWARE DISK, LEAD  
CONNECTOR, PROFESSIONAL  
PC BOARD & INSTRUCTIONS

Power Supply £3.99

EXTRA CHIPS:

PIC 16F84 £4.84

Based on February '96 EPE. Magenta designed PCB and kit. PCB with 'Reset' switch, Program switch, 5V regulator and test L.E.D.s, and connection points for access to all A and B port pins.

## PIC 16C84 DISPLAY DRIVER

INCLUDES 1-PIC16F84 WITH  
DEMO PROGRAM SOFTWARE  
DISK, PCB, INSTRUCTIONS  
AND 16-CHARACTER 2-LINE  
**LCD DISPLAY**

Kit 860 **£19.99**

Power Supply £3.99

FULL PROGRAM SOURCE  
CODE SUPPLIED – DEVELOP  
YOUR OWN APPLICATION!

Another super PIC project from Magenta. Supplied with PCB, industry standard 2-LINE x 16-character display, data, all components, and software to include in your own programs. Ideal development base for meters, terminals, calculators, counters, timers – Just waiting for your application!

## PIC 16F84 MAINS POWER 4-CHANNEL CONTROLLER & LIGHT CHASER

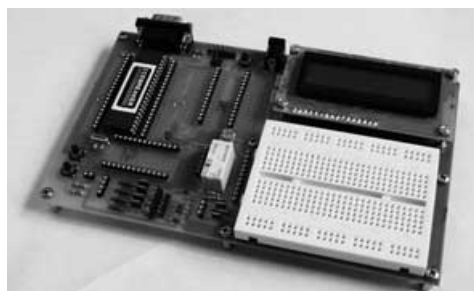
- WITH PROGRAMMED 16F84 AND DISK WITH SOURCE CODE IN MPASM
- ZERO VOLT SWITCHING
- MULTIPLE CHASE PATTERNS
- OPTO ISOLATED
- 5 AMP OUTPUTS
- 12 KEYPAD CONTROL
- SPEED/DIMMING POT.
- HARD-FIRED TRIACS

Kit 855 **£39.95**

LOTS OF OTHER APPLICATIONS

Now features full 4-channel chaser software on DISK and pre-programmed PIC16F84 chip. Easily re-programmed for your own applications. Software source code is fully 'commented' so that it can be followed easily.

## ICEBREAKER



## PIC Real Time In-Circuit Emulator

- Icebreaker uses PIC16F877 in circuit debugger
- Links to Standard PC Serial Port (lead supplied)
- Windows™ (95+) Software included
- Works with MPASM and MPLAB Microchip software
- 16 x 2 L.C.D., Breadboard, Relay, I/O devices and patch leads supplied

As featured in March '00 EPE. Ideal for beginners AND advanced users. Programs can be written, assembled, downloaded into the microcontroller and run at full speed (up to 20MHz), or one step at a time. Full emulation means that all I/O ports respond exactly and immediately, reading and driving external hardware.

Features include: Reset; Halt on external pulse; Set Breakpoint; Examine and Change registers, EEPROM and program memory; Load program, Single Step with display of Status, W register, Program counter, and user selected 'Watch Window' registers.

**KIT 900 . . . £34.99**

POWER SUPPLY **£3.99** STEPPING MOTOR **£5.99**

## EPE PIC Tutorial

At last! A Real, Practical, Hands-On Series

- **Learn Programming from scratch using PIC16F84**
- **Start by lighting I.e.d.s and do 30 tutorials to Sound Generation, Data Display, and a Security System.**
- **PIC TUTOR Board with Switches, I.e.d.s, and on board programmer**

### PIC TUTOR BOARD KIT

Includes: PIC16F84 Chip, TOP Quality PCB printed with Component Layout and all components\* (\*not ZIF Socket or Displays). Included with the Magenta Kit is a disk with Test and Demonstration routines.

**KIT 870 .... £27.95, Built & Tested .... £42.95**

Optional: **Power Supply – £3.99, ZIF Socket – £9.99**

**LCD Display ..... £7.99 LED Display ..... £6.99**

Reprints Mar/Apr/May 98 – £3.00 set 3

## PIC TOOLKIT V2

- SUPER UPGRADE FROM V1 • 18, 28 AND 40-PIN CHIPS
- READ, WRITE, ASSEMBLE & DISASSEMBLE PICS
- SIMPLE POWER SUPPLY OPTIONS 5V-20V
- ALL SWITCHING UNDER SOFTWARE CONTROL
- MAGENTA DESIGNED PCB HAS TERMINAL PINS AND OSCILLATOR CONNECTIONS FOR ALL CHIPS
- INCLUDES SOFTWARE AND PIC CHIP

**KIT 878 ... £22.99 with 16F84 ... £29.99 with 16F877**

## SUPER PIC PROGRAMMER

- READS, PROGRAMS, AND VERIFIES
- WINDOWS™ SOFTWARE
- PIC16C6X, 7X, AND 8X
- USES ANY PC PARALLEL PORT
- USES STANDARD MICROCHIP • HEX FILES
- OPTIONAL DISASSEMBLER SOFTWARE (EXTRA)
- PCB, LEAD, ALL COMPONENTS, TURNED-PIN SOCKETS FOR 18, 28, AND 40 PIN ICs

- SEND FOR DETAILED INFORMATION – A SUPERB PRODUCT AT AN UNBEATABLE LOW PRICE.

Kit 862 **£29.99**

Power Supply £3.99

DISASSEMBLER  
SOFTWARE **£11.75**

## PIC STEPPING MOTOR DRIVER

INCLUDES PCB,  
PIC16F84 WITH  
DEMO PROGRAM,  
SOFTWARE DISC,  
INSTRUCTIONS  
AND MOTOR.

Kit 863 **£18.99**

FULL SOURCE CODE SUPPLIED  
ALSO USE FOR DRIVING OTHER  
POWER DEVICES e.g. SOLENOIDS

Another NEW Magenta PIC project. Drives any 4-phase unipolar motor – up to 24V and 1A. Kit includes all components and 48 step motor. Chip is pre-programmed with demo software, then write your own, and re-program the same chip! Circuit accepts inputs from switches etc and drives motor in response. Also runs standard demo sequence from memory.

## 8-CHANNEL DATA LOGGER

As featured in Aug./Sept. '99 EPE. Full kit with Magenta redesigned PCB – LCD fits directly on board. Use as Data Logger or as a test bed for many other 16F877 projects. Kit includes programmed chip, 8 EEPROMs, PCB, case and all components.

**KIT 877 £49.95 inc. 8 x 256K EEPROMS**

# MAGENTA

All prices include VAT. Add **£3.00** p&p. Next day **£6.99**

Tel: 01283 565435 Fax: 01283 546932 E-mail: [sales@magenta2000.co.uk](mailto:sales@magenta2000.co.uk)

Everyday Practical Electronics, December 2000

881





**Editorial Offices:**  
 EVERYDAY PRACTICAL ELECTRONICS EDITORIAL  
 ALLEN HOUSE, EAST BOROUGH, WIMBORNE  
 DORSET BH21 1PF  
 Phone: Wimborne (01202) 881749  
 Fax: (01202) 841692.  
**E-mail:** editorial@epemag.wimborne.co.uk  
**Web Site:** http://www.epemag.wimborne.co.uk  
**EPE Online** www.epemag.com  
 See notes on **Readers' 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

## BUMPER

A bumper issue this month with the extra 16 pages devoted to Christmas projects. We have a regular problem with trying to fit everything into each issue, and I try to balance the content to appeal to a wide range of readers. With regular series like *Teach-In 2000* (Nov 1999 to Oct 2000) and now *The Schmitt Trigger*, plus a range of constructional projects and the regular features it's always a bit of a tight squeeze and sometimes it's difficult to know what to leave out. Only occasionally can we afford to go "over the top" with the number of pages to bring you extra content, we are, however, planning a couple more bumper issues for the Spring.

Incidentally, our educational series are always very popular and we are presently working at putting *Teach-In 2000* on a mini CD-ROM. The complete course, together with all the software, should soon be available in this form, hopefully there will be more news on this in the next issue.

## DESIGN

We are often asked by readers how to design circuits and sometimes more specifically to tell them how we arrived at the values of each component in a particular circuit design – not something we can offer to provide, I'm afraid.

As an insight to the variations and complexity of circuit design the present *Schmitt Trigger* series should be an eye-opener for many readers. One *EPE* contributor has already commented that he did not realise there was so much to say about Schmitt Triggers – and that was after Part 1! This series is a little above the general level of theory we normally carry in *EPE*, but should interest those of you who are above the beginner level and who want to understand more about circuit design.

We can't promise to tell you everything there is to know about Schmitt Triggers, but you will certainly learn a lot.

*Mike Kenward*

**Editor:** MIKE KENWARD

**Deputy Editor:** DAVID BARRINGTON

**Technical Editor:** JOHN BECKER

**Business Manager:** DAVID J. LEAVER

**Subscriptions:** MARILYN GOLDBERG

**Administration:** FAY KENWARD

**Editorial/Admin:** Wimborne (01202) 881749

**Advertisement Manager:**  
 PETER J. MEW, Frinton (01255) 861161

**Advertisement Copy Controller:**  
 PETER SHERIDAN, Wimborne (01202) 882299

**On-Line Editor:** ALAN WINSTANLEY

**EPE Online** (Internet version) **Editors:**  
 CLIVE (MAX) MAXFIELD and ALVIN BROWN

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

## COMPONENT SUPPLIES

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

## ADVERTISEMENTS

**E-mail:** adverts@epemag.wimborne.co.uk  
 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 below), from all UK newsagents (distributed by COMAG) and from the following electronic component retailers: Omni Electronics and Yobo Electronics in S. Africa. *EPE* can also be purchased from retail magazine outlets around the world. An Internet on-line version can be purchased for just \$9.99(US) per year available from [www.epemag.com](http://www.epemag.com)

## SUBSCRIPTIONS

Subscriptions for delivery direct to any address in the

UK: 6 months £14.50, 12 months £27.50, two years £50; Overseas: 6 months £17.50 standard air service or £27 express airmail, 12 months £33.50 standard air service or £51 express airmail, 24 months £62 standard air service or £97 express airmail.

Online subscriptions, for downloading the magazine via the Internet, \$9.99(US) for one year available from [www.epemag.com](http://www.epemag.com).

Cheques or bank drafts (in £ sterling only) payable to *Everyday Practical Electronics* and sent to EPE Sub. Dept., Allen House, East Borough, Wimborne, Dorset BH21 1PF. Tel: 01202 881749. Fax: 01202 841692. **E-mail:** 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 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 £5.95 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 and MasterCard accepted, minimum credit card order £5. Send, fax or phone your card number and card expiry date 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.**





# PIC-MONITORED DUAL PSU

JOHN BECKER

Part One

*Ever keen to add tools to the workshop, the author designs yet another, and finds more uses for a PIC16F877!*



**T**HE dual power supply unit (PSU) described here can be built in several forms.

At the simplest level it can be built with a single d.c. output switched for 5V or variable between about 6V and 9V. This shortened version is probably an ideal starter power supply for those who have been following the recent *Teach-In 2000* series and now wish to start adding workshop equipment.

This version will be described in Part 2, as will other constructional options. Some aspects of the main PSU have also been described in such a way as to reinforce the understanding of power supplies by *Teach-In 2000* readers.

It is emphasised that mains a.c. electrical power is dangerous and that construction of any of the versions of this power supply should only be undertaken (or supervised) by those who are suitably qualified or experienced.

### FULL VERSION

The full version of the dual power supply provides PIC microcontroller monitoring of voltage and current, displaying the data on a liquid crystal display (l.c.d.). It has the specifications shown opposite.

### Specifications

- **Dual channel**, switchable for series or parallel operation:

Two outputs per channel (four outputs total).

Output 1 switchable for fixed voltages of 5V, 6V, 9V, 12V, 15V or 18V.

Output 2 fully variable from about 0V up to 1V less than the switch-selected fixed voltage.

In series connection mode, the common rail of Channel B is connected to the selected fixed voltage of Channel A, providing a maximum output of +18V from Channel A and +36V from Channel B, or -18V from Channel A and +18V from Channel B.

All outputs are "floating" with respect to mains earth (ground) and any output can be regarded as the 0V (common) level.

- **Output monitoring:**

PIC16F877 microcontroller simultaneously monitors voltage and current for both outputs of both channels (four outputs).

Monitored data is output to a 2-line 16-character (per line) alphanumeric l.c.d.

The PIC controls l.e.d.s and buzzer in response to preset current limits being exceeded.

- **Display modes:**

1. Each channel's data shown individually, stating output voltage, output current, preset alarm-trip current. Channels switch-selectable on a cycle of four.

2. All four monitored voltages shown simultaneously.

3. All four monitored currents shown simultaneously.

- **Maximum output currents:**

Output 1 (switched voltage), 1A but see text and Table 6 later.

Output 2 (variable voltage), 350mA but see text in Part 2.

- **Current limiting:**

Output 2 can be set to limit the power supplied to the load circuit, using a panel control.



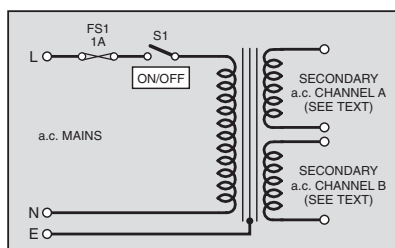
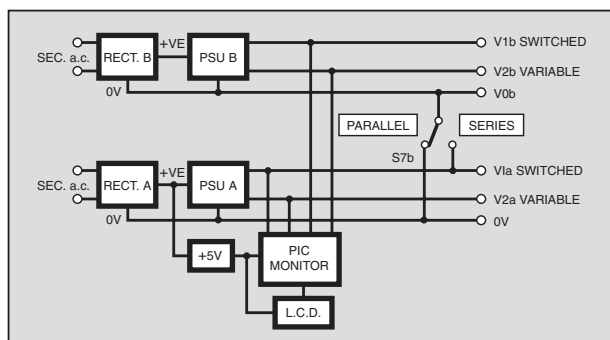
Each of the four outputs can have a maximum current limit set via pushbutton switches. If the preset current is exceeded, a light emitting diode (l.e.d.) indicates which channel is overloaded. A buzzer sounds if the total current drawn from either channel exceeds 1A. Physical limitation of the current supplied is *not* controlled by this option.

The PIC's EEPROM data memory retains the limit value set even when the power supply unit is switched off.

The basic block diagram for the power supply is shown in Fig.1. All controls are omitted except for the Series/Parallel switch.

### TRANSFORMER

Illustrated in Fig.2 is the circuit diagram for the mains a.c. input and transformer. For use in the UK, transformer T1 should have the primary winding rated for 230V a.c. For the USA, the primary winding should be rated for 110V a.c. Readers from other countries should select the primary



*Fig.2. Mains transformer circuit diagram.*

winding voltage to suit their domestic mains supply.

The choice of secondary winding voltage and current ratings is somewhat up to the user. In the author's prototype described here, each is rated at 15V a.c. 1-67A (25VA per winding). Lower voltage and current types may be selected instead, but with an accompanying reduction in the power supply's capabilities.

It should be remembered that the bridge-rectified d.c. output voltage is approximately 1.414 times the a.c. voltage supplied by the transformer secondary, minus 1.4V for the bridge rectifier voltage drop, and that the voltage regulator requires a minimum voltage drop across it of about 2V d.c.

Thus, for example, the 15V a.c. secondary of the prototype is rectified to produce approximately 20V d.c. at the input to the regulator. In practice, the rectified voltage is likely to be somewhat higher than this when the power supply is not

connected to an external load circuit (approx 22.3V on the prototype).

## ***BASIC REGULATION***

The circuit diagram of the power supply as a basic concept for a single channel is shown in Fig.3. It is this circuit which will be returned to when construction of the simple power supply is described in Part 2. For the dual supply, two modified versions of this circuit are used.

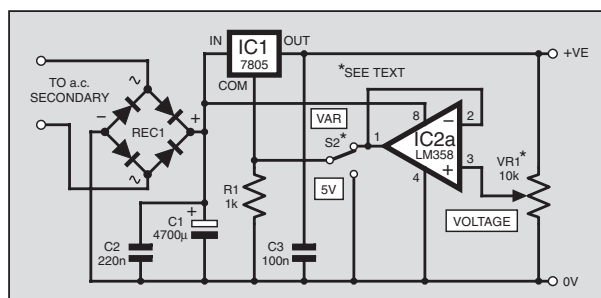
The bridge rectifier is shown as REC1, with capacitors C1 and C2 providing the initial smoothing to eliminate the ripple voltage from the rectifier. As said earlier, the voltage at this node is likely to be about 20V minimum.

In *Teach-In 2000* it was stated that the working voltage for the smoothing capacitor (C1) should ideally be twice that of the rectified output voltage, to provide a reasonable safety margin in the event of power line spikes or surges.

For the sake of expediency, however, in the prototype a capacitor rated at 35V d.c. is used (the author had them in stock). However, the printed circuit board has been designed to accept the physical size of capacitors rated at greater than 35V should you prefer to use them.

The bridge rectifier used is rated at 50V 1A and is a commonly available device, type W005. It should not be called upon to supply a current greater than the rated 1A.

This factor limits the actual current which can be drawn from each power supply channel, a value which must take into account the current drawn by the



*Fig.3. Circuit diagram for one channel of the power supply as a simple concept.*

controlling and monitoring circuit. For Channel A, allow for an "internal" current of about 50mA maximum should all the monitoring l.e.d.s and the buzzer be on together.

The voltage regulation circuit comprises regulator IC1, op.amp IC2a, potentiometer VR1, resistor R1 and switch S2.

**WELL ESTABLISHED**

This circuit is based on the "industry standard" that has been around for several decades, as shown in National Semiconductor's linear device data book, for example.

The regulator, a +5V device, tries to maintain a difference of 5V between its output and common pins. If the voltage to which the common pin is connected is 0V, then the output will, of course, be 5V. However, if the voltage at the common pin is raised, then the output voltage will rise similarly, to maintain the 5V differential.

To achieve a practical variable output voltage an op.amp is used as a unity gain buffer whose non-inverting input is fed with a variable voltage, as supplied by potentiometer VR1. The buffer's output thus sets the voltage supplied to IC1's common pin. Resistor R1 provides a minimum current flow from the common pin to 0V.

Because VR1 is supplied by the output of IC1, the circuit configuration maintains the desired 5V output/common differential, and the final output voltage of the circuit is held regulated at the value set by VR1.

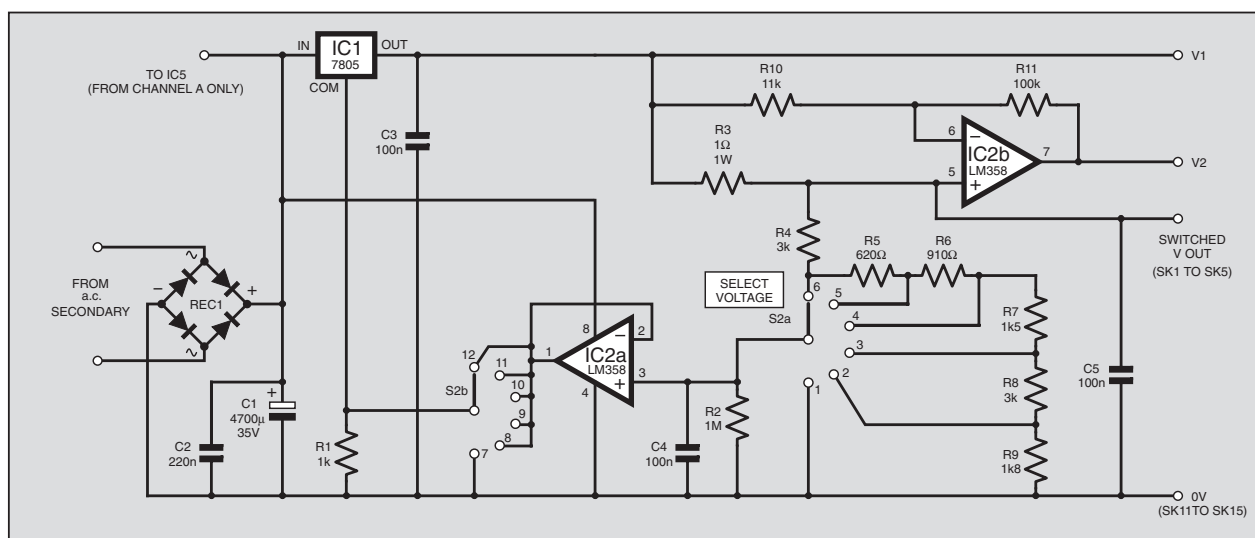


Fig.4. Circuit diagram of a single channel as used in the full power supply discussed. It is an expanded variant of that in Fig.3.



It should be noted, though, that the output of the op.amp (a type LM358) can never fall to 0V. More typically the minimum output voltage available will be about 0.5V. Consequently, the minimum regulated voltage that can be set by VR1 will be about 5.5V. The maximum voltage will about 2V below the rectified voltage fed into the input of regulator IC1.

In Fig.3, switch S2 selects whether IC1's common pin is connected to 0V (for fixed 5V output) or to the op.amp's output (for variable voltage control).

SWITCHED SUPPLY

For the full power supply design, the circuit of Fig.3 is expanded to become that in Fig.4.

Here the single potentiometer of Fig.4 has been replaced by a chain of six resistors, providing a tapped potential divider whose nodes are selected by rotary switch S2a. The reason for the inclusion of resistor R3 will be stated presently.

Capacitor C4 and resistor R2 are included to minimise voltage surges when the voltage range is switched. A smoothing capacitor is NOT connected between the op.amp's output and the 0V line since it was found that this could cause oscillation in the regulated supply.

Switch S2b replaces S2 of Fig.3, selecting between 5V and the preset output voltage from the buffering op.amp.

POTENTIAL CALCULATIONS

When considering the design of this power supply, the author originally believed that the tapped controlling voltages fed to the op.amp would need to be provided via individual preset potentiometers, each set for a different bias voltage, 5V below the required output from the regulator. The first constructed model actually used presets.

Initial calculations for a fixed multi-node potential divider had showed that the required resistors would have unusual values. The calculations were based on a total resistance across the divider of 10kΩ (as used for the basic potentiometer control).

As an example, and referring to Fig.5, consider the situation for Vout = 6V:

Rtotal = Rx + Ry = 10kΩ

Vout = 6V

Vbias = Vout - 5V = 1V

(5V is the voltage differential between IC1's output and common pins)

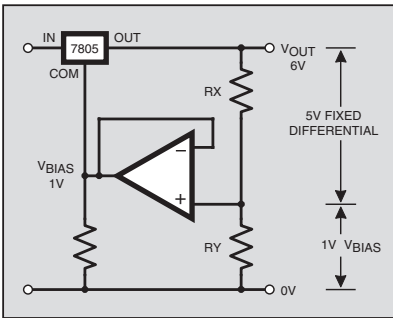


Fig.5. Potential divider use to control the voltage output from regulator IC1 at 6V.

Using the potential divider formula of:

Vbias = Vout x (Ry / Rtotal)

the equation can be stated as:

1V = 6V x (Ry / 10k)

Making Ry the subject produces the equation:

Ry = (1V / 6V) x 10k = 1.666667k

Thus Rx becomes:

Rtotal - Ry = 10k - 1.666667k = 8.333333k

Table 1 shows the individual resistor values in the divider chain of Fig.6 calculated for all five required output voltages. The calculations were produced by the QBasic program in Listing 1, in which Rtotal is the total resistance set at 10 (the "k" factor being omitted).

Table 1

IDEAL VALUES for Rtotal = 10k

Vout	Vbias	Resistor
6V	1V	R1 1.666667k
9V	4V	R2 2.777778k
12V	7V	R3 1.388889k
15V	10V	R4 .8333332k
18V	13V	R5 .5555557k
R6 = Rtotal-(R1+R2+R3+R4+R5) = 2.777778k		

The calculations were originally done by hand without the computer program. However, in an idle moment some weeks after building the power supply, the author gave the problem to the computer, using Listing 1. Calculations were made for several different values of Rtotal. A value for Rtotal of 11(k) produced the results shown in Table 2.

Table 2

IDEAL VALUES for Rtotal = 11k

Vout	Vbias	Resistor
6V	1V	R1 1.833333k
9V	4V	R2 3.055556k
12V	7V	R3 1.527778k
15V	10V	R4 .9166668k
18V	13V	R5 .6111109k
R6 = Rtotal-(R1+R2+R3+R4+R5) = 3.055555k		

Since these values appeared to be close to the available E24 series values, a second program, was written (Listing 2). In the program, the calculated output voltages were derived for a divider chain comprised of E24 values nearest to those in Table 2, i.e. 1k8, 3k, 1k5, 910Ω, 620Ω, 3k. The results are shown in Table 3.

Table 3

E24	Values	Vout
R1	1k8	5.996678V
R2	3k	8.9801V
R3	1k5	11.95364V
R4	910Ω	14.95856V
R5	620Ω	18.05V
R6	3k	
Rtotal = 10.83k		

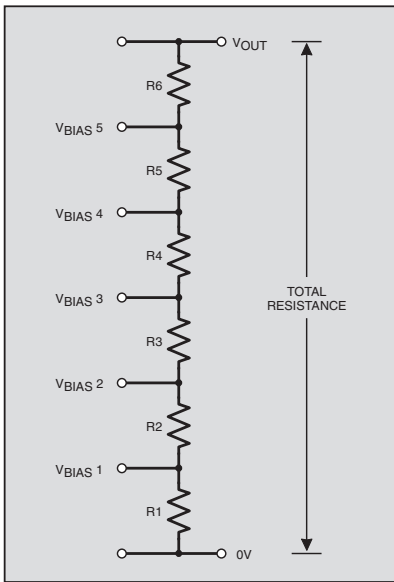


Fig.6. Basic potential divider chain used for voltage control selection.

LISTING 1

```
DATA 6,9,12,15,18: ' required Vout
rtotal = 10: rn = 0
PRINT "IDEAL VALUES for Rtotal";
PRINT " = "; rtotal; "k";
PRINT "Vout"; TAB(10); "Vbias";
PRINT TAB(20); "Resistor"
FOR a = 1 TO 5: READ vout
vbias = vout - 5
r(a) = ((vbias / vout) * rtotal) - rn.
rn = rn + r(a)
PRINT vout; "V"; TAB(10); vbias;
PRINT "V"; TAB(20); "R";
PRINT LTRIM$(STR$(a));
PRINT r(a); "k": NEXT
PRINT "R6 = "
Rtotal-(R1+R2+R3+R4+R5);
PRINT " = "; rtotal - rn; "k"
```

LISTING 2

```
DATA 1.8,3.0,1.5,910,620,3.0
PRINT : PRINT "E24 VALUES";
PRINT TAB(16); "CURRENT";
PRINT TAB(31); "Vout"
FOR a = 1 TO 6: READ r(a)
t = t + r(a): NEXT
ry = 0: rx = t
FOR a = 1 TO 5
rx = rx - r(a)
ry = ry + r(a)
I = 5000 / rx
v = (I * ry) / 1000 + 5
PRINT "R"; a; " = "; r(a); "k";
PRINT TAB(15); I; "mA";
PRINT TAB(30); v; "V": NEXT
PRINT "R"; a; " = "; r(a); "k";
PRINT TAB(20); "Rtotal = "; t; "k"
```

Table 4

Ideal	Chan 1	Chan 2
5V	4.97V	4.98V
6V	5.97V	5.98V
9V	8.93V	8.94V
12V	11.86V	11.87V
15V	14.84V	14.74V
18V	17.91V	17.82V

The values in Table 3 were considered to be close enough to the ideal for them to be acceptable. In practice, they will differ slightly because of resistor tolerance factors. Those obtained with the prototype are given in Table 4 (note that even the "fixed" 5V output of the two regulator i.c.s is not exactly 5V).

The basic formulae used in the programs are those for potential dividers, as given earlier (Listing 1), and Ohm's Law (Listing 2),  $V = I \times R$ .

Referring to Fig.5, the voltage (call it  $V_b$ ) across  $R_x$  is automatically specified as 5V, and thus the current ( $I$ ) flowing through  $R_x$  is calculated as:

$$I = V_b / R_x$$

The current flowing through a potential divider chain is constant at whatever point in the chain it is measured. Consequently, the same current flows through  $R_y$  as flows through  $R_x$ .

Therefore the voltage drop across  $R_y$  ( $V_{bias}$ ) simply equals  $I \times R_y$ , and so the regulated output voltage ( $V_{out}$ ) for the specified values of  $R_x$  and  $R_y$  is  $V_{bias}$  plus 5V.

As an example, and referring to Fig.6 and the resistor values in Table 3, to find  $V_{out}$  when  $V_{bias}$  at the junction of  $R_5$  and  $R_6$  is selected ( $V_{bias5}$ ), the following reasoning is used:

Since a voltage of 5V exists across  $R_6$  (3k), then a current of  $5V/3k = 1.66667mA$  flows through  $R_6$  (Ohm's Law derivative  $I = V/R$ ). Consequently the voltage drop ( $V_{bias}$ ) across the total of  $R_1 + R_2 + R_3 + R_4 + R_5$  (7.83k) is calculated as  $1.66667mA \times 7.83k = 13.05V$ . Thus the regulated output voltage  $V_{out} = V_{bias} + 5V = 18.05V$ , as listed in Table 3.

As a result of these calculations, the presets were dropped from the prototype and a resistor chain substituted instead, as shown in Fig.4 earlier. (All of which confirms the author's belief that a computer is one of his most important workshop tools!)

The two programs listed can be modified to calculate other tapped potential divider characteristics, for as many nodes are required.

## CURRENT MONITORING

The switched voltage from IC1 (Fig.4) is taken to the output sockets (SK1 to SK5) via a 1Ω resistor,  $R_3$ . This allows current flow to be monitored, according to the voltage drop across  $R_3$  caused by the amount of current flowing (Ohm's Law again). The resistor is included in the bias setting (potential divider) chain to maintain the correct output voltage irrespective of load currents.

Op.amp IC2b is configured as a differential amplifier. The voltage to either side of  $R_3$  is fed to the op.amp's inputs (pins 5 and 6) and the amplified difference is routed to the PIC microcontroller (discussed later) from point V2. The gain as seen by changes in voltage on the non-inverting input is about ten, as set by  $R_{11} / (R_{10} + 1)$ .

If current monitoring is not required, the circuit around IC2b may be omitted and the switched voltage fed to the output sockets, SK1 to SK5, from point V1.  $R_3$  must be replaced by a wire link.

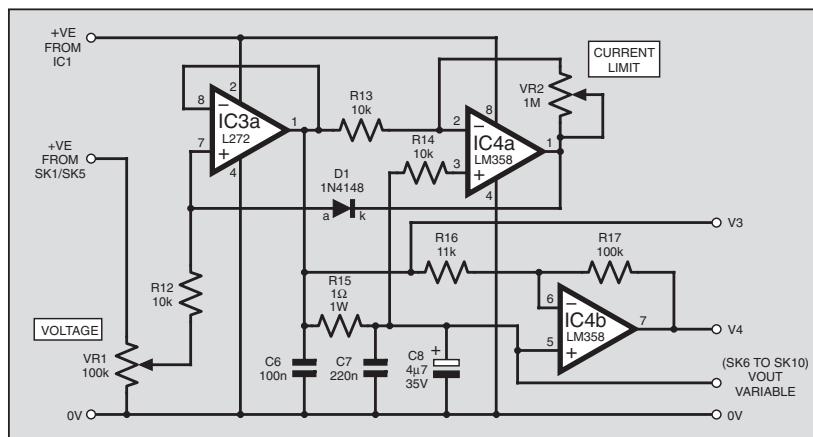


Fig.7. Variable voltage and current limiting circuit.

## VARIABLE SUPPLY

As it stands, the circuit in Fig.4 is perfectly usable on its own, with or without current monitoring. However, the author frequently has the need for a control voltage that can be varied from 0V upwards. Whilst a potentiometer across a fixed supply can provide such a voltage via its wiper, the current available is limited by the resistance at the wiper.

Consequently, this power supply has had a buffer circuit added, the circuit diagram for which is shown in Fig.7.

The buffer is formed around op.amp IC3a, one half of an L272 dual power op.amp (the other half is unused). The L272 is capable of supplying a current of 1A, but there are limitations imposed by the circuit, as discussed presently.

Power for the op.amp is taken from the switch-selected voltage output from regulator IC1. Potentiometer VR1 is also connected across the same supply, but following resistor  $R_3$ , and its wiper voltage is fed via resistor  $R_{12}$  to the non-inverting input of IC3a, pin 7.

The op.amp's output from pin 1 could be used directly as a variable voltage supply via the connection marked V3. However, as with the switched supply, it has a 1Ω resistor ( $R_{15}$ ) in series with it, through which the voltage is fed to the output sockets (SK6 to SK10). This allows current flow to be monitored via differential amplifier IC4b, which has the same function as IC2b, outputting an amplified current-dependent voltage to the PIC.

## CURRENT LIMITING

The variable supply has been given a simple current limiting facility, via the circuit around IC4a.

This circuit is also configured as a differential amplifier, monitoring the voltage across  $R_{15}$  and amplifying it according to the ratio of  $R_{13}$  and the resistance across potentiometer VR2.

The output of IC4a is connected back to the non-inverting input of IC3a via diode D1. If the current through  $R_{15}$  causes the amplified output voltage from IC4a to fall 0.7V (the "diode drop" voltage for a silicon diode) below the voltage on IC3a pin 7, the latter will be pulled down across resistor  $R_{12}$ . The result is that the output voltage from IC3a will fall by the same amount, so limiting the power fed to the load circuit.

Potentiometer VR2 permits the threshold gain to be varied from roughly unity ( $VR2 = 0\Omega$ ) to about 100 ( $VR2$  at maximum resistance). By test on the prototype, with  $VR2$  at zero resistance, a current flow of about 350mA through  $R_{15}$  causes the threshold to be reached, beyond which the input to IC3a is progressively reduced. With  $VR2$  at maximum resistance, 5mA across  $R_{15}$  has the same effect.

Any circuit powered from the variable supply must have a smoothing capacitor across its input power lines in order to prevent the current limiting circuit from oscillating when the threshold is reached. Without the capacitor, when the threshold is reached the output voltage falls, and so the current flow decreases, causing the voltage to rise again, etc.

Note that the presence of  $R_{15}$  on its own will also cause a voltage drop at the output sockets in response to increasing current, simply according to Ohm's Law (100mA causes a 0.1V drop).

## PIC MONITOR

The PIC microcontroller, IC6 in Fig.8, monitors the voltages input to it from the four power supply circuits, outputting data to the I.e.d.s. and the I.c.d. It interprets and displays the data according to factors input to it from switches S3 to S6. It does not actually control the power supply in any way.

As discussed in previous published PIC16F87x designs, this family of devices has several inputs which can be used for analogue-to-digital conversion. The PIC16F877 used here has eight A/D inputs, allowing the twin voltage levels from all channels to be monitored.

For each channel, the twin voltages are tapped prior to the 1Ω current sensing resistor and at the output of the respective differential amplifier.

The voltages can be several times greater than the PIC can safely handle and are attenuated by eight 20k/2k2 potential dividers, formed around  $R_8$  to  $R_{33}$ . The attenuation ratio is 1:10, which at first sight may seem high.

The reason is that Channel B can be connected in series with Channel A (refer back to Fig.1). In this situation, Channel B can produce a possible maximum voltage of 36V with reference to the PIC's 0V line. The 1:10 attenuation thus results in 3.6V at the input to PIC. Whilst a ratio of 5:36 (1:7.2) would allow slightly greater



precision of the digital conversion, a ratio of 1:10 makes the software processing somewhat easier.

The software repeatedly samples the eight inputs, and produces 10-bit conversion values. From these it calculates the source voltages prior to the attenuators. The value of the voltage prior to each 1Ω resistor is stored for output to the l.c.d.

This value is also compared with the voltage from the respective differential amplifier and a value for the current being drawn by the load circuit is calculated. This too is stored for subsequent output to the l.c.d.

The current values are additionally compared with the current limit values preset via switches S3 to S5. If the limit is being exceeded, the appropriate l.e.d. (D3 to D6) is turned on. Resistors R39 to R42 are the l.e.d. ballast resistors.

If the total current being supplied by a channel, via either or both of its outputs, exceeds 1A then *both* l.e.d.s for that channel are turned on, as is buzzer WD1.

The current being drawn must be reduced below the limits before the l.e.d.s and buzzer are turned off.

Remember that the PIC does not control the power supply in response to these limits being reached.

## L.C.D. MODULE

Data is sent to the l.c.d. module (X2) in 4-bit mode, with the same physical pin connection order as used with all the author's l.c.d. controlling designs over the last couple of years.

Readers who already have l.c.d.s with connectors that match those designs can simply plug them straight in to this Power Supply's monitor p.c.b. via the matching terminal pins (notated as TB1).

Preset potentiometer VR3 adjusts the l.c.d. screen contrast.

A point worth considering is whether or not to use a back-lit l.c.d. The author's workshop is well lit and the screen of the normal reflective type of l.c.d. used can be clearly seen.

In a less well-lit situation, however, the use of a (slightly more expensive) back-lit version could be beneficial, because the screen is on the front panel and faces forwards, rather than upwards as with the majority of published designs using l.c.d.s.

Typically, back-lit l.c.d.s have illumination provided by internal l.e.d.s. It is possible that the l.e.d.s can be powered from the monitor board's 5V supply (check the l.c.d. data sheet for the backlighting power requirements and connections). If this is the case, it would be prudent to use a 7805 1A regulator for IC5, instead of the 78L05 100mA device listed.

## CONTROL SWITCHES

Pushbutton switches S3 to S5 allow the PIC's current limiting data to be changed as required. S6 selects which of three display modes is shown: full data for one output, voltage data for all four outputs, or current data for all four outputs. Each push of S6 steps the display through the modes, on a repeating cycle.

When in the mode for single-output full data display, switch S5 steps the display through each output, on a repeating cycle of four. Typical displays are shown in Part 2.

Top left of the screen shows the output identity. This is notated in the form Ch1 to Ch4, where:

- Ch1 = Channel A switched output
- Ch2 = Channel A variable output
- Ch3 = Channel B switched output
- Ch4 = Channel B variable output

Top right of the screen shows the preset current limit for that output. It can be increased by S4 or decreased by S3. The limit is changed in steps of 10mA, with a minimum of 10mA and a maximum of 1A.

When S3 or S4 are released, the value displayed is stored in the PIC's EEPROM data memory. It remains there even after power has been switched off. It is recalled when the unit is again switched on.

Bottom left of the screen shows the voltage presently supplying the selected output (before the 1Ω resistor), in steps of 0.05V.

Bottom right of the screen shows the current being drawn from the output, in steps of 5mA.

Be mindful of the fact that the monitored voltage and current details on the l.c.d. screen are not as precise as those which a multimeter will display. They should be treated only as an approximate guide to prevailing conditions.

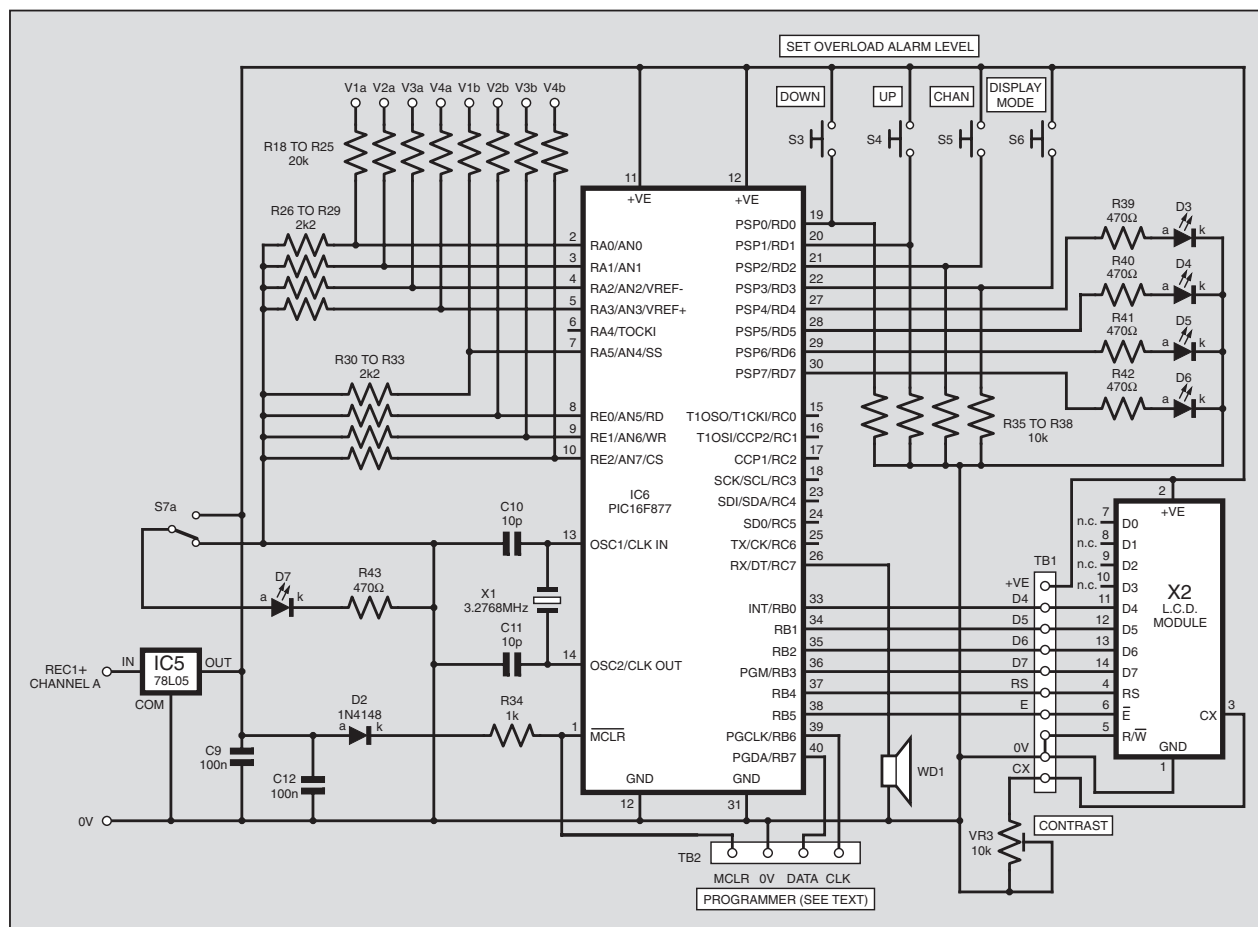


Fig.8. Circuit diagram for the PIC-monitoring option of the full power supply.

## COMPONENTS

### SINGLE FULL PSU CHANNEL Excluding the PIC monitoring circuit

#### Resistors

R1	1k 0.25W 5%
R2	1M 0.25W 5%
R3, R15	1Ω 1W 5% (or better) (2 off)
R4, R8	3k 0.25W 1% (2 off)
R5	620Ω 0.25W 1%
R6	910Ω 0.25W 1%
R7	1k5 0.25W 1%
R9	1k8 0.25W 1%
R10, R16	11k 0.25W 1% (2 off)
R11, R17	100k 0.25W 1% (2 off)
R12 to R14	10k 0.25W 5% (3 off)

#### Potentiometers

VR1	100k lin rotary
VR2	1M lin rotary

#### Capacitors

C1	4700μF radial elect. (see text)
C2, C7	220n ceramic disc, 5mm pitch (2 off)
C3 to C6	100n ceramic disc, 5mm pitch (4 off)
C8	4μF radial elect. 35V

#### Semiconductors

D1	1N4148 silicon signal diode
IC1	7805 +5V 1A voltage regulator
IC2, IC4	LM358 dual op.amp (2 off)
IC3	L272 dual power op.amp

#### Miscellaneous

REC1	W005 50V 1A bridge rectifier, or similar
S1	s.p.d.t. switch, mains rated
S2	2-pole 6-way rotary switch
SK1 to SK15	2mm socket, 3 colours, 5 off each (see text)

Printed circuit board (power supply), available from the *EPE PCB Service* code 280; knob (3 off); TO220 insulating washer kit for IC1; 8-pin d.i.l. socket (3 off)

All above parts repeated for second channel.

#### Also required

FS1	20mm fuseholder, panel mounting, with 1A 20mm fuse, slow blow
T1	mains transformer, 0-15V, 0-15V secondaries, 50VA (25VA per winding)

Metal case, 255mm × 160mm × 196mm (see text); heatsink compound (see text); eyelet tag; mains cable clamping grommet; nuts and bolts for mounting transformer (2 off each); cable ties; 1mm terminal pins; 3-core mains cable, 5A; connecting wire; solder, etc

Approx. Cost  
Guidance Only

**£30**  
excluding case

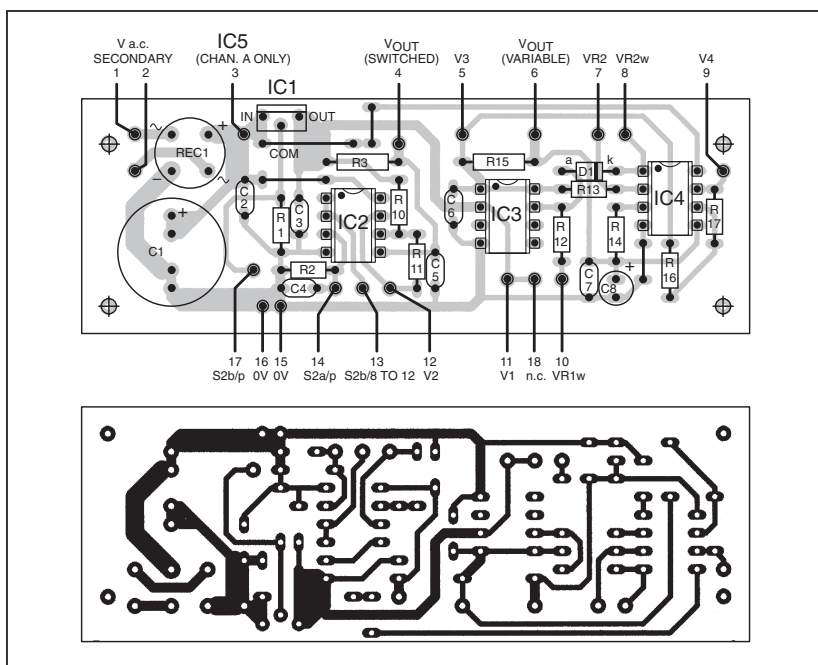
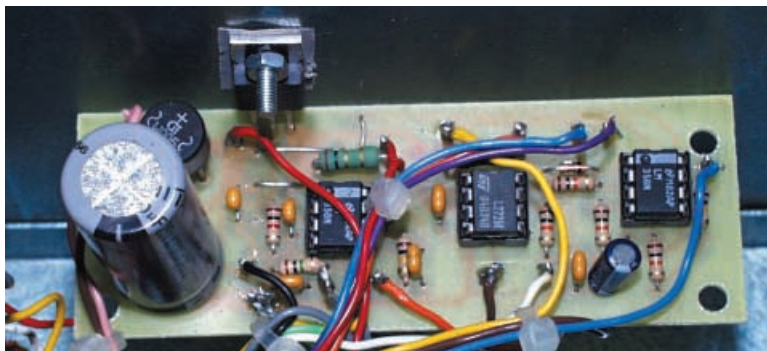


Fig.9. Printed circuit board component layout and full size copper foil master track pattern for the power supply in Fig.4.



## MISCELLANY

The PIC and I.c.d. are powered at 5V. This is provided by regulator IC5, whose input is connected directly to the rectified voltage at capacitor C1 (approximately 20V) of Channel A. The current drawn, with the I.e.d.s inactive, is a little under 6mA.

Crystal X1 sets the PIC's clock frequency at 3.2768MHz.

Selection of parallel or serial connection of Channels A and B is made by switch S7b in Fig.1 earlier. In Fig.8, S7a is the second half of the same switch and turns on I.e.d. D7 when the channels are connected in series.

## CONSTRUCTION

There are two printed circuit boards, one for the PIC monitoring circuit, the other for the power supply components of a single channel (two are needed if both channels are required).

Their constructional and track layout details are shown in Fig.9 and Fig.10. The boards are available from the *EPE PCB Service*, code 281 for the monitor and 280 for the power supply.

Preferably assemble the components in ascending order of size, commencing with the on-board link wires. Use sockets for IC2, IC3, IC4 and IC6. Do not insert IC6 (the PIC) into its socket until a few circuit

tests have been made later. Ensure the correct orientation of all other semiconductors and the electrolytic capacitors.

Mount the rectifier (REC1) and 1Ω resistors (R3 and R15) so that their bodies stand a bit above the p.c.b., allowing air to circulate around them. Also mount regulator IC1 somewhat above the p.c.b. to allow it to be easily bolted to the side of the case during the final stages of connecting up.

For terminal pin blocks TB1 and TB2 use 1mm pin-header strips. For the other off-board connection points insert 1mm terminal pins.

## CASE PREPARATION

The case used in the prototype and shown in the photographs is one which the author has had for some years. Regrettably it has been discontinued by the supplier, but an alternative case of a similar size is quoted in *Shoptalk*. The size of the original is 255mm × 160mm × 196mm (l × h × d). The detachable front and rear panels measure 245mm × 135mm. They are made from aluminium, whilst the rest of the case is mild steel.

Referring to the photographs, plan and drill your chosen case with care. Allow ample clearance between all mains powered connections and other items. Use a clamping cable grommet for the mains input lead.

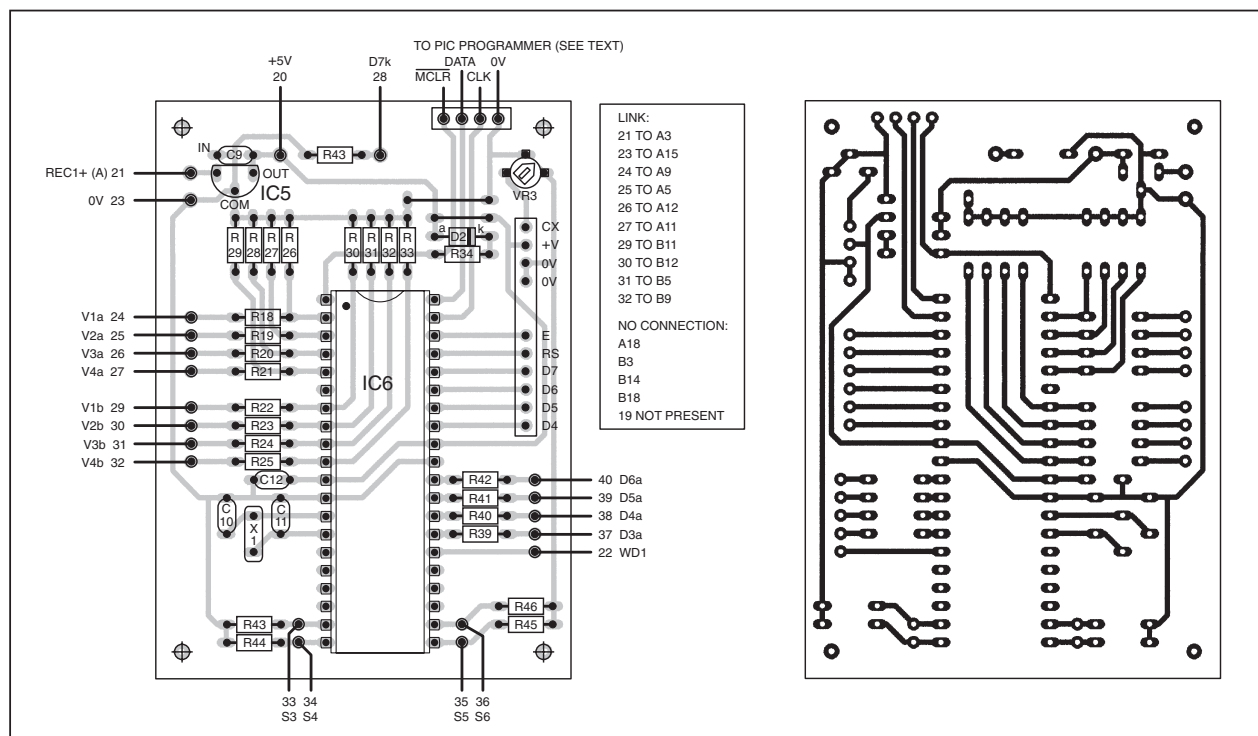


Fig. 10. Component layout and full size copper foil master track pattern for the PIC-monitoring circuit in Fig. 8.



If you prefer to use output sockets of a larger size to the 2mm type used in the prototype, you may not have room for the same quantity. The author prefers having several sockets connected to a single power supply output, allowing several circuits to be powered simultaneously from the same source.

Allow reasonable space for the control knobs to be rotated.

Mark the l.c.d. position carefully, then drill a succession of holes inside the perimeter of its screen position to ease the sawed removal of the oblong cut-out. Finish off with a file.

The l.e.d.s in the prototype were purchased as panel mounting components complete with pre-connected leads. Conventional l.e.d.s and mounting clips may be used instead. The wiring diagram in Part 2 shows the connections for the latter type.

Drill a hole in each side panel through which the IC1 regulators have to be bolted, attached to their p.c.b. Insulating washers and bushes should be used with the regulators, together with heatsink compound (some types of washer do not require the compound – consult your supplier when ordering the washers).

**It is essential to check that there is no electrical connection between the case and the tabs of the regulators.**

## NEXT MONTH

In the concluding part next month the wiring up of the full power supply is detailed, heat sinking is discussed, and operation of the software is described. Details of constructing simpler versions will also be given.

See this month's *Shoptalk* page for information on obtaining the software, and general information on buying the components.

## COMPONENTS

Approx. Cost  
Guidance Only

**£30**  
excluding case

### MONITOR UNIT

#### Resistors

- R18 to 20k 0.25W  
R25 1% (8 off)  
R26 to 2k 0.25W  
R33 1% (8 off)  
R34 1k 0.25W  
R35 to 10k 0.25W 5% (4 off)  
R38  
R39 to 470Ω 0.25W 5% (5 off)  
R43

#### Capacitors

- C9, C12 100n ceramic disc, 5mm pitch (2 off)  
C10, C11 10p ceramic disc, 5mm pitch (2 off)

#### Potentiometer

- VR3 10k min. preset, round

#### Semiconductors

- D2 1N4148 silicon signal diode

See  
**SHOP**  
**TALK**  
page

- D3 to D7 red l.e.d. (5 off) (see text)  
IC5 78L05 +5V 100mA voltage regulator (see text)  
IC6 PIC16F877-4 microcontroller, pre-programmed (see text)

#### Miscellaneous

- S3 to S6 s.p. min. push-to-make switch (4 off)  
S7 d.p.d.t. min. toggle switch  
TB1, TB2 1mm pin header strips (see text)  
WD1 5V to 9V active buzzer  
X1 3.2768MHz crystal  
X2 2-line, 16-character (per line) liquid crystal display (see text)

Printed circuit board, available from the *EPE PCB Service*, code 281 (monitor); 40-pin d.i.l. socket; nuts and bolts for l.c.d. (4 off each); cable ties; connecting wire; solder, etc.



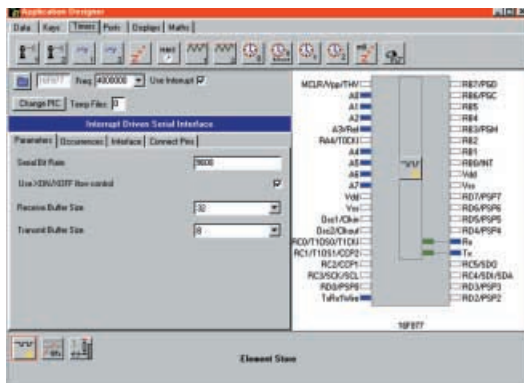
## NEW From FED - PIXIE - Visual PIC C Development

### PIXIE

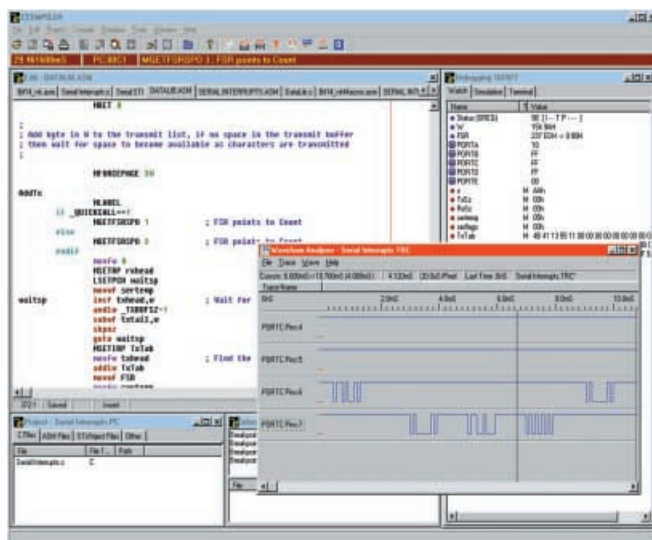


#### Fully featured C Compiler with drag 'n drop components

- An application designer for the FED PIC C Compiler FULLY including the PIC C Compiler
- Drag a software component on to your design
- Set up the parameters using check boxes, drop down boxes and edit boxes (see shot right).
- Connect the component to the PIC pins using the mouse
- Select your own C functions to be triggered when events occur (e.g. Byte received, timer overflow etc.)
- Generate the base application automatically and then add your own functional code
- Supports all 14 bit core PICs, 16F87x, 16C55x, 16C6x, 16F8x, 16C7xx etc.
- Complete development environment includes editor, compiler, assembler, simulator, waveform analyser, and terminal emulator. (Screen below)



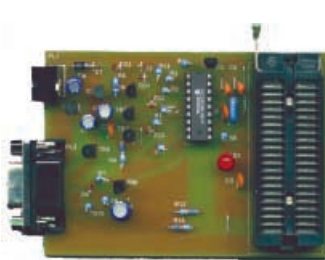
- Components include -
  - Software driven serial interfaces
  - Fully buffered hardware driven serial port with XON/XOFF signalling
  - Display drivers - LCD, 7 Segment
  - Switches and keypads with debounce/repeat
  - Timers and clocks
  - I<sup>2</sup>C, Clocked and Dallas 1 wire buses
  - Component and event interfaces to PIC hardware
- Includes Element editor to create your own components
- C Compiler designed to ANSI C Standards
- Link into MPLAB



#### Prices

- PIXIE with Introductory manual (C Manuals on CD) - £70
- C Compiler with all manuals on CD ROM - £60,
- C Compiler manuals (paper copy) - £10.00
- Buy PIXIE with WIZPIC or our Programmer - £50.00 CD-ROM
- Upgrade - C Compiler users, £15.00
- Upgrade - WIZPIC/FED PIC Programmer users, £50.00

### PIC & AVR Programmers



#### PIC Serial Programmer (Left) including 18Cxxx

Handles serially programmed PIC devices in a 40 pin multi-width ZIF socket. 16C55X, 16C6X, 16C7X, 16C8x, 16F8X, 12C508, 12C509, 16C72XPIC 14000, 16F87X, 18Cxxx etc. Also In-Circuit programming. Operates on PC serial port

Price : £45/kit  
£50/built & tested

**PIC Introductory** – Programs 8 and 18-pin devices : 16C505, 16C55X, 16C61, 16C62X, 16C71, 16C71X, 16C8X, 16F8X, 12C508/9, 12C671/2 £25/kit.

**AVR** – AVR1200,2313,4144,8515, 8535, 4434 etc. in ZIF. 4.5V battery powered. Price: £40 for the kit or £45 built & tested.

All our Programmers operate on PC serial interface. No hard to handle parallel cable swapping ! Programmers supplied with instructions, + Windows 3.1/95/98/NT software. Upgrade programmers from our web site !

### WIZPIC now with 18Cxxx

#### PIC Visual Development



- Rapid Application Development for the PIC microcontroller
- Drag and drop your software component selections on to your design
- Included components support timers, serial interfaces, I<sup>2</sup>C, LCD, 7 Seg displays, keypads, switches, port controls, and many more.
- Connect software components to PIC pins by point and click using the mouse
- Set parameters for each component from drop down list boxes, check boxes, or text entry
- Links your code automatically into library events
- Up to 10 times faster than MPLAB
- Supports all 14 bit core PIC's – 12C67x, 16C55x, 16C6x, 16C7x, 16C8x, 16C87x, 18Cxxx, etc

Cost – CD-ROM with Data sheets and application notes – £35.00, Floppy version £30.00.

#### Forest Electronic Developments

60 Walkford Road, Christchurch, Dorset, BH23 5QG.

Email – info@fored.co.uk, or sales@fored.co.uk

Web Site – <http://www.fored.co.uk>

01425-274068 (Voice/Fax)

Prices are fully inclusive, Add £3.00 for P&P and handling to each order. Cheques/POs payable to Forest Electronic Developments, or phone with credit card details.



#### 18C452

New architecture (more instructions + Hardware multiply), 40MHz clock, 16K program words, 1536 bytes RAM. Easy to upgrade from 16F877

18C452/JW	£20.00
18C452/OTP	£8.00

## MOBILE PROMISES . . . PROMISES . . .

Can Packet Radio make marketplace headway if it does not fulfil promised expectations? Barry Fox reports.

**T**HE cellphone industry risks crippling the fledgling market for GPRS by making the same kind of undeliverable promises that turned users off WAP.

GPRS, the new General Packet Radio Service due for consumer launch this Christmas, is already being wildly overhyped. It will deliver much slower data speeds than promised and looks sure to disappoint – like WAP before it.

“Who needs 3G (the third generation cellphone system due in a few years), when GPRS is here now,” asks Motorola, the first company to deliver GPRS handsets. BT, now trialling the first commercial GPRS service, says “accessing video and multimedia applications on your mobile phone is now a reality.”

“GPRS opens the mobile market to wireless multimedia,” promises Motorola’s web site, “with streaming and live video content.”

Technical and medical issues make even the theoretical speeds unattainable.

### TIME SLOTS

The European GSM digital cellphone system is now used in most countries. Channels 25kHz wide are sliced into eight time slots. Each slot carries a separate conversation, or data, at 9.6Kbps, one sixth the speed of a fixed phone line and modem. Users are charged for the time they use a slot.

GPRS lets users share time slots, with charges levied for data moved, not time on line. Several coding systems are used to protect against transmission errors. CS-1 has the most powerful error correction, but delivers only 9.05Kbps per slot. Where the radio signal is strong, CS-2 coding delivers 13.4Kbps.

Some of this data is wasted on “headers” needed to label Internet data. The data rate also varies depending on how many people are sharing slots. Most important, four or five slots can eventually be used for reception, a handset or PC card can transmit only one or two slots before the chips get too hot and burn out. Above two slots there is a health risk from excessive radiation (Specific Absorption Rate). Battery drain doubles for two slot working, so life halves.

Motorola’s first GPRS phones, such as the Timeport, will handle only one time slot out of the phone and two into the phone. New phones next year will work with one slot out and four down. The first models are not upgradeable. Ericsson will wait and launch with one out and four down.

### EXPERT OPINIONS

Rainer Lischetzki of Motorola says, “The realistic maximum rates we can get from GPRS are 64Kbps into the handset and 30Kbps out. We have known for ages about these limitations. We regret the sales talk, and data rate exaggeration.”

A BT Cellnet engineer was privately even more conservative, promising only between 7Kbps and 10Kbps per slot, or a best case scenario next year of 10Kbps transmit and 40Kbps receive.

But Motorola’s own web site and technical briefing documents promise speeds up to 171.2Kbps with “streaming and live video content”, while BT’s

publicity literature promises the chance to “send and receive data up to five times faster than is currently possible . . . and speeds will increase up to ten times faster in the coming months.”

Because GPRS is an always-on system, with charges for the quantity or quality of data handled, rather than time on line, it becomes the ideal tool for receiving E-mail on the move. But people who believe the publicity and buy GPRS as a mobile multimedia tool will be sorely disappointed. Even low quality mono sound needs two time slots; MPEG-4 videophone links can manage only one or two coarse video pictures a second.

## IT SUCKS – IN STYLE!



THE new Shesto Pal range of suction pick-up tools is invaluable for model making, craft and hobby uses, and they work without batteries.

Held like a pen, a gentle press of the button or bulb creates the correct amount of pressure to pick up, rotate and easily place small objects. To release them simply press the button again. The tools easily handle electronic components and a variety of other materials without risk of damage or blemish.

There are two models: the Model Pal at £7.95, comprising suction bulb and three cups, and the Hobby Pal at £14.95, which includes suction generator, four cups, two straight holders and two angled holders. The prices are quoted as *post free*.

For more information contact Shesto Ltd., Dept EPE, Unit 2, Sapcote Trading Centre, 374 High Road, Willesden, London NW10 2DH. Tel: 020 8451 6188. Fax: 020 8451 5450. E-mail: [sales@shesto.co.uk](mailto:sales@shesto.co.uk). Web: [www.shesto.com](http://www.shesto.com).

## GREENWELD AND KITMASTER



TWO well known companies, Greenweld and Kitmaster, have announced that they are to combine.

Greenweld, having been successfully resurrected after the closure of the old company in 1999, have seen high levels of demand for their new and surplus range of electronic bargain buys. During the same period, the arrival of Kitmaster by David Johns has brought back the era of valve radios.

Recently, Greenweld have been featuring Kitmaster products for sale through their own mail order and online shopping services. Realising the potential offered by these popular designs, Greenweld are combining their established mail order infrastructure with David John's expertise in electronics and valve radio design.

Geoffrey Carter of Greenweld tells us that Kitmaster's novel approach to electronic kit building has revived interest in valve technology assembly for both novices and experienced users alike. Models such as the popular Four Valve Regeneration Unit are selling at a high rate. Recent introductions include a range of battery-operated valve radios, which are becoming even more sought after. Each kit contains all the necessary parts, together with a detailed and comprehensive manual.

Greenweld will continue their commitment to offering a huge range of electronic components, together with frequent purchases of surplus electronic equipment of every type which is, as usual, offered at bargain prices. David Johns will continue to develop new products.

For a free catalogue contact Greenweld Ltd, Dept *EPE*, Unit 24, Horndon Industrial Park, West Horndon, Brentwood, Essex CM13 3XD. Tel: 01277 811042. Fax: 01277 812419. E-mail: [service@greenweld.co.uk](mailto:service@greenweld.co.uk). Web: [www.greenweld.co.uk](http://www.greenweld.co.uk).

## EWB WITH PCB CAD

ELECTRONICS Workbench devotees will be pleased to learn that this superb circuit design and simulation software package has now had printed circuit design facilities added to its pedigree. The sense of making such an addition will be obvious to anyone who is familiar with EWB.

EWB multiSIM is a complete system design tool which offers schematic entry, comprehensive component database, SPICE simulation, VHDL/Verilog entry and simulation, waveform analysis, r.f. capabilities and "seamless" transfer to p.c.b. layout. It is said to offer a unique combination of advanced functionality and exceptional ease of use.

Many of you will recall that we featured the basic EWB software in Mike Tooley's excellent *Electronics from the Ground Up* series of Oct '94 to Jun '95.

For more information contact Adept Scientific plc, Dept *EPE*, Amor Way, Letchworth, Herts SG6 1ZA. Tel: 01462 480055. Fax: 01462 480213.

E-mail: [ewb@adeptsience.co.uk](mailto:ewb@adeptsience.co.uk).

Web: [www.adeptsience.co.uk](http://www.adeptsience.co.uk).

## MAPLIN 2000/2001 CAT

MAPLIN Electronics have launched their new 2000/2001 catalogue with a huge range of products, over £100 worth of money-off vouchers and many brand new lines.

Maplin comment that their catalogue is "widely regarded as *the* electronics product bible." Now in its 28th year, it contains products ranging from individual components to state-of-the-art electronic equipment. It is available in traditional format (cost £3.99) or on a CD-ROM (£1.99).

The products can also be found at 57 Maplin stores nationwide, where specialist staff are available to help with technical and product enquiries. The Maplin website also features full product range details and a secure on-line ordering service with stock checking facilities.

For more catalogue information contact Maplin Electronics, Dept *EPE*, Valley Road, Wombwell, Barnsley S73 OBS. Tel: 0870 264 6002.

Web: [www.maplin.co.uk](http://www.maplin.co.uk).

## Sparing DVD Egg-spense?

By Barry Fox

TECHNICS launched DVD-Audio at the Hammersmith HiFi show. Consumers now have the chance to spend £900 on a new format player with no new format software to play on it. The only discs at the show were DVD-R dubs from Universal. None exploited the full DVD-Audio specification of 192kHz.

"It's chicken and egg," says Technics.

Most people may prefer to wait until there are eggs to go with their £900 chickens.

## Talking Signs

ON a number of occasions we have mentioned NXT, the inventors of Surface Sound flat panel loudspeaker technology. They tell us that they have unveiled a multilingual talking sign incorporating this revolutionary technology.

Using the latest digital audio techniques (MP3), the sign speaks in nine languages and is installed at the Whittington Hospital in Highgate, London. Research had shown that many public areas encounter a growing number of ethnic issues, including the variety of languages spoken and the need for simple spoken information.

Simply touching the panel gives the user instant access to customised information in a selection of languages. The combination of colourful graphics and clear high quality sound allows a wide range of messages and information to be imparted in a concise and friendly manner to both English and non-English speakers.

A spokesman for the Whittington Hospital said "This is a very exciting development for us, and we are pleased to be the first hospital in the UK with this particular initiative. We serve a culturally mixed community and we are always striving to improve our standards of health and ethnic issues."

For further information contact New Transducer Ltd., Dept *EPE*, 37 Ixworth Place, London SW3 3QH. Tel: 020 7343 5050. Fax: 020 7343 5055.

E-mail: [marketing@nxtsound.com](mailto:marketing@nxtsound.com).

Web: [www.nxtsound.com](http://www.nxtsound.com).

## Patents Rising

APPLICATIONS for patents have risen by six per cent to over 30,000 for 1999, according to figures released by the UK Patent Office. Most patents were granted in the telecomms sector, 865 patents, but electric circuitry also came high, at 429 patents.

The Patent Office web site ([www.patent.gov.uk](http://www.patent.gov.uk)) is receiving 50,000 hits daily (up from 20,000 a day last year), signifying that more people are wanting to find out how to protect their ideas and inventions.

The DTI (Department of Trade and Industry) also tells us that 27 per cent of UK businesses are now trading on-line. This puts the UK on a par with the USA and Canada, and ahead of Germany and Sweden (see [www.ukonlineforbusiness.gov.uk](http://www.ukonlineforbusiness.gov.uk)).



# Starter Project

# STATIC FIELD DETECTOR

ROBERT PENFOLD

*Amuse your friends and family with this novel "electroscope" starter project. – See if they are highly charged characters!*

**T**HIS ultra-simple device was designed as a low cost project for complete beginners, but it should also be of interest to those who like to experiment with unusual gadgets. It is a form of electroscope, which is a device that detects static electricity.

No doubt most readers have seen demonstration of purely mechanical devices that use electrostatic forces to show the presence of high static voltages. This device uses some simple electronics to detect much smaller potentials, with a twin l.e.d. display showing any increase or decrease in the detected voltage.

It has to be emphasised that this very simple unit is only intended to be a "fun" project, and it is not suitable for serious scientific purposes. Those with a serious interest in the subject of atmospheric electricity should refer to the recent *EPE* articles (*Atmospheric Electricity Detector* – June/July 2000) on this subject by Keith Garwell.

## BASICS

What is the difference between static electricity and the regular variety, and why is it not possible to measure static electricity using ordinary test equipment?

In normal electronics we are concerned with a flow of electricity, with electrons moving along wires or into and out of components. Static electricity is not fundamentally different to the electrical signals we normally deal with in that it is still comprised of electrons. The difference is that the electrons are not going anywhere.

Although normal matter contains electrons, it does not necessarily have a static charge. Matter has a positive charge when it has fewer electrons than normal, or a negative charge if it has an excess of electrons.

As most readers will be aware, static charges can be generated by friction, and rubbing many plastics will generate quite high voltages. The fact that static charges are present in most environments is probably less well known. Where you are right now there could well be a potential of 50V to 100V between the air near the floor and the air about two metres higher up.

On the face of it, measuring voltages of this order should be easy enough and any multimeter should be able to handle the task. In practice matters are more complicated due to the nature of the signals involved. The voltages may be quite high, but the available current is quite low. To be more precise, an appreciable current is available, but only very briefly.

Although a digital multimeter has a high input resistance of typically over 10 megohms, this will still rapidly leak away the charge being measured. In fact, it will leak it away before a meaningful measurement can be made.

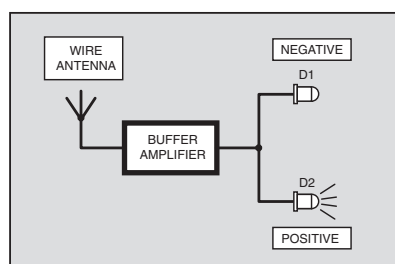


Fig.1. The static detector is basically just a buffer amplifier and two l.e.d.s.

A voltmeter having an extremely high input resistance is needed in order to measure static charges. The amount of current drawn by the test instrument is then so low that it does not significantly reduce the charge voltage during the measurement process.

Obtaining a suitably high input resistance is not difficult, since this is a natural characteristic of field effect transistors (f.e.t.s). It is also an attribute of many operational amplifiers (op.amps) which use field effect devices in their input stages. Op.amps having input resistances of one million megohms or more are commonplace, and this is more than adequate for the present application.

## SYSTEM OPERATION

This Static Field Detector uses the simple arrangement shown in Fig.1. An antenna consisting of a short piece of wire is connected to the input of a buffer amplifier that

has an ultra-high input resistance. This amplifier has no voltage gain, and its sole purpose is to provide the circuit with an ultra-high input resistance. There are no bias resistors or other components at the input of the amplifier, which is therefore free to float to whatever potential the antenna assumes.

The output of the amplifier drives two l.e.d. indicators. With the output of the amplifier at about half the supply potential both l.e.d.s are switched on fairly brightly.

If the output potential rises, the brightness of l.e.d. D2 increases but l.e.d. D1 becomes dimmer and will switch off if the output potential becomes high enough. A decrease in the output voltage has the opposite effect, with D1 becoming brighter and D2 going dimmer or even switching off altogether. This method is very simple and inexpensive, but it clearly shows any variations in the detected voltage.

## MEASURING WHAT?

When measuring voltages in a circuit you do not simply place one test prod on a test point and read its voltage. Most equipment is of the negative earth variety, and voltages are therefore measured relative to the negative supply rail. One test prod is connected to the earth rail (0V), and the other is placed on the test points.

Here we are effectively using a single test prod in the form of the antenna, with voltage measurements being made relative to nothing. Although it might seem as though the same middle reading will always be obtained, this is not actually the case.

When the unit is first switched on the two l.e.d.s will switch on to indicate a middle voltage. If the unit is moved around the l.e.d.s should soon start to indicate changes in potential. The unit is registering changes in voltage relative to the antenna's starting potential. It would be possible to connect the negative supply rail of the unit to an earth and then make measurements relative to the earth's potential.

However, a simple circuit such as this can only handle an input voltage range of about 0V to 9V, whereas signals of either polarity and up to a few hundred volts in magnitude might be encountered. Also, using an earth is relatively awkward and restrictive. The method used here is freer, easier, and works quite well.

## CIRCUIT OPERATION

The full circuit diagram for the Static Field Detector appears in Fig.2. The



operational amplifier, IC1, is the buffer amplifier, and is a bi-f.e.t. device that uses junction gate field effect transistors in its input stage. A device having a MOSFET input stage should work equally well on the input side of things, as should any other bi-f.e.t. op.amp.

The specified TL061CP op.amp has an output stage that will drive both l.e.d.s from fully switched off to fully switched on, whereas most other op.amps will fail to do this. Consequently, the use of alternative devices is not recommended.

No voltage gain is required in this application, so 100 per cent negative feedback is provided by coupling the output of the amplifier (pin 6) to the inverting input (pin 2) via resistor R1. The output adopts the same voltage as the non-inverting input at pin 3, but there is a massive current gain through IC1.

The input current is probably a few nanoamps or even picoamps, but the output can provide a few milliamps to drive the l.e.d.s at good brightness. Resistors R2 and R3 limit the current fed to l.e.d.s D1 and D2 to a safe level.

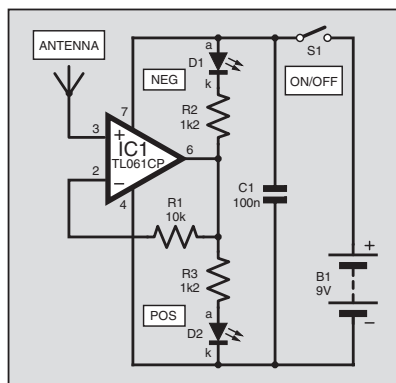


Fig.2. Complete circuit diagram for the Static Field Detector.

The maximum drive current is about 5mA. The TL061CP used for IC1 is a low current device, and the current consumption of the circuit as a whole is never much more than about 5mA.

## CONSTRUCTION

The construction of the Static Field Detector is based on the EPE multi-project printed circuit board. This board is available from the EPE PCB Service, code 932. The component layout, wiring and the actual size foil master pattern are shown in Fig.3.

Although there are very few components to fit onto the circuit board, the usual warning is still in order here. Unlike a normal custom printed circuit board, this board does not have one hole per component lead. It has many holes that are left unused, and the small number of components used in this circuit means that the vast majority of them are not used.

The low component count actually makes it easier to make a mistake, so it is essential to take more care than normal when fitting the components. Also, carefully check the completed board for errors.

In all other respects construction of the board offers nothing out of the ordinary. The TL061CP used for IC1 is not a device that is vulnerable to damage from static charges, but it is still advisable to mount it on the board via an i.c. socket.

There are two ways of dealing with the l.e.d.s. One is to mount them in panel holders and then hard wire them to the circuit board. The board should be fitted with single-sided solder pins at the points where the connections to the two l.e.d.s will be made. Incidentally, it should also be fitted with pins at the points where connections will be made to on/off switch S1, the battery, and the antenna.

Finished handheld detector showing labelling of the two "static" l.e.d.s.



The alternative method is to mount the l.e.d.s D1 and D2 on the printed circuit board, and to leave the leadout wires quite long. With the printed circuit board mounted on the base panel of the case, the l.e.d.s will then fit into two 5mm dia. holes drilled at the appropriate positions in the top panel.

Note that l.e.d.s, unlike filament bulbs, will only operate if they are connected with the correct polarity. The cathode (k) lead-out wire is normally shorter than the anode (a) lead. Also, most l.e.d.s. have a "flat" on the component's body, next to the cathode lead.

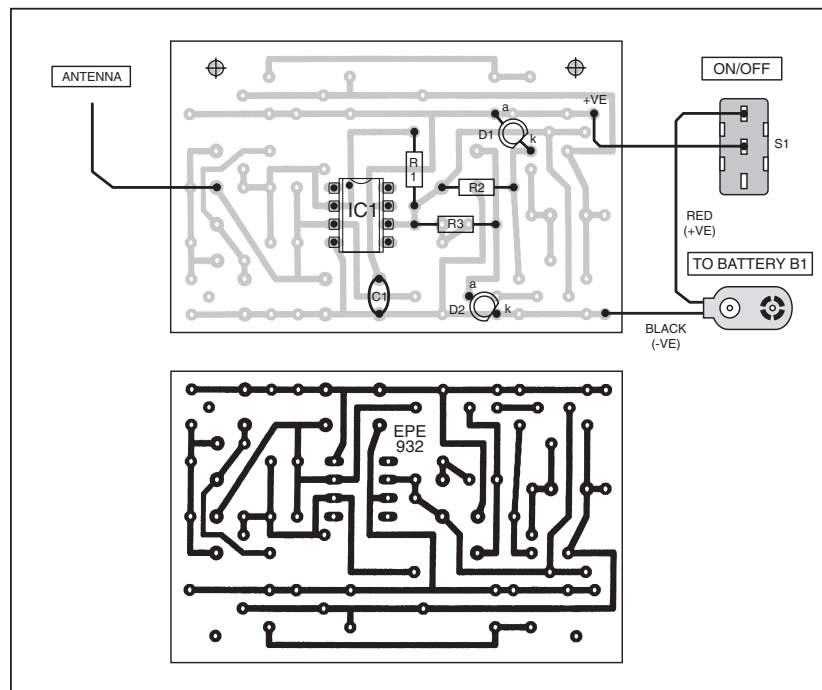


Fig.3. Component layout on the multi-project printed circuit board and full-size copper foil master. Double-check layout as not all holes are used.

## COMPONENTS

### Resistors

R1 10k  
R2, R3 1k2 (2 off)  
All 0.25W 5% carbon film

### Capacitor

C1 100n ceramic

### Semiconductors

D1, D2 5mm panel l.e.d.s, red  
IC1 TL061CP (see text)

### Miscellaneous

S1 s.p.s.t. min toggle switch  
B1 9V battery (PP3 size)

Small plastic case, size to choice; printed circuit board available from the EPE PCB Service, code 932; battery connector; stout tinned copper wire for antenna; plastic stand-off pillars or M3 nuts and bolts (see text); single-sided solder pins (3 off); solder, etc.

Approx. Cost  
Guidance Only

£10



## CASING-UP

Any small to medium size plastic case is suitable for this project. It is best not to use a metal box as it could interfere with the correct operation of the device, and would complicate fitting the antenna.

The completed printed circuit board is mounted inside the case using either plastic stand-offs or metric M3 bolts and fixing nuts. If bolts are used, spacers a few millimetres long must be fitted between the case and the board.

On/off switch S1 is mounted at any convenient point on the case, and a hole about 2mm dia. is drilled in the top side panel of the case, see photographs. This hole is for the antenna, which is merely a piece of tinned copper wire that protrudes about 75mm to 100mm beyond the front of the case. This wire should be fairly thick, but anything from about 0.7mm to 1.6mm (22 to 16s.w.g.) is suitable.

To complete the unit add the battery connector, fit the antenna, and add the wire from S1 to the circuit board.

## TESTING

Start with the lid of the case removed so that you have access to the circuit board.

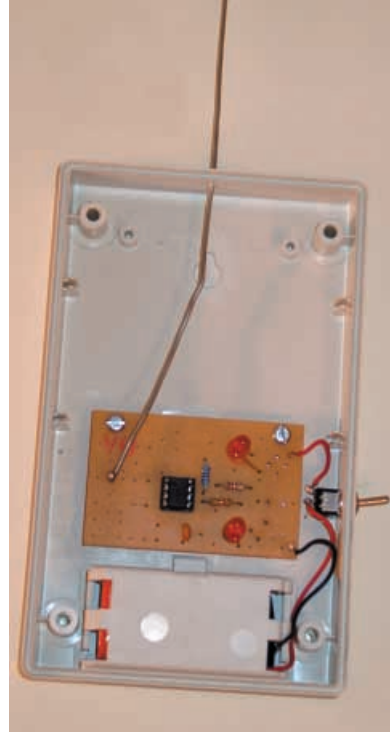
Both I.e.d.s should light up quite brightly when the unit is switched on. Try touching the antenna and the solder pin on the circuit board that takes the connection from the negative (black) battery lead. This should result in I.e.d. D2 switching off and D1 increasing in brightness.

Next touch the antenna and the solder pin that takes the lead from S1. This should have the opposite effect, with l.e.d. D1 switching off and D2 lighting more brightly. If there is any sign of a malfunction switch off at once and recheck the circuit board, etc.

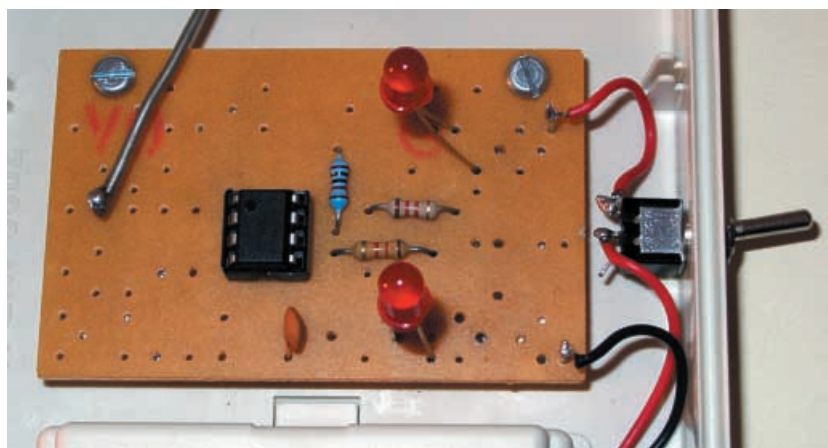
If all is well, refit the lid of the case and make some initial tests with the detector. In general, there is more to detect in a dry atmosphere than in a humid one where charges tend to leak away. Up and down movement will usually produce some change in the display.

Placing the unit near the ground invariably produces a strong positive indication, as will placing the antenna near anything that is earthed. This includes things like the metal case of a computer, a radiator, or the walls of a house.

You can amuse you friends and family by checking to see if they are highly charge



The simple layout of components inside the handheld case.



Completed circuit board. Note the unused holes.

characters, and whether they emit positive or negative energy. Get them to rub their clothes and then try again to see if different results are obtained.

The device used for IC1 has built-in protection circuitry that should prevent the input voltage from going outside the range that the unit can handle. If the l.e.d.s seem to get stuck showing a fully positive or negative indication try switching off, waiting a second or two, and then switching on again.

Attempts to deliberately "zap" IC1 by placing the antenna near known sources of high static voltages such as television screens proved fruitless. This suggests that the unit is reasonably "zap" resistant, but large static charges *can* destroy most modern semiconductors, so you try this sort of thing at your own risk. □

★ MAKE IT A SPECIAL GIFT EVERY MONTH ★

## SUBSCRIPTION ORDER FORM



I enclose payment of £..... (cheque/PO in £  
sterling only),  
payable to Everyday Practical Electronics



Access or Visa No.

[illegible]

Signature.....

Card Ex. Date .....

Please supply name and address of cardholder if different from the subscription address shown below. **Subscriptions can only start with the next available issue.** For back numbers see the Editorial page.

**Annual subscription rates (2000/2001):**

**6 Months: UK £14.50, Overseas £17.50 (standard air service),  
£27 (express airmail)**

**1 Year: UK £27.50, Overseas £33.50 (standard air service)  
£51 (express airmail)**

**2 Years: UK £50.00, Overseas £62.00 (standard air service)  
£97 (express airmail)**

**To: Everyday Practical Electronics,  
Allen House, East Borough, Wimborne, Dorset BH21 1PF  
Tel: 01202 881749 Fax: 01202 841692  
E-mail: [subs@epemag.wimborne.co.uk](mailto:subs@epemag.wimborne.co.uk)**

Name .....

Address .....

Post code ..... 12/05



# FRUSTRATED!

## Looking for ICs TRANSISTORS?

A phone call to us could get a result. We offer an extensive range and with a world-wide database at our fingertips, we are able to source even more. We specialise in devices with the following prefix (to name but a few).



2N 2SA 2SB 2SC 2SD 2P 2SJ 2SK 3N 3SK 4N 6N 17 40 AD  
ADC AN AM AY BA BC BD BDT BDV BDW BDX BF  
BFR BFS BFT BFX BFY BLX BS BR BRX BRY BS  
BSS BSV BSW BSX BT BTA BTB BRW BU BUK BUT BUV  
BUW BUX BUY BUZ CA CD CX CXA DAC DG DM DS  
DTA DTC GL GM HA HCF HD HEF ICL ICM IRF J KA  
KIA L LA LB LC LD LF LM M M5M MA MAB MAX MB  
MC MDAJ MJE MJF MM MN MPS MPSA MPSH MPSU  
MRF NJM NE OM OP PA PAL PIC PN RC S SAA SAB  
SAD SAJ SAS SDA SG SI SL SN SO STA STK STR STRD  
STRM STRS SV1 T TA TAA TAG TBA TC TCA TDA TDB  
TEA TIC TIP TIPL TEA TL TLC TMP TMS TPU U UA  
UAA UC UDN ULN UM UPA UPC UPD VN X XR Z ZN  
ZTS + many others

We can also offer equivalents (at customers' risk)

We also stock a full range of other electronic components  
Mail, phone, Fax Credit Card orders and callers welcome



Connect

## Cricklewood Electronics Ltd

40-42 Cricklewood Broadway London NW2 3ET  
Tel: 0181 452 0161 Fax: 0181 208 1441



## DISTANCE LEARNING COURSES in:

Analogue and Digital Electronics, Fibre Optics,  
Fault Diagnosis, Mechanics, Mathematics and  
Programmable Logic Controllers leading to a

## BTEC PROFESSIONAL DEVELOPMENT CERTIFICATE

- Suitable for beginners and those wishing to update their knowledge and practical skills
- Courses are very practical and delivered as self contained kits
- No travelling or college attendance
- Learning is at your own pace
- Each course can stand alone or be part of a modular study programme
- Tutor supported and BTEC certified

For information contact:

NCT Ltd., P.O. Box 11

Wendover, Bucks HP22 6XA

Telephone 01296 624270; Fax 01296 625299

Web: <http://www.nct.ltd.uk>

## VARIABLE VOLTAGE TRANSFORMERS

INPUT 220V/240V AC 50/60Hz OUTPUT 0V-260V  
PANEL MOUNTING

	Price	P&P
0.5KVA 2.5 amp max	£33.00	£6.00
	(£45.84 inc VAT)	£7.00
1KVA 5 amp max	£45.25	£7.00
	(£61.39 inc VAT)	

**SHROUDED**  
0.5KVA 2.5 amp max £34.00 £6.00

1KVA 5 amp max	£46.25	£7.00
	(£62.57 inc VAT)	

2KVA 10 amp max	£65.00	£8.50
	(£86.36 inc VAT)	

3KVA 15 amp max	£86.50	£8.50
	(£111.63 inc VAT)	

5KVA 25 amp max	£150.00	(+ Carriage & VAT)
Buy direct from the Importers. Keenest prices in the country.		

**500VA ISOLATION TRANSFORMER**  
Input lead 240V AC. Output via 3-pin 13A socket. 240V AC continuously rated, mounted in fibreglass case with handle. Internally fused. Price £35.00 carriage paid + VAT (£41.13)

**TOROIDAL L.T. TRANSFORMER**  
Primary 0-240V AC. Secondary 0-30V + 0-30V 600VA. Fixing bolt supplied. Price £25.00 carriage paid + VAT (£29.38)

**COMPREHENSIVE RANGE OF TRANSFORMERS - LT - ISOLATION & AUTO**  
110V-240V Auto transfer either cased with American socket and mains lead or open frame type. Available for immediate delivery.

**ULTRA VIOLET BLACK LIGHT BLUE FLUORESCENT TUBES**  
4ft. 40 watt £14.00 (callers only) (£16.45 inc VAT)  
2ft 20 watt £9.00 (callers only) (£10.58 inc VAT)  
12in 8 watt £4.80 + 75p p&p (£5.52 inc VAT)  
9in 6 watt £3.96 + 50p p&p (£4.46 inc VAT)  
6in 4 watt £3.96 + 50p p&p (£4.46 inc VAT)

**230V AC BALLAST KIT**  
For either 6in, 9in or 12in tubes £6.95 £1.40 p&p (£8.75 inc VAT)  
The above Tubes are 3500/4000 angstrom (350-400nm) ideal for detecting security markings, effects lighting & Chemical applications.  
Other Wavelengths of UV TUBE available for Germicidal & Photo Sensitive applications. Please telephone your enquiries.

**400 WATT BLACK LIGHT BLUE UV LAMP**  
C55 Mercury Vapour lamp suitable for use with a 400W P.F. Ballast. Only £39.95 incl. p&p & VAT



## 5 KVA ISOLATION TRANSFORMER

As New. Ex-Equipment, fully shrouded, Line Noise Suppression, Ultra Isolation Transformer with terminal covers and knock-out cable entries. Primary 120V/240V. Secondary 120V/240V, 50/60Hz, 0.005pF Capacitance. Size, L 37cm x W 19cm x H 16cm, Weight 42 kilos. Price £120 + VAT. Ex-warehouse. Carriage on request.

**24V DC SIEMENS CONTACTOR**  
Type 3TH8022-0B 2 x NO and 2 x NC 230V AC 10A. Contacts. Screw or Din Rail fixing. Size H 120mm x W 45mm x D 75mm. Brand New Price £7.63 incl. p&p and VAT.

**240V AC WESTOOL SOLENOIDS**  
Model TT2 Max. stroke 16mm, 15lb. pull. Base mounting. Rating 1. Model TT6 Max. stroke 25mm, 15lb. pull. Base mounting. Rating 1. Series 400 Max. stroke 28mm, 15lb. pull. Front mounting. Rating 2. Prices inc. p&p & VAT: TT2 £5.88, TT6 £8.81, Series 400 £8.64.

**AXIAL COOLING FAN**  
230V AC 120mm square x 38mm 3 blade 10 watt Low Noise fan. Price £7.29 incl. p&p and VAT. Other voltages and sizes available from stock. Please telephone your enquiries.

**INSTRUMENT CASE**  
Brand new. Manufactured by Imhof. L 31cm x H 18cm x 19cm Deep. Removable front and rear panel for easy assembly of your components. Grey textured finish, complete with case feet. Price £16.45 incl. p&p and VAT. 2 off £28.20 inclusive.

**DIECAST ALUMINIUM BOX**  
with internal PCB guides. Internal size 265mm x 165mm x 50mm deep. Price £9.93 incl. p&p & VAT. 2 off £17.80 incl.

**230V AC SYNCHRONOUS GEARED MOTORS**  
Brand new Ovoid Gearbox Crouzet type motors. H 65mm x W 55mm x D 35mm, 4mm dia. shaft x 10mm long. 6 RPM anti cw. £9.99 incl. p&p & VAT. 20 RPM anti cw. Depth 40mm. £11.16 incl. p&p & VAT.

**16 RPM REVERSIBLE** Crouzet 220V/230V 50Hz geared motor with ovoid geared box. 4mm dia. shaft. New manu. surplus. Soid complete with reversing capacitor, connecting block and cord. Overall size: h 68mm x w 52mm x 43mm deep. PRICE incl. P&P & VAT £9.99

**EPROM ERASURE KIT**  
Build your own EPROM ERASURE for a fraction of the price of a made-up unit. Kit of parts less case includes 12in. 8 watt 2537 Angstrom Tube Ballast unit, pair of bi-pin leads, neon indicator, on/off switch, safety microswitch and circuit £15.00+£2.00 p&p. (£19.98 inc VAT)

**WASHING MACHINE WATER PUMP**  
Brand new 240V AC fan cooled. Can be used for a variety of purposes. Inlet 1 1/2in., outlet 1in. dia. Price includes p&p & VAT. £11.20 each or 2 for £20.50 inclusive.

## Watch Slides on TV.

Make videos of your slides. Digitise your slides (using a video capture card)

"Liesgang diatv" automatic slide viewer with built in high quality colour TV camera. It has a composite video output to a phono plug (SCART & BNC adaptors are available). They are in very good condition with few signs of use. More details see [www.diatv.co.uk](http://www.diatv.co.uk). £91.91 + VAT = £108.00



Board cameras all with 512 x 582 pixels 8.5mm 1/3 inch sensor and composite video out. All need to be housed in your own enclosure and have fragile exposed surface mount parts. They all require a power supply of between 10V and 12V DC 150mA. 47MIR size 60 x 36 x 27mm with 6 infra red LEDs (gives the same illumination as a small torch but is not visible to the human eye) £37.00 + VAT = £43.48 30MP size 32 x 32 x 14mm spy camera with a fixed focus pin hole lens for hiding behind a very small hole £35.00 + VAT = £41.13 40MC size 39 x 38 x 27mm camera for 'C' mount lens these give a much sharper image than with the smaller lenses £32.00 + VAT = £37.60 Economy C mount lenses all fixed focus & fixed iris

VSL1220F 12mm F1.6 12 x 15 degrees viewing angle £15.97 + VAT £18.76

VSL4022F 4mm F1.22 63 x 47 degrees viewing angle £17.65 + VAT £20.74

VSL6022F 6mm F1.22 42 x 32 degrees viewing angle £19.05 + VAT £22.38

VSL8020F 8mm F1.22 32 x 24 degrees viewing angle £19.90 + VAT £23.38

## Better quality C Mount lenses

VSL1614F 16mm F1.6 30 x 24 degrees viewing angle £26.43 + VAT £31.06

VWL813M 8mm F1.3 with iris 56 x 42 degrees viewing angle £77.45 + VAT = £91.00

1206 surface mount resistors E12 values 10 ohm to 1M ohm

100 of 1 value £1.00 + VAT 1000 of 1 value £5.00 + VAT

866 battery pack originally intended to be used with an orbital mobile telephone it contains 10 1.6Ah sub C batteries (42 x 22 dia. the size usually used in cordless screwdrivers etc.) the pack is new and unused and can be broken open quite easily £7.46 + VAT = £8.77



Please add £1.66 + vat = £1.95 postage & packing per order

## JPG Electronics

276-278 Chatsworth Road, Chesterfield, S40 2BH.

Tel 01246 211202 Fax 01246 550959

Mastercard/Visa/Switch

Callers welcome 9.30 a.m. to 5.30 p.m. Monday to Saturday

We can supply back issues of *EPE* by post, most issues from the past five years are available. An *EPE* index for the last five years is also available – see order form. Alternatively, indexes are published in the December issue for that year. Where we are unable to provide a back issue a photostat of any *one* article (or *one* part of a series) can be purchased for the same price. Issues from Nov. 98 onwards are also available to download from [www.epemag.com](http://www.epemag.com).

## DID YOU MISS THESE?

### JULY '99

**PROJECTS** • 12V Lead-acid Battery Tester • L.E.D. Stroboscope • EPE Mood Picker • Intruder Deterrent.  
**FEATURES** • Practical Oscillator Designs-1 • Practically Speaking • Circuit Surgery • Ingenuity Unlimited • New Technology Update • Net Work – The Internet.

### AUG '99

**PROJECTS** • Ultrasonic Puncture Finder • Magnetic Field Detective • Freezer Alarm • 8-Channel Analogue Data Logger-1 • Sound Activated Switch.  
**FEATURES** • Practical Oscillator Designs-2 • Power Generation from Pipelines to Pylons-1 • Ingenuity Unlimited • Circuit Surgery • Interface • Net Work – The Internet.

### SEPT '99

**PROJECTS** • Loop Aerial SW Receiver • Child Guard • 8-Channel Analogue Data Logger-2 • Variable Dual Power Supply.  
**FEATURES** • Practical Oscillator Designs-3 • Power Generation from Pipelines to Pylons-2 • Practically Speaking • Circuit Surgery • Ingenuity Unlimited • New Technology Update • Net Work.

### OCT '99

**PROJECTS** • Interior Lamp Delay • Mains Cable Detector • QWL Loudspeaker System • Micro Power Supply.  
**FEATURES** • PIC16F87x Mini Tutorial • Practical Oscillator Designs-4 • Circuit Surgery • Interface • Ingenuity Unlimited • Net Work – The Internet.

### NOV '99

**PROJECTS** • Acoustic Probe • Vibralarm • Ginormous Stopwatch-1 • Demister One-Shot.  
**FEATURES** • Teach-In 2000-Part 1 • Ingenuity Unlimited • Practically Speaking • Practical Oscillator Designs-5 • Circuit Surgery • New Technology Update • Net Work – The Internet  
*FREE* Identifying Electronic Components booklet.



### DEC '99

**PROJECTS** • PIC Micro-Probe • Magnetic Field Detector • Loft Guard • Ginormous Stopwatch – Giant Display-2.  
**FEATURES** • Teach-In 2000-Part 2 • Practical Oscillator Designs-6 • Interface • Ingenuity Unlimited (Special) • Circuit Surgery • Network-The Internet • 1999 Annual Index.

### JAN '00

**PROJECTS** • Scratch Blanker • Versatile Burglar Alarm • Flashing Snowman • Vehicle Frost Box.  
**FEATURES** • Ingenuity Unlimited • Teach-In 2000-Part 3 • Circuit Surgery • Practically Speaking • Tina Pro Review • Net Work – The Internet.

### FEB '00 Photostats Only

**PROJECTS** • PIC Video Cleaner • Voltage Monitor • Easy-Typist Tape Controller • Find It – Don't Lose It!  
**FEATURES** • Technology Timelines-1 • Circuit Surgery • Teach-In 2000-Part 4 • Ingenuity Unlimited • Interface • Net Work – The Internet.

### MAR '00

**PROJECTS** • EPE ICEbreaker • High Performance Regenerative Receiver-1 • Parking Warning System • Automatic Train Signal.  
**FEATURES** • Teach-In 2000 – Part 5 • Practically Speaking • Technology Timelines-2 • Ingenuity Unlimited • Circuit Surgery • New Technology Update • Net Work – The Internet.

### APRIL '00

**PROJECTS** • Flash Slave • Garage Link • Micro-PICscope • High Performance Regenerative Receiver-2.  
**FEATURES** • Teach-In 2000-Part 6 • Ingenuity Unlimited • Technology Timelines-3 • Circuit Surgery • Interface • Telcan Home Video • Net Work – The Internet.



### MAY '00

**PROJECTS** • Versatile Mic/Audio Preamplifier • PIR Light Checker • Low-Cost Capacitance Meter • Multi-Channel Transmission System-1.  
**FEATURES** • Teach-In 2000-Part 7 • Technology Timelines-4 • Circuit Surgery • Practically Speaking • Ingenuity Unlimited • Net Work – The Internet • *FREE* Giant Technology Timelines Chart.

### JUNE '00

**PROJECTS** • Atmospheric Electricity Detector-1 • Canute Tide Predictor • Multi-Channel Transmission System-2 • Automatic Nightlight.  
**FEATURES** • Teach-In 2000 – Part 8 • Technology Timelines-5 • Circuit Surgery • Interface • New Technology Update • Ingenuity Unlimited • Net Work – The Internet.



### JULY '00

**PROJECTS** • G-Meter • Camera Shutter Timer • PIC-Gen Frequency Generator/Counter • Atmospheric Electricity Detector-2.  
**FEATURES** • Teach-In 2000-Part 9 • Practically Speaking • Ingenuity Unlimited • Circuit Surgery • PICO DrDAQ Reviewed • Net Work – The Internet.

### AUG '00

**PROJECTS** • Handy-Amp • EPE Moodloop • Quiz Game Indicator • Door Protector  
**FEATURES** • Teach-In 2000-Part 10 • Cave Electronics • Ingenuity Unlimited • Circuit Surgery • Interface • New Technology Update • Net Work – The Internet.

### SEPT '00

**PROJECTS** • Active Ferrite Loop Aerial • Steeplechase Game • Remote Control IR Decoder • EPE Moodloop Power Supply.  
**FEATURES** • Teach-In 2000-Part 11 • New Technology Update • Circuit Surgery • Ingenuity Unlimited • Practically Speaking • Net Work – The Internet Page.

### OCT '00

**PROJECTS** • Wind-Up Torch • PIC Dual-Chan Virtual Scope • Fridge/Freezer Alarm • EPE Moodloop Field Strength Indicator.  
**FEATURES** • Teach-In 2000-Part 12 • Interface • Ingenuity Unlimited • New Technology Update • Circuit Surgery • Peak Atlas Component Analyser Review • Net Work – The Internet Page.

### NOV '00

**PROJECTS** • PIC Pulsometer • Opto-Alarm System • Sample-and-Hold • Handclap Switch.  
**FEATURES** • The Schmitt Trigger-Part 1 • Ingenuity Unlimited • PIC Toolkit Mk2 Update V2.4 • Circuit Surgery • New Technology Update • Net Work – The Internet • *FREE* Transistor Data Chart.

## BACK ISSUES ONLY £3.00 each inc. UK p&p.

Overseas prices £3.50 each surface mail, £4.95 each airmail.

We can also supply issues from earlier years: 1992 (except March, April, June to Sept. and Dec.), 1993 (except Jan. to March, May, Aug., Dec.), 1994 (except April to June, Aug., Oct. to Dec.), 1995 (No Issues), 1996 (except Jan. to May, July, Aug., Nov.), 1997 (except Feb. and March), 1998 (except Jan., March to May, July, Nov., Dec.), 1999.

We can also supply back issues of *ETI* (prior to the merger of the two magazines) for 1998/9 – Vol. 27 Nos 1 to 13 and Vol. 28 No. 1. We are not able to supply any material from *ETI* prior to 1998. Please put *ETI* clearly on your order form if you require *ETI* issues.

Where we do not have an issue a photostat of any *one* article or *one* part of a series can be provided at the same price.

### ORDER FORM – BACK ISSUES – PHOTOSTATS – INDEXES

☐ Send back issues dates .....  
☐ Send photostats of (article title and issues date) .....  
☐ Send copies of last five years indexes (£3.00 for five inc. p&p – Overseas £3.50 surface, £4.95 airmail)  
Name .....  
Address .....  
  
☐ I enclose cheque/P.O./bank draft to the value of £ .....  
☐ Please charge my Visa/Mastercard £ .....  
Card No. .... Card Expiry Date .....  
**Note:** Minimum order for credit cards £5. Please supply name and address of cardholder if different from that shown above.  
SEND TO: **Everyday Practical Electronics, Allen House, East Borough, Wimborne, Dorset BH21 1PF.**  
Tel: 01202 881749. Fax: 01202 841692.  
E-mail: [orders@epemag.wimborne.co.uk](mailto:orders@epemag.wimborne.co.uk)  
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.

M12/00



# STORE YOUR BACK ISSUES IN YOUR WALLET!



A new way to buy *EPE* Back Issues – our wallet-sized CD-ROMs contain back issues from our *EPE Online* website plus bonus articles, all the relevant PIC software and web links. All this for just £12.45 including postage and packing.

**VOL 2  
NOW AVAILABLE**

**ONLY  
£12.45**

including VAT  
and p&p



## VOL 1 CONTENTS

**BACK ISSUES** – November 1998 to June 1999 (all the projects, features, news, IUs etc. from all eight issues). Note: No advertisements or Free Gifts are included.

**PIC PROJECT CODES** – All the available codes for the PIC based projects published in issues from November 1998 to June 1999.

**EPE ONLINE STORE** – Books, PCBs, Subscriptions, etc.

## VOL 2 CONTENTS

**BACK ISSUES** – July 1999 to December 1999 (all the projects, features, news, IUs, etc. from all six issues). Note: No advertisements or Free Gifts are included.

**PIC PROJECT CODES** – All the available codes for the PIC-based projects published in issues from July to December 1999.

**EPE ONLINE STORE** – Books, PCBs, Subscriptions, etc.

## EXTRA ARTICLES – ON ALL VOLUMES

**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.

**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.D.s**, By Julyan Ilett – An utterly practical guide to interfacing and programming intelligent liquid crystal display modules.

**PhyzyB COMPUTERS BONUS ARTICLE 1** – Signed and Unsigned Binary Numbers. By Clive "Max" Maxfield and Alvin Brown.

**PhyzyB 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 in an interesting and understandable way with full colour graphics.

NOTE: This mini CD-ROM is suitable for use on any PC with a CD-ROM drive. It requires Adobe Acrobat Reader (available free from the Internet – [www.adobe.com/acrobat](http://www.adobe.com/acrobat))

Order on-line from [www.epemag.com](http://www.epemag.com) or by Phone, Fax, E-mail or Post

## BACK ISSUES CD-ROM ORDER FORM

Please send me ..... (quantity) BACK ISSUES CD-ROM **VOL 1**

Please send me ..... (quantity) BACK ISSUES CD-ROM **VOL 2**  
Price £12.45 (approx \$20) 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 £ .....

Card No. .... Expiry Date .....

**Note: Minimum order for credit cards £5.** Please supply name and address of cardholder if different from that shown above.

**SEND TO: Everyday Practical Electronics, Allen House, East Borough, Wimborne, Dorset BH21 1PF.**

Tel: 01202 881749. Fax: 01202 841692.

E-mail: [orders@epemag.wimborne.co.uk](mailto:orders@epemag.wimborne.co.uk)

Payments must be by credit 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.





# 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 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 relevant component values. **Please draw all circuit schematics as clearly as possible.** Send your circuit ideas to: Alan Winstanley, *Ingenuity Unlimited*, Wimborne Publishing Ltd., Allen House, East Borough, Wimborne, Dorset BH21 1PF. (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

- 50MSPS Dual Channel Storage Oscilloscope
- 25MHz 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 six months, Pico Technology will be awarding an ADC200-50 digital storage oscilloscope for the best *IU* submission. In addition, two single channel ADC-40s will be presented to the runners-up.

## Car Wash-Wipe Latch – More Delays

**F**OR cars which have only a simple rear wash-wipe control giving a single sweep of the wiper each time the switch is operated, the latching circuit of Fig. 1 will additionally provide a sweep automatically every few seconds, for use in continuous spray conditions. No extra switches are needed and the normal single-sweep operation can still be used at any time.

In the circuit diagram of Fig.1, IC1a is one half of a 556 dual timer, with the reset terminal (pin 4) connected unusually to the output (pin 5) via resistor R6 to form a latch. This can be set or reset depending on the duration of the wiper switch closure. When power is first applied (probably by switching on the car ignition), capacitor C2 briefly pulls the reset terminal high which enables the timer.

The trigger terminal (pin 6) voltage is low, so the output goes high and maintains the

reset terminal high. The timing capacitor C1 charges from the output via R4, R5 and R6, but because of resistor R7 it does not reach the timer's threshold voltage (two-thirds of the supply voltage).

When the wiper switch is closed, capacitor C1 charges further via resistor R2, and will reach the threshold voltage in about 0.4 seconds, at which point the timer output will go low. (If the switch is opened before this, C1 simply discharges again.) The output then holds the reset terminal low after the wiper switch is opened, and C1 then discharges through R7. The latch remains in this state until the wiper switch is closed again, which takes the reset high and allows the output to go high again.

If the wiper switch is then held closed for more than 0.4 seconds capacitor C1 will have charged above the threshold voltage and so when the switch is opened the

output will go low, resetting the latch. Releasing the switch in less than 0.4 seconds sets the latch.

While the output of the latch is low it enables IC1b, which is an astable multivibrator with a duty cycle of 5 per cent. The inclusion of diode D3 enables the on and off times to be set independently by resistors R9 and R10 respectively. The output at IC1b pin 9 drives the existing transistorised wiper relay to give one sweep every ten seconds.

The circuit is powered from the car battery via resistor R1 and Zener diode D1 which provide a regulated 6.2V. To prevent damage to the i.c. from any voltage spikes from the wiper switch, the signal from R2 is clamped to the regulated supply rail by diode D2.

**N. Jewell,  
Ilfracombe,  
Devon.**

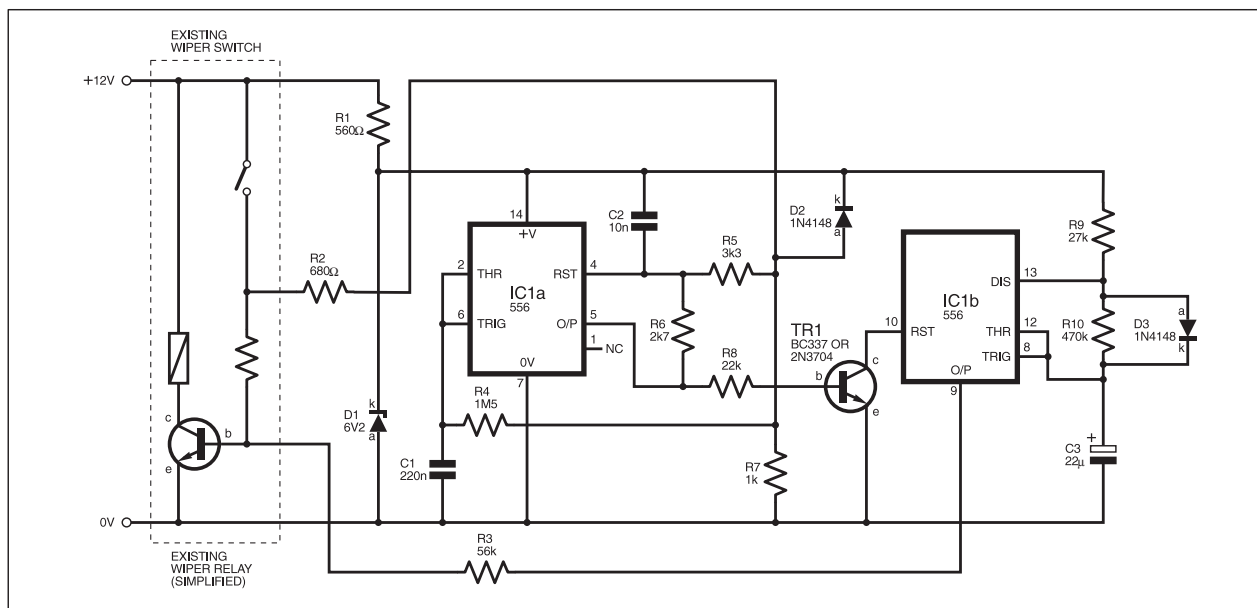


Fig.1. Circuit diagram for the Car Wash-Wipe Latch.



# READOUT

E-mail: [editorial@epemag.wimborne.co.uk](mailto:editorial@epemag.wimborne.co.uk)

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

## WIN A DIGITAL MULTIMETER

A 3 $\frac{1}{2}$  digit pocket-sized I.c.d. multimeter which measures a.c. and d.c. voltage, d.c. current and resistance. It can also test diodes and bipolar transistors.

Every month we will give a Digital Multimeter to the author of the best Readout letter.



## ★ LETTER OF THE MONTH ★

### BASE-32 CODE

Dear EPE,

Your extension of base-16 (so-called *hexadecimal*) code to provide a compact date/time code for file names in the *PIC Dual-Channel Virtual Scope* project (Oct '00), is easily extended further to provide a full base-32 code and allow even more compactness.

As you point out, the month requires only one digit in base-16 code, and by extending the code as you have done, hours from 0 to 24 can also be represented by only one digit. With a further extension of the code to base 32, the day of the month could also be represented by only one digit, and three digits would suffice to represent any year up to 32,767 AD.

I have been using such a base-32 code for some time, with some modifications (dare I emulate Microsoft and call them *enhancements*?) that I find useful. These are:

1. Leaving out I (eye) and O (oh), which can be confused with 1 (one) and 0 (zero)

2. For those, like me, who prefer to use lower-case letters, also leaving out l (el), easily confused with 1 (one).

So with the above, the code sequence is: 0 to 9, a to f (as in the commonly used base-16 code), g h j k m n, p to y. This leaves z for use as a dummy symbol.

3. I considered devising a base-64 code to represent minutes and seconds, but decided that it would be more bother than it was worth, so like you I have retained base-10 for these.

4. The most significant digit is placed first, i.e. the date and time are expressed as year + month + day + hour + minute + second. This simplifies sorting and arithmetical operations.

5. The code may have uses beyond incorporating date and time information in file names. So for, say, astronomical events, dates BC are expressed by prefixing a minus sign, and the BC/AD discontinuity smoothed out by assigning 000 to 1 BC. Examples:

1. My E-mail user name (pk1V7) comprises my initials and my birth year (yes, 1927 in base-10 code) 1x0 means 1984; this year (2000) is 1xg = 1984 + 16

2. The inventor of the Julian calendar made his first attempt to invade Britain in -01p

To conform with the DOS file-name and extension format of up-to-eight + up-to-three characters, the code for the seconds is placed in the extension. This leaves room to include the Admiralty time-zone designation as well: z for GMT, a for BST, k for my part of Oz. Your example of 7 Sep 2000 at 1:37:13 a.m., which you code as 07913713.Y00, then becomes lxx97137.13a

The advantages of this coding scheme, it seems to me, are its generality and its versatility. There can be a trade-off between time span and precision, with the code truncated at one or both ends to suit the application, thereby leaving room within file-naming conventions for other information.

**Peter Kelly,  
Woombye, Queensland, Australia**

Many thanks Peter for raising this discussion. Your comments are interesting for several reasons.

First, you highlight the problem of differentiating between several characters. It has long bugged me that some programmers insist on using the letter I (or i) as a variable name. For example: **FOR A = 1 TO K**, which if seen in print could be taken as **FOR A = (ONE) TO K** when in fact it means **FOR A = (the value stored in the variable represented by letter I) TO K**, a misinterpretation that could have a profound effect on the successful running of the program.

To me, programming use of characters i, I and l (eye, EYE, el) should be prohibited by cosmic edict (or at least common sense)! I'm currently getting to grips with VisualBASIC and even in its demo software there are frequent instances where I am not immediately sure which of the three characters is meant. (Oh, alright, I've been known to use them myself in my own software!)

Incidentally, my OCR scanner can also be confused by these characters, plus ' ' \ and ! (lefthand single quote, apostrophe, forward slash, backslash, exclamation) and 5 and S (five, ESS).

You are quite right about using base-32 for coding. For characters that have to be read by a human eye, as in a file name within a computer directory (folder) for example, base-32 seems a reasonable limit. However, if it is only the computer that has to read coded data, almost the full extent of base-256 can be used.

Some years ago, I wrote a fixtures allocation program for a local Sunday football league. This was written for a very low powered machine (Commodore PET) and to economise on memory space (32K bytes) I succeeded in coding each data item within single bytes, one each for date, venue, teams, home/away, score points etc. These bytes only needed to be read by the computer from a single string of characters within a data file, it then translated them according to calculation and lookup tables.

Whilst a few ASCII values within the possible 0 to 255 range could not be used (comma, semicolon, ASCII 0 and 13, for instance) because the computer had its own ideas of their use in a string of characters, most could be used, and were.

On using the file name extension for seconds coding, I avoided this option in order to simplify file name searching (and possible interpretation by the computer as having a different significance). Using the dot-suffix of .Y allows a more ready search for file types. For example keying in **DIR \*.Y0?** immediately calls up all PSCOPE (and VSCOPE) files for the years 2000 to 2009 (I don't think I actually coded the year number).

Lastly, I was interested to read that time zones have officially (Admiralty) allocated letter designations.

### BASIC AND DELPHI

Dear EPE,

I would like to make some comments on replacements for GWBasic, QBASIC interpreters and the QuickBASIC compiler for use in simple interfacing projects, and to comment on Delphi.

FirstBASIC, which is shareware and for DOS, can be downloaded from [www.powerbasic.com](http://www.powerbasic.com) and registered within the UK for £30.55, see [www.greymatter.co.uk](http://www.greymatter.co.uk) for this. It is a very good BASIC compiler with a simple Integrated Development Environment (IDE) and, in the registered version, on-screen help.

Like QBasic and QuickBASIC it has all the constructs for structured programming and the syntax is easy to learn, but the IDE does not support the use of the mouse. See PowerBASIC website for comparisons and some help with translating between Basics.

Having written a number of large programs in QuickBASIC for student use, some of which need to write to or poll the printer port to examine the hardware connected to it, I'm now trying to move them to Delphi. I think this is essential if I'm going to be able to run them under future operating systems.

Until recently all the books and articles I have come across have concentrated almost exclusively on the "components" used to build the various types of windows. This approach quickly allows you to build a "gee whiz" user interface, but to use Delphi seriously it is necessary to learn to use Object Pascal, which in turn requires an understanding of standard Pascal program structure.

*Computer Programming in Pascal* by David Lightfoot, *Teach Yourself Series*, is old, 1983, but adequate for understanding Pascal program structure. *Delphi in a Nutshell* by Ray Lischner is a new, 2000, desktop quick reference to Object Pascal, and is very comprehensive, 560pp, but it assumes some knowledge of Pascal. It also mentions that Delphi is being ported to Linux.

Delphi 1 is still available from Greymatter for £57.68p (see above) as *Learn to Program with Delphi 1*. This is a thick, 900pp, self-study manual and CD-ROM containing Delphi 1. It covers both the components and the Object Pascal language, though you have to dig a little to find what you want to know about the latter and there are some mistakes and ambiguities in the text. The "hidden gem" tucked away on the CD-ROM is the 300 page Object Pascal manual which can be printed from Adobe Acrobat.

Having no previous knowledge of Pascal, I almost gave up on Delphi because I could not figure out how to store, retrieve and manipulate data. Now I'm hooked. I've concluded that a rule of thumb is to ignore any book with less than 300 pages as it will be too superficial. It's a steep learning curve and I'm still in the foothills, but I'm still climbing!

**Dr Les May,  
Rochdale, Lancs**

Interesting. Thank you Dr Les. It's an aspect that some readers may find it worthwhile looking into. Personally, I'm now just about coming to grips with VisualBASIC 6 and, despite finding the documentation inadequate, believe that this, with its Windows base, is the route to pursue.



## BCD CHALLENGE ACCEPTED

Dear EPE,

I was very intrigued by the Binary to BCD conversion routine given in September 2000 *EPE*, as I had always seen this done by some method involving division by ten.

After a lot of thought, I managed to come up with what I think is an improved version. The procedure used to do the conversion is: "Start with a Partial Result (PR) of zero. For each bit in the binary, starting at the left hand end, multiply the PR by two and add the bit."

By doing this arithmetic in decimal, the PR at the end has the converted value which holds the digits as binary coded decimal (BCD) in the lower four bits of each of a succession of bytes, bits 4 to 7 are zeroes (Unpacked BCD). You could also, with a different program, use Packed BCD with two digits in a byte, one in each nibble.

Throughout the process, decimal adjustment (DecAdj) of the PR is necessary to maintain its BCD nature, so that 0 to 9 are unchanged but a result in the range 10 to 15, which is stored as hex 0A to 0F, is converted to 0 to 5 with a 1 carry ready to go in the next BCD, i.e. 0A to 0F become 10 to 15 hex.

The actual process is to add six to the unadjusted result. If this causes a 1 in the fifth bit (bit 4) then the changed pattern is used, other-

wise the original unadjusted pattern is retained. For Unpacked BCD the state of bit 4 can be used as the test.

The algorithm in Sep '00 uses "Add 3" before the "times 2" shift. This is best when Packed BCD is converted since for the "top" nibble there is no bit corresponding to bit 4. By "Adding 3" before the shift instead of "Add 6" after, the same effect is obtained using bit 7. However, in this case the carry into the decimal cannot be done until after the shift, hence the two passes through the digits for each bit.

The following is a version using one pass, for Unpacked BCD. I have used the locations BIN0 to BIN2 to hold the three bytes of binary, with the most significant (m.s.) byte in BIN2. The PR goes in the eight bytes DIGIT0 to DIGIT7, with the m.s. digit in DIGIT7. BINCNT and DECCNT hold counts for the two nested loops.

Harry West, via the Net

*Congrats on picking up the challenge Harry! In fact I'd already seen in our Chat Zone that you'd been in contact with Peter Hemsley (who started it all off) and that he'd accepted your improvement. Well done. You now hold the BCD Place of Honour - can you be deposed we wonder? Well, readers, what do you think?*

### BINDEC:

CALL CLRDIG ; Clear decimal digits  
MOVLW 24 ; Decimal count  
MOVWF BINCNT

### BITLP:

RLF BIN0,F ; Shift binary left  
RLF BIN1,F  
RLF BIN2,F  
MOVLW DIGIT0  
MOVWF FSR  
MOVLW 8 ; Count for the decimal digits  
MOVWF DECCNT  
MOVLW 6 ; The Working Register holds 6 throughout. For each bit the inner loop is repeated 8 times, with shift in of the next bit, "times 2" and DecAdj of each digit

### ADJLP:

RLF INDF,F ; 2\*digit, then shift in "next bit" for DIGIT0 or else the carry from the previous digit  
ADDWF INDF,F ; Add 6, clears Cf and gives 1 in bit 4 if the

BTFSS INDF,4 ; addition is needed; zero if not, when  
SUBWF INDF,F ; we subtract it again. Sets Cf  
BSF STATUS,C ; Cf could be 0 or 1, so make it 1 as default  
BTFSS INDF,4 ; Bit 4 is the carry to the next digit  
BCF STATUS,C ; Reset Cf to zero if bit 4 is clear  
BCF INDF,4 ; For BCD clear bit 4 in case it's one  
INCF FSR,F ; Go to next digit, (Cf not affected)  
DECFSZ DECCNT,F ; End of inner loop. check digit count and  
GOTO ADJLP ; round again if it's not zero  
DECFSZ BINCNT,F ; End of outer loop, one pass through digits,  
GOTO BITLP ; check bit count and repeat if necessary.  
RETURN

## E-MAIL VIRUSES

Dear EPE,

Barry Fox's article in *News* of September '00 raised the question of whether a virus can hide in plain text E-mails. He is essentially correct in saying that a computer-executable program cannot be transmitted through a text-only E-mail.

However, viruses are more than just computer programs. A virus is an entity that uses its host to replicate itself. If a text E-mail simply says "Copy this E-mail to everybody you know", it is a virus. It utilises the human user as the host to replicate itself. In 1994 an E-mail virus "Good Times" infected thousands of people's E-mail systems, as detailed in <http://www.mdfsnet.f9.co.uk/Docs/Comp/Viruses/GoodTimes>.

It was essentially a chain letter containing a hoax warning about a virus, recommending that the reader E-mail it on to all their friends. As Clay Skirky on [alt.folklore.urban](http://alt.folklore.urban) put it: "It works by finding hosts with defective parsing apparatus which prevents them from understanding that a piece of E-mail which says there is an E-mail virus, and then asking them to re-mail the message to all their friends, is the virus itself."

P.S. A super computer is a machine that runs an endless loop in just two minutes.

Councillor Jonathan G. Harston,  
Sheffield, via the Net

*Editor Mike comments that we recently received a "self-executing" virus of the type you refer to. It trusted the user to delete all the files on his hard disk and then send on the E-mail!*

*We wonder whether by publishing your letter through so many thousands of EPE copies that it too has persuaded human hosts to perpetuate it as a virus?*

## NEW ELECTRONICS eGROUP

Dear EPE,

I wish to inform you of a new electronics egroup which has been set up specifically to address the needs of persons involved in all forms and branches of electronics in the UK, but particularly enthusiasts and students, whatever their experience. The main emphasis is on the sharing of information, designs, advice and support.

Further information, and joining instructions can be found at:

[www.egroups.com/group/Electronics-UK](http://www.egroups.com/group/Electronics-UK), or from: [Electronics-UK-owner@egroups.com](mailto:Electronics-UK-owner@egroups.com).

I warmly invite your friends and colleagues to join.

Ross Currie,  
Belfast, Northern Ireland, UK,  
via the Net

*Thanks Ross. We hope readers will flock to join your worthwhile enterprise.*

## BINARY TO DECIMAL

Dear EPE,

Thanks for publishing Peter Hemsley's BIN-DEC routine in Sept '00 *Readout*. However, the second instruction could better be written `MOVLW D'24`. If the default radix happens to be hexadecimal, as in MPASM, the program won't work right as written unless the radix is changed to decimal.

Stan Ockers, via the Net

*Thanks Stan. Yes, that would be the case with MPASM, although TASM automatically recognises the value as decimal, not having a facility for setting the radix. In TASM, hex is expressed with a \$ (dollar) symbol before the value.*

## DATA SHEETS

Dear EPE,

I refer to *Readout* of Sept '00 and Roger Nightingale's query regarding data sheet availability on the web. Since I work in a computer workshop at the University of Dundee, information is a prime requirement to efficiency and fault finding and data sheets are crucially important. Having 24 hours a day access to the web I have been able to find numerous sites for data sheets but none to rival the one at [www.bgs.nu/sdw/a.html](http://www.bgs.nu/sdw/a.html).

If Roger can't find his required data sheet on this site, then he is in deep trouble.

Sandy Smith,  
Dundee, via the Net

*Most useful info Sandy, thanks.*

## PIC PULSOMETER

Dear EPE,

You published my *PIC Pulsometer* project in the Nov '00 issue. It was written in TASM and I owe you a word of thanks. This was my first PIC project, and your *PIC Tutorial* (Mar-May '98) and excellent *Toolkit Mk1* (Jul '98) programmer gave me an easy route into picking up the basics to add to my previous if different experience.

Richard Hinckley,  
Congleton, Cheshire

*Thank you Richard. We are sure that many readers will appreciate the result your efforts! Why not give Toolkit Mk2 (May-Jun '99) a try now? It has even more facilities and the software has been updated again (see Nov '00 issue).*

## ANTI-TAMPER LOOP

Dear EPE,

In the application of Alan Bradley's *Anti-Tamper Loop Alarm* in *Ingenuity Unlimited* Oct '00, particularly when being deployed for the protection of a bicycle, motorcycle or car steering wheel, a good practice is to use coaxial cable such as RG58 or similar for the loop. This cable is then threaded through a chain with links of a suitable diameter, leaving several links at either end for the purpose of securing the chain with a padlock.

The cable may then be terminated with BNC connectors, which offer not only good connection reliability, but also, from the point of reducing false alarms, would be unlikely to become inadvertently disconnected through, for example, vibration or innocent, inadvertent movement of the protected item.

In this situation, good security is provided by not only having the security factor of the loop alarm, but also the physical security of the chain, which, if the loop is assembled within it correctly, will be very difficult to cut without cutting the loop and therefore activating the alarm. It also restricts access to the loop for bypass measures.

Ross Currie,  
Belfast, Northern Ireland,  
via the Net

*Ah, hello again Ross! As a cyclist (in good weather only!) I agree with your suggestion. Also see Please Take Note this month.*

# SURVEILLANCE

## Electronic Surveillance Equipment Kits from the UK's No.1 Supplier

SUMA DESIGNS has been supplying professional quality electronic surveillance equipment kits for over 20 years. Whether your requirement is hobbyist, amateur or professional you can be sure that you are buying from a company that knows the business. We ONLY sell surveillance products, no alarms, disco lights or computer bits. All of our kits are designed for self assembly and are well tried, tested and proven. All kits are supplied complete with top grade components, fibreglass PCB, full instructions, circuit diagrams and assembly details. Unless otherwise stated all transmitter kits are tuneable and can be received using an ordinary VHF FM radio.

### UTX Ultra-miniature Room Transmitter

At less than 1/2 the size of a postage stamp the UTX is the smallest room transmitter kit in the world! Incredible 10mm x 20mm including microphone, 3-12V operation. Range up to 500m. . . . . **£13.95**

### MTX Micro-miniature Room Transmitter

Our best selling room transmitter kit. Just 17mm x 17mm including mic. Extremely sensitive. 3-12V operation. Range up to 1000m. . . **£14.95**

### STX High-performance Room Transmitter

High performance transmitter with buffered output for greater stability and range. Measures just 22mm x 22mm including mic. 6-12V operation. Range up to 1500m. . . . . **£16.95**

### VT500 High-power Room Transmitter

Our most powerful room transmitter with around 250mW of output power. Excellent range and penetration. Size 20mm x 40mm, 6-12V operation. Range up to 3000m. . . . . **£17.95**

### VXT Voice-activated Room Transmitter

Triggers only when sounds are detected by on-board mic. Variable trigger sensitivity and on-time with LED trigger indicator. Very low standby current. Size 20mm x 67mm, 9V operation, range up to 1000m. . . . . **£21.95**

### HVX400 Mains Powered Room Transmitter

Connects directly to 240V AC supply. Ideal for long-term monitoring. Size 30mm x 35mm, range up to 500m. . . . . **£21.95**

### SCRX Subcarrier Scrambled Room Transmitter

To increase the security of the transmission the audio is subcarrier modulated. Receiver now requires the decoder module (SCDM) connected to allow monitoring. Size 20mm x 67mm, 9V operation, up to 1000m range. . . . . **£24.95**

### SCDM Subcarrier Decoder for SCRX

Connects to earphone socket on receiver and provides decoded audio output to headphones. Size 32mm x 70mm, 9-12V operation. . . **£27.95**

### UTLX Ultra-miniature Telephone Transmitter

Smallest kit available. Connects onto telephone line, switches on and off automatically as phone is used. All conversations transmitted. Size 10mm x 20mm, powered from line, up to 500m range. . . . . **£13.95**

### TLX700 Micro-miniature Telephone Transmitter

Best selling kit. Performance as UTLX but easier to assemble as PCB is 20mm x 20mm. . . . . **£14.95**

### STLX High-performance Telephone Transmitter

High-performance transmitter with buffered output for greater stability and range. Connects onto telephone line and switches on and off automatically as phone is used. Both sides of conversation transmitted up to 1000m. Powered from line. Size 22mm x 22mm. . . . **£16.95**

### PTS7 Automatic Telephone Recording Interface

Connects between telephone line (anywhere) and normal cassette recorder. Automatically switches recorder on and off as phone is used. Both sides of any conversation recorded. 9V operation, size 20mm x 67mm. . . . . **£21.95**

### CD400 Pocket Size Bug Detector/Locator

LED and piezo bleeper pulse slowly. Pulse rate and tone pitch increase as signal source is approached. Variable sensitivity allows pinpointing of signal source. 9V operation, size 45mm x 54mm. . . . . **£34.95**

### CD600 Professional Bug Detector/Locator

Multicolour bargraph LED readout of signal strength with variable rate bleeper and variable sensitivity allows pinpointing of any signal source. When found, unit is switched into AUDIO CONFIRM mode to distinguish between bugging devices and legitimate signals such as pagers, cellphones etc. Size 70mm x 100mm. 9V operation. . . . . **£59.95**

### QTX180 Crystal Controlled Room Transmitter

Narrow band FM crystal transmitter for ultimate in privacy. Output frequency 173.225 MHz. Designed for use with QRX180 receiver unit. Size 20mm x 67mm, 9V operation, range up to 1000m . . . . . **£44.95**

### QLX180 Crystal Controlled Telephone Transmitter

Specifications as per QTX180 but connects onto telephone line to allow monitoring of both sides of conversations. . . . . **£44.95**

### QSX180 Line Powered Crystal Telephone Transmitter

Connects onto telephone line, switches on and off as phone is used. Power is drawn from line. Output frequency 173.225 MHz. Designed for use with QRX180 receiver. Size 32mm x 37mm. Range up to 500m. . . . . **£39.95**

### QRX180 Crystal Controlled FM Receiver

Specifically designed for use with any of the SUMA 'O' range kits. High sensitivity design. Complex RF front end section supplied as pre-built and aligned sub-assembly so no difficult setting up. Headphone output. PCB size 60mm x 75mm. 9V operation. . . . . **£69.95**

### TKX900 Signalling/Tracking Transmitter

Transmits a continuous stream of audio beeps. Variable pitch and bleep rate. Ideal for signalling, alarm or basic tracking uses. High power output. Size 25mm x 63mm, 9-12V operation, up to 2000m range. . . . **£23.95**

### MBX-1 Hi-Fi Micro Broadcaster

Connects to headphone socket of CD player, Walkman or Hi-Fi and broadcasts your favourite music around house and garden up to 250m. Size 27mm x 60mm, 9V operation. . . . . **£22.95**

### DLTX/RX Radio Remote Switch System

Two kits, transmitter sends a coded signal (256 selectable codes) when button pressed. Receiver detects signal, checks code and activates relay. Can be set to be momentary or toggle (on/off) operation. Range up to 100m, 9V operation on both units. TX 45mm x 45mm, RX 35mm x 90mm. . . . . **£44.95**

#### TO ORDER:

Post, fax or telephone your order direct to our sales office. Payment can be Credit card (Visa or Mastercard), Postal Order, cash (please send registered) or cheques. Kits despatched same day (cheques need clearing). All orders sent by recorded or registered post. Please add postage as follows:

ORDER UP TO £30.00: To UK £2.50 To EUROPE £5.50 All other £7.50

ORDERS OVER £30.00: To UK £3.65 To EUROPE £7.50 All others call

Overseas customers please use credit cards or send sterling cheque or bank draft.



#### SEND 2 x 1st CLASS STAMPS FOR OUR 2000 KIT CATALOGUE CONTAINING FULL DETAILS OF THESE AND OTHER KITS.

A BUILD-UP SERVICE IS AVAILABLE ON ALL OF OUR KITS, DETAILS IN CATALOGUE. VISIT OUR WEBSITE: [www.suma-designs.co.uk](http://www.suma-designs.co.uk)

Please note: Some of our part numbers are being unscrupulously used by other companies selling kits eg. MTX, VXT. DO NOT BE MISLEAD! These are NOT GENUINE SUMA KITS which are only available direct from us or our appointed distributors.

If you wish to collect kits direct from our office  
PLEASE TELEPHONE

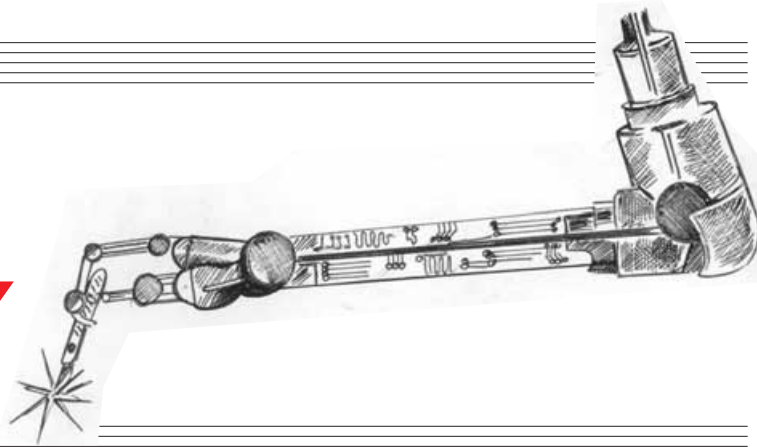
**SUMA  
DESIGNS**

Dept. EE, The Workshops, 95 Main Road,  
Baxterley, Warwickshire, CV9 2LE, U.K.  
Website: [www.suma-designs.co.uk](http://www.suma-designs.co.uk)

TEL/FAX: 01827 714476  
(24 HOUR ORDERLINE)  
email: [sales@suma-designs.co.uk](mailto:sales@suma-designs.co.uk)

# CIRCUIT SURGERY

ALAN WINSTANLEY  
and IAN BELL



**Our intrepid circuit surgeons explore switched-mode power supplies, whilst under heavy sedation!**

## Switched Mode Supplies

Richard Torpey of Merseyside writes by E-mail, asking for advice about designing step-up voltage regulators:

*A friend of mine has recently asked me to construct a microphone pre-amplifier for portable use, running from a 9V PP3 cell. The microphone he's using requires a +48V (in practice, anything from +40V to +50V) supply (phantom powering) to operate.*

*I have identified a circuit which provides the necessary gain and d.c. blocking to satisfy this function, and it runs quite happily off a bench PSU. However, I cannot find an easy solution for obtaining a +48V supply.*

*A method considered was generating a sinewave to feed a step up transformer primary, and rectifying and smoothing the secondary output, but finding a suitable transformer for this application seems difficult.*

*I have heard of a solution involving use of a "Cockcroft Ladder" voltage-doubling network, but am unsure as to how such a system would be put into practice for the desired application. The most important considerations are, primarily, obtaining a clean, steady +48V output, and also efficiency to preserve battery life. Current consumption will be in the order of milliamps.*

As Richard indicates, there are a number of possible approaches to this problem. We will look at a number of solutions to step-up voltage converter design in general over the next couple of months, hopefully Richard will then be able to select a circuit suitable for his application. But before we start, let's check some basic concepts.

Efficiency is often a key parameter in power conversion. Power is given by voltage multiplied by current ( $V \times I$ ), so if a power converter is 100 per cent efficient then  $P_{in} = V_{in}I_{in} = P_{out} = V_{out}I_{out}$ . If the converter is less than 100 per cent efficient, then  $P_{out}$  will be less than  $P_{in}$  by the efficiency factor.

In this application we need a high efficiency so that the battery is not drained too

quickly. The ideal situation of  $V_{in}I_{in} = V_{out}I_{out}$  also shows us that if we increase the voltage ( $V_{out} > V_{in}$ ), the current available at the output will be proportionally less than  $I_{in}$ . With a perfect converter, 5mA at 48V output would draw 27mA from a 9V input. A real converter would draw more current, which should be borne in mind when considering battery life.

## Regulation

Another important power supply specification is regulation. In fact, there are two factors to consider here – *line regulation* and *load regulation*. Line regulation indicates how much the output voltage changes as the input voltage changes, and it's calculated using:

$$\text{Line regulation} = \frac{V_{out} \text{ at max input} - V_{out} \text{ at min input}}{V_{out} \text{ required}} \times 100\%$$

Load regulation indicates how much the output varies with varying load and is calculated using:

$$\text{Load regulation} = \frac{V_{out} \text{ at 50\% load} - V_{out} \text{ at full load}}{V_{out} \text{ required}} \times 100\%$$

There may be a small a.c. signal superimposed on the d.c. output of a supply. This is known as a "ripple voltage" and is usually expressed simply in volts, but could also be given a percentage of the supply voltage.

Richard suggests the use of a sinewave generator feeding a transformer as a possible approach. The transformer provides the voltage step-up in accordance with its turns ratio and must be driven by a varying voltage (only a.c. signals are coupled to the secondaries of transformers).

In mains power supplies the input to the transformer primary is a 50Hz or 60Hz sinewave, depending where you live. For d.c. to d.c. "converters" (a power supply circuit that raises a lower d.c. voltage to a higher one), neither a sinewave nor a frequency as low as this need be used. Higher frequencies enable smaller transformers to

be used, and furthermore if it operates above audio frequencies, then it will allow for silent operation (otherwise some transformers may emit an annoying whine or whistle).

Pulsed inputs to the transformer (or other type of inductor) are commonly used in "switching power supplies" (ones which use an oscillator to generate pulses which can be converted into a higher voltage output), as they are relatively easy to generate using control logic. This logic often uses pulse modulation (switching pulses on or off, or modifying their length) to control the output voltage as the load varies.

## Royer Converter

A classic power converter circuit in which the transformer input is a switched waveform rather than a sinewave, is the "Royer Converter" described by G.H. Royer in 1954. This is shown in its basic form in Fig.1.

The circuit is self-oscillating, with feedback provided from a transformer winding. The oscillation is "square wave" in nature rather than sinusoidal because the transformer is driven into saturation (an appropriate transformer must be used to achieve efficient operation).

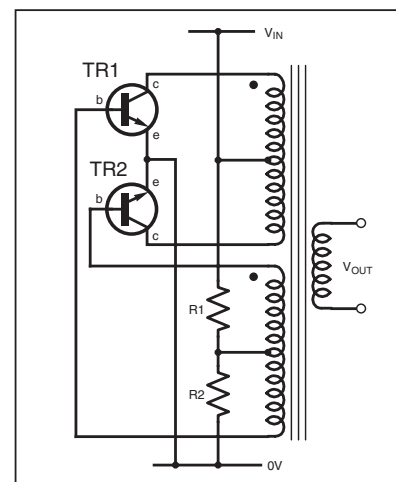


Fig.1. Basic Royer power converter.



The resistor network provides bias and ensures that the circuit starts oscillating when power is applied. The transistors switch on and off out of phase with each other, with a duty cycle of 50 per cent. The voltage induced in the secondary winding depends on  $V_{in}$  and the transformer turns ratio. Appropriate transistors should be used which have a high gain ( $h_{FE}$ ), low  $V_{CE(sat)}$ , low on-resistance ( $R_{CE(sat)}$ ) and high collector-base breakdown voltage. Transistors specifically designed for high current switching applications should be used.

In Fig.2 is shown a modified Royer converter based on a circuit from a design note by Zetex ([www.zetex.com](http://www.zetex.com)), who are renowned for high current, high performance transistors including the ZTX650, ZTX849 and ZTX449, which are suitable for use in these circuits. The circuit is a slight modification of Fig. 1, which itself does not need a centre-tapped feedback winding.

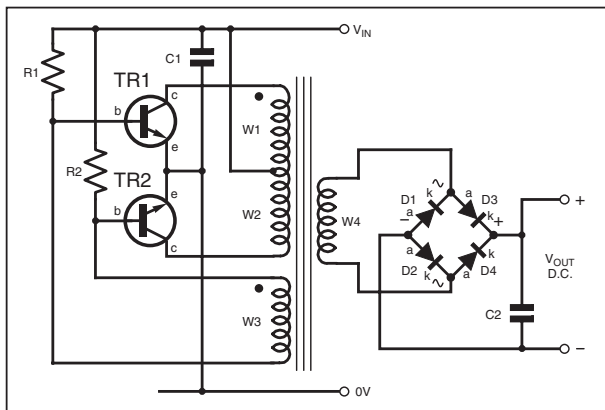


Fig.2. Royer step-up d.c. to d.c. converter.

The Zetex circuit uses two ZTX449 transistors, two 560 ohm resistors and two ceramic 100nF decoupling capacitors, together with a suggested toroidal transformer, with windings W1 and W2 (primary) having 10 turns, W3 (feedback) at 4 turns and W4 (secondary) at 28 turns. Note that this circuit has not been proven by us: if you decide to wind your own toroid, simply wind the correct number of turns using as thick an enamelled copper wire as can be accommodated by the ferrite core.

The output is 12V at 2W from a 5V supply at 77 per cent efficiency, and has an operating frequency of over 80kHz. Increasing the input voltage or number of secondary windings will give a higher output voltage (adjust the resistors and capacitors to suit).

Other Zetex switching transistors (or equivalent) may be used in more demanding versions of the circuit. We have shown the rectifier and smoothing capacitor in Fig. 2, but will not do so in all the circuits in order to save space. As Zetex says, circuits like this look deceptively simple, but many components interact in a complex way.

Having said that "the use of sinewaves is not necessary", there are step-up converters that *do* use sinusoidal oscillation, which can be useful at times. The use of sinewaves cuts the level of harmonics of the basic switching frequency, which can otherwise be responsible for radio frequency noise and

interference (r.f.i.). A modified Royer circuit, in which sinusoidal operation occurs due to the presence of the inductor L1 and capacitor C1, is shown in Fig.3.

### Switch Mode

Finding a suitable transformer for a particular step-up power supply design can be very difficult; it is possible to wind your own transformer using the various ferrite core kits etc. which are sold for this purpose, but this adds another dimension to the design problem that not everyone would want to tackle. Useful results can often be obtained by experimenting to optimise the circuit.

However, it is not necessary to use a transformer to produce a step-up converter – some switch mode power supply (SMPS) configurations only require an inductor, and certain voltage multipliers and charge-pump circuits achieve step-up neatly by using capacitors (but voltage multipliers are usually driven from a transformer secondary). We will look at each of these options next, and also in next month's column.

An example SMPS circuit, using a National Semiconductor LM2586-ADJ device, is shown in Fig.4. An SMPS design is often regarded as being quite difficult – which is true if you do not follow manufacturer's design guidelines, and also because they are demanding circuits requiring the use of appropriately specified components together with high quality construction. At this point it should be mentioned that the higher voltages generated with ease by these efficient circuits must be treated with due respect, using suitably-rated parts, with good insulation and reasonable standards of assembly.

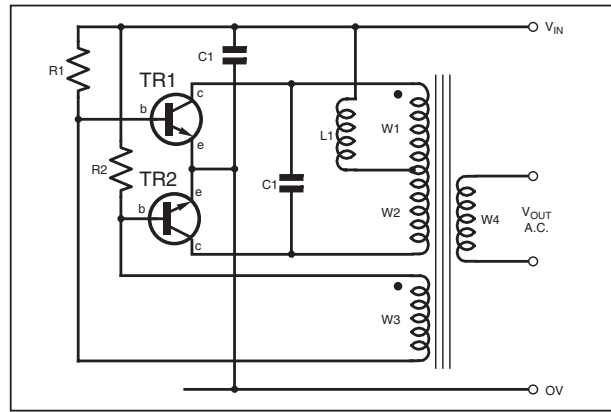


Fig.3. Version of Royer circuit with sinusoidal operation.

### Design On-line

Rather than struggle, we took the easy, modern route and obtained this circuit using on-line tools available on National Semiconductor's Power Web Site at [www.national.com/appinfo/power/](http://www.national.com/appinfo/power/). This is a particularly interesting site which allows you to design and simulate SMPSs on-line using National's versatile *WebBench*<sup>(tm)</sup> and *WebSIM*<sup>(tm)</sup> tools. The web site even allows you to organize your designs with secure password protected storage. Design details including your specifications, bill of materials, schematic, and simulations results are stored on the server, and are available on-line.

Note that the WebSIM simulation tools are installed on a server owned by National Semiconductor, not on the user's machine, as would be the case with most simulators. The user gains access to the simulator using a browser, executing the simulation on the server instead of on their own machine.

This enables very large amounts of computing power and memory to be used by the simulator environment. The simulation tools can be constantly upgraded, ensuring that users always have the most up-to-date version.

We created an SMPS for an 8V to 10V input and 47V output using National's on-line tools, and we simulated the steady state output from the circuit using WebSIM to obtain the results shown in Fig.5. Note that there is about 400mV of ripple on the supply. Using a large value for  $C_{OUT}$  could reduce this.

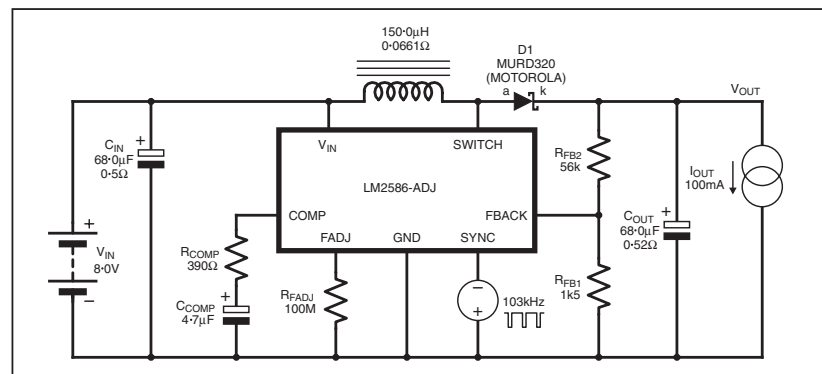
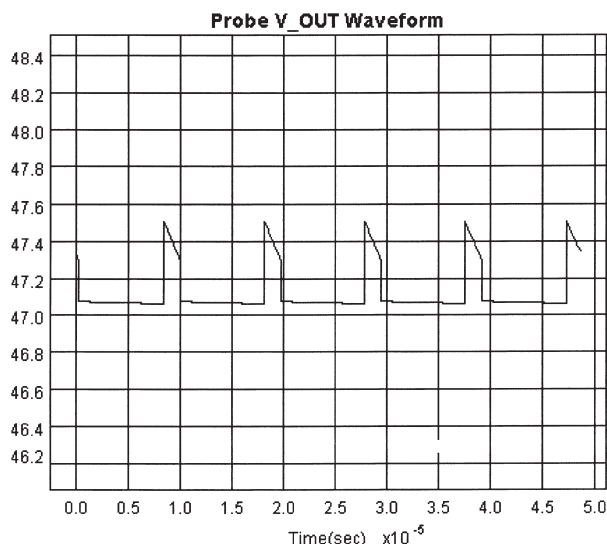


Fig.4. Switched-mode step-up converter for 8V to 10V input giving 47V output. Courtesy National Semiconductor's web site (see text).



This SMPS may not be very appropriate for the reader's application though (which calls for a few milliamps only) as its efficiency will be impaired at low output currents. This circuit is not particularly suitable for output currents less than 100mA. However, we did not attempt to find an optimal SMPS for this purpose.

As we said earlier, SMPS circuits are demanding on the components used: you cannot use any old diode from the junk box for D1 for example – you must use a suitable high-speed power switching diode. SMPS and similar circuits tend to destroy low frequency rectifier diodes such as the 1N4001 very quickly. In switched-mode power supplies, circuit capacitors must be able to stand high pulse currents and also have a low effective resistance, and inductors should have low resistance as well.

Next month, we'll take a good look at voltage multiplier circuits which use diode-capacitor networks. These are often used where a higher d.c. voltage is needed. For many users, they form a more practical proposition than a demanding switched-mode power supply. *I.M.B.*

*Fig.5 (left). Simulation of the steady state response of the SMPS circuit in Fig.4 using National Semiconductor's WebSIM™ on-line simulator.*

# Radio Bygones

The leading magazine for vintage radio enthusiasts



WHETHER your interest is in domestic radio and TV or in amateur radio, in military, aeronautical or marine communications, in radar and radio navigation, in instruments, in broadcasting, in audio and recording, or in professional radio systems fixed or mobile, RADIO BYGONES is the magazine for you.

ARTICLES on restoration and repair, history, circuit techniques, personalities, reminiscences and just plain nostalgia – you'll find them all. Plus features on museums and private collections and a full-colour photo-feature in every issue.

IT'S MOSTLY about valves, of course, but 'solid-state' – whether of the coherer and spark-gap variety or early transistors – also has a place.

FROM THE DAYS of Maxwell, Hertz, Lodge and Marconi to what was the state-of-the-art just a few short years ago . . .

THERE IS ALSO a selection of free readers' For Sale and Wanted advertisements in every issue.

## Radio Bygones covers it all!

THE MAGAZINE is published six times a year, and is only available by postal subscription. **It is not available at newsagents.**

TO TAKE OUT a subscription, or to request a sample copy, please complete the form below and return it to:

**RADIO BYGONES, Allen House, East Borough, Wimborne, Dorset BH21 1PF.**

Tel: 01202 881749. Fax 01202 841692. Web sites: [www.radiobygones.co.uk](http://www.radiobygones.co.uk) [www.radiobygones.com](http://www.radiobygones.com)



## RADIO BYGONES ORDER FORM



A SAMPLE COPY of Radio Bygones . . . . . £3.25  
(Add 70p for overseas Airmail postage)

**SUBSCRIPTIONS (post paid):**                      **1 YEAR**    **2 YEAR**

UNITED KINGDOM                                      £18.50      £35.00

REST OF EUROPE (AIRMAIL)                      £20.50      £39.00

REST OF THE WORLD (AIRMAIL)                      £24.50      £47.00

☐ Yes, I would like a sample copy of RADIO BYGONES

☐ Yes, I would like to take out a subscription for:

☐ One year (6 issues)    ☐ Two years (12 issues)

☐ I enclose a cheque/Eurocheque/PO for £ . . . . . payable to Wimborne Publishing Ltd

☐ Please debit my Visa/Mastercard

**NOTE** Minimum credit card payment is £5

My credit card number is:

--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

*Please print clearly, and check that you have the number correct*

The card is valid from: . . . . . to: . . . . .

My name is . . . . .

My address . . . . .

. . . . .

Post Code/Zip . . . . .

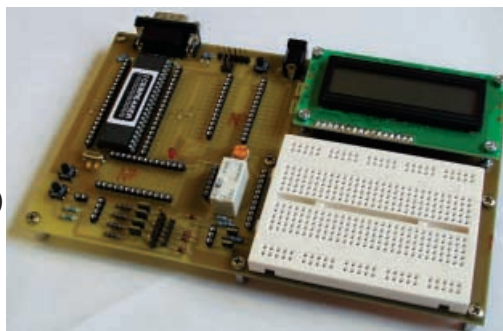
Signed . . . . .



20MHz full speed operation  
PC Serial port connection  
Use With Microchip MPLAB  
Standard MPASM Language  
PCB with solder mask & component ID  
Kit with all components, PIC16F877  
Solderless Breadboard, lcd,  
Serial Lead, and Software  
Kit 900 ..... £34.99

**MAGENTA**  
ELECTRONICS LTD

## PIC Real Time In-Circuit Emulator



Stepping Motor & Power Supply Extra

135 Hunter Street, Burton-on-Trent, Staffs. DE14 2ST  
Tel: 01283 565435 Fax: 546932  
<http://www.magenta2000.co.uk>  
E-mail: [sales@magenta2000.co.uk](mailto:sales@magenta2000.co.uk)  
All Prices include VAT. Add £3.00 p&p. £6.99 next day

### MARCONI 2019A



AM/FM SYNTHESISED SIGNAL  
GENERATOR  
80 kHz - 1040MHz  
NOW ONLY **£400**

H.P. 3312A Function Gen., 0-1Hz-13MHz, AM/FM Sweep/Tri/Gate/Brst etc. £300  
H.P. 3310A Function Gen., 0-005Hz-5MHz, Sine/Sq/Tri/Ramp/Pulse £125  
FARNELL LFM4 Sine/Sq Oscillator, 10Hz-1MHz, low distortion, TTL output, Amplitude Meter £125  
H.P. 545A Logic Probe with 546A Logic Pulser and 547A Current Tracer £90  
FLUKE 77 Multimeter, 3 1/2-digit, handheld £80  
FLUKE 77 Series 11 £70  
HEME 1000 L.C.D. Clamp Meter, 00-1000A, in carrying case £60

### RACAL 9008

Automatic  
Modulation Meter,  
AM/FM  
1-5MHz-2GHz  
ONLY **£95**

H.P. 8494A Attenuator, DC-4GHz, 0-1dB, N/SMA £250  
H.P. 8492A Attenuator, DC-18GHz, 0-6dB, APC7 £95  
MANY OTHER ATTENUATORS, LOADS, COUPLERS ETC. AVAILABLE

### DATRON 1061

HIGH QUALITY 5 1/2-DIGIT  
BENCH MULTIMETER  
True RMS/4 wire Res/Current Converter/IEEE **£150**

### TIME 1051 LOW OHM RES. BOX

0-01 ohm to 1Mohm in  
0-01 ohm steps.  
UNUSED **£100**

### STILL AVAILABLE AS PREVIOUSLY ADVERTISED WITH PHOTOS

MARCONI 893C AF Power Meter, Sinad Measurement Unused £100, Used £60  
MARCONI 893B, No Sinad £30  
MARCONI 2610 True RMS Voltmeter, Autoranging, 5Hz-25MHz £195  
GOULD J3B Sine/Sq Osc., 10Hz-100kHz, low distortion £75-£125  
AVO 8 Mk. 6 in Every Ready case, with leads etc. £80  
Other AVOs from £50  
GOODWILL GFC8010G Freq. Counter, 1Hz-120MHz, unused £75  
GOODWILL GVT427 Dual Ch AC Millivoltmeter, 10mV-300V in 12 ranges, Freq. 10Hz-1MHz £100-£125  
SOLARTRON 7150 DMM 6 1/2-digit Tru RMS-IEEE £95-£150  
SOLARTRON 7150 Plus £200

### RACAL TRUE RMS VOLTMETERS

9300 5Hz-20MHz usable to 60MHz, 10V-316V £95  
9300B Version £150  
9301/9302 RF Version to 1-5Hz from £200-£300  
HIGH QUALITY RACAL COUNTERS  
9904 Universal Timer Counter, 50MHz £50  
9916 Counter, 10Hz-520MHz £75  
9918 Counter, 10Hz-560MHz, 9-digit £50  
FARNELL AMM255 Automatic Mod Meter, 1-5MHz-2GHz, unused £400

### CLASSIC AVOMETER DA116

Digital 3-5 Digit  
Complete with batteries and  
leads  
ONLY **£30**



**SOLARTRON 7045  
BENCH MULTIMETER**  
4 1/2-Digit bright l.e.d. with leads  
It's so cheap you should have it as a spare  
ONLY **£30**

MARCONI TF2015 AM/FM sig gen, 10-520MHz £175  
RACAL 9008 Auto Mod Meter, 1-5MHz-2GHz £200  
LEVELL TG2000MP RC Oscillator, 1Hz-1MHz £50  
Sine/Sq Meter, battery operated (batts. not supplied)  
FARNELL LF1 Sine/Sq. Oscillator, 10Hz-1MHz £75  
RACAL/AM 9343M LCR Databridge. Digital  
Auto measurement of R, C, L, Q, D £200  
HUNTRON TRACKER Model 1000 £125  
H.P. 5315A Universal Counter, 1GHz, 2-ch £80  
FLUKE 8050A DMM 4 1/2-digit 2A Tru RMS £75  
FLUKE 8010A DMM 3 1/2-digit 10A £50

### RADIO COMMUNICATIONS TEST SETS

MARCONI 2955/2958 £2000  
MARCONI 2955A/2960 £2500  
MARCONI 2022E Synth AM/FM sig gen  
10kHz-1.01GHz l.c.d. display etc £525-£750  
H.P. 8672A Synth 2-18GHz sig gen £4000  
H.P. 8674A Synth sig gen, 100kHz-1040MHz £2000  
H.P. 8656B Synth sig gen, 100kHz-990MHz £1350  
H.P. 8656A Synth sig gen, 100kHz-990MHz £395  
H.P. 8640A AM/FM sig gen, 500kHz-102MHz £400  
H.P. 8640A AM/FM sig gen, 500kHz-512MHz £250  
PHILIPS PM5328 sig gen, 100kHz-180MHz with 200MHz freq. counter, IEEE £550  
RACAL 9081 Synth AM/FM sig gen, 5-520MHz £250  
H.P. 3325A Synth function gen, 21MHz £560  
MARCONI 8500 Amplitude Analyser £1500  
H.P. 4275A LCR Meter, 10kHz-10MHz £2750  
H.P. 8903A Distortion Analyser £1000  
WAYNE KERR 3245 Inductance Analyser £2000  
H.P. 8112A Pulse Generator, 50MHz £1250  
DATRON Autocal Multimeter, 5 1/2-7 1/2-digit, 1065/1081A/1071 from £300-£600  
MARCONI 2400 Frequency Counter, 20GHz £1000  
H.P. 5350B Frequency Counter, 20GHz £2000  
H.P. 5342A 10Hz-18GHz Frequency Counter £800  
FARNELL AP10030 Power Supply £1000  
FARNELL AP7030 Power Supply £800  
PHILIPS PM5418TN Colour TV Pattern Generator £1750  
PHILIPS PM5418TX1 Colour TV Pattern Generator £2000  
B&K Accelerometer, type 4366 £300  
H.P. 11692D Dual Directional Coupler, 2MHz-18GHz £1600  
H.P. 11691D Dual Directional Coupler, 2MHz-18GHz £1250  
TEKTRONIX P6109B Probe, 100MHz readout, unused £50  
TEKTRONIX P6106A Probe, 250MHz readout, unused £85  
MARCONI AMM2000 Auto Mod Meter, 10Hz-2-4GHz Unused £950  
MARCONI 2035 Mod Meter, 500kHz-2GHz from £750  
TEKTRONIX 577 Transistor Curve Tracer £500

### ROHDE & SCHWARZ APN 62

Synthesised 1Hz-260kHz  
Signal Generator.  
Balanced/unbalanced output  
LCD display **£425**

H.P. 6012B DC PSU, 0-60V, 0-50A, 1000W £1000  
FARNELL AP6050 1kW Autoranging £1000  
PHILIPS HM6050 0-60V, 0-50A £750  
FARNELL HM6025 0-60V, 0-25A £400  
Power Supply HP53010 0-30V, 0-10A £140  
FARNELL L30-2 0-30V, 0-2A £80  
FARNELL L30-1 0-30V, 0-1A £50  
Many other Power Supplies available  
Isolating Transformer 250V In/Out 500VA £40

### WELLER EC3100A

Temperature controlled Soldering Station  
200°C-450°C. Unused **£125**

### SPECTRUM ANALYSERS

TEKTRONIX 492 50kHz-18GHz £3500  
EATON/AILTECH 757 0-001-22GHz £2500  
ADVANTEST R3261A 9kHz-2-6GHz, synthesised £4000  
H.P. 853A (Dig. Frame) with 8559A 100kHz-21GHz £2750  
H.P. 8558B with main frame, 100kHz-1500MHz £1250  
H.P. 3580A Audio Analyser 5Hz-50kHz, as new £1000  
MARCONI 2382 100kHz-400MHz, high resolution £2000  
B&K 2033R Signal Analyser £1500  
ADVANTEST TR4131 10kHz-3-5GHz £2750  
MARCONI 2370 30Hz-110MHz from £500  
H.P. 141 SYSTEMS  
8553 1kHz-110MHz from £500  
8554 500kHz-1250MHz from £750  
8555 10MHz-18GHz from £1000

### UNUSED OSCILLOSCOPES

TEKTRONIX TD5600A 4-ch, 500MHz, 2G/S £4000  
TEKTRONIX TD5380 dual trace, 400MHz, 2G/S £2000  
TEKTRONIX TD5350 dual trace, 200MHz, 1G/S £1250  
TEKTRONIX TS4485 4-ch, 200MHz, etc. £900  
H.P. 54600B dual trace, 100MHz, 20M/S £900

### OSCILLOSCOPES

PHILIPS PM3092 2+2-ch, 200MHz, delay, etc., £800 as new £950  
PHILIPS PM3082 2+2-ch, 100MHz, delay etc., £700 as new £800  
TEKTRONIX TAS465 dual trace, 100MHz, delay etc. £800  
TEKTRONIX 2465B 4-ch, 400MHz, delay cursors etc. £1250  
TEKTRONIX 2465 4-ch, 300MHz, delay cursors etc. £900  
TEKTRONIX 2445A/B 4-ch 150MHz, delay cursors etc. £500-£900  
TEKTRONIX 468 dig. storage, dual trace, 100MHz, delay £450  
TEKTRONIX 466 Analogue storage, dual trace, 100MHz £250  
TEKTRONIX 465 dual trace, 350MHz, delay sweep £600  
TEKTRONIX 475 dual trace, 200MHz, delay sweep £400  
TEKTRONIX 465B dual trace, 100MHz, delay sweep £325  
PHILIPS PM3217 dual trace, 50MHz delay £250-£300  
GOULD OS1100 dual trace, 30MHz delay £200

JUST IN  
HAMEG HM363.4 dual trace, 30MHz component testm... £325  
HAMEG HM303 dual trace, 30MHz component tester £300  
HAMEG HM263.7 dual trace, 20MHz component tester £250  
FARNELL DTV20 dual trace, 20MHz component tester £180



**GOULD OS 300**  
Dual Trace, 20MHz  
**£160**

### MANY OTHER OSCILLOSCOPES AVAILABLE

PORTABLE APPLIANCE TESTER  
Megger Pat 2 ONLY **£180**

## STEWART OF READING

110 WYKEHAM ROAD, READING, BERKS. RG6 1PL  
Telephone: (0118) 9268041. Fax: (0118) 9351696



Callers welcome 9am-5.30pm Monday to Friday (other times by arrangement)

### Used Equipment - GUARANTEED. Manuals supplied

This is a VERY SMALL SAMPLE OF STOCK. SAE or Telephone for lists.  
Please check availability before ordering.  
CARRIAGE all units £16. VAT to be added to Total of Goods and Carriage

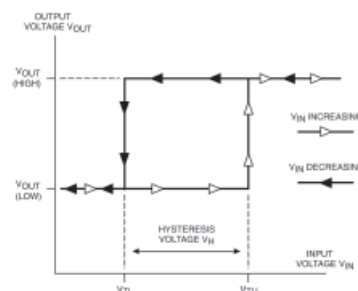


# THE SCHMITT TRIGGER

ANTHONY H. SMITH

Part 2

**In this short series, we investigate the Schmitt trigger's operation; explore the various ways of implementing its special characteristics and also look at how we can use it to create oscillators and pulse width modulators.**



## Op.amp and Comparator Triggers

IN the first part of this series, we looked at discrete Schmitt triggers based on bipolar transistors. Although effective and flexible, we saw how they could be somewhat difficult to design, especially where the interconnection of several transistors demanded careful attention to biasing levels and resistance values.

In this article, we look at Schmitt triggers based on operational amplifiers (op.amps) and comparators, devices which free us from most of the effort required in designing discrete, transistor-based circuits. By considering the op.amp or comparator as a “black box” having just input and output terminals and power supply pins, we can ignore its inner workings to a large degree, and instead concentrate on using it as a highly versatile circuit building block.

However, designing with op.amps and comparators is not a trivial undertaking: they bring their own set of requirements, terminology, and design rules, and if not applied correctly they will either malfunction or suffer permanent damage. The practice of designing with op.amps and comparators is a vast subject that is way beyond the scope of this article. Nevertheless, we’ll deal with the main points and examine several practical circuits that illustrate different aspects of Schmitt triggers based on them.

### INVERTING SCHMITT TRIGGER

In Fig.2.1a (next page) is shown a simple, inverting Schmitt trigger requiring only two resistors ( $R_1$  and  $R_2$ ), an op.amp (IC1), and an optional voltage reference ( $V_{REF}$ ). In some cases, a small “speed-up” capacitor,  $C_S$ , may be connected across  $R_2$  to improve the transient response. Before examining the operation of the circuit, we’ll deal with some basic op.amp behaviour.

The op.amp’s input terminals are denoted “+” for the *non-inverting* input, and “-” for the *inverting* input. The term *non-inverting* implies that a voltage applied to that terminal will cause the output voltage to “move” in the same direction, i.e., with the same polarity.

For example, applying a small negative voltage to the non-inverting input will result in a much larger negative voltage at the output. The opposite is true of the inverting input, where a small negative voltage would be “inverted” at the output and result in a much larger *positive* voltage.

The op.amp is a *differential* amplifier, meaning that it amplifies the voltage *difference* between the input terminals. Ideally, an op.amp would have infinite open-loop differential gain. In practice, this can never be achieved, but most op.amps do have very high differential gain, usually in the order of 100,000 or more. The venerable 741, for example, has a typical open-loop gain of around 200,000, meaning that a differential voltage of just  $10\mu\text{V}$  will swing the output by 2V.

If the input terminals of an ideal op.amp were shorted together to make the differential input voltage zero, the output voltage would also be zero. In practice, however, all op.amps feature a small “input offset voltage” (usually denoted  $V_{IO}$ , or sometimes  $V_{OS}$ ) which results in a non-zero output voltage when the inputs are shorted together.

For example, an input offset voltage of +2mV would require applying an actual differential voltage of -2mV in order to

“neutralise” the offset and make the output voltage zero. General-purpose op.amps like the 741, LM358 and MC33171 have  $V_{IO}$  in the millivolt range, whereas precision devices such as the OP177 have offsets that are a thousand times smaller, typically just  $10\mu\text{V}$ .

For the circuits we’ll be examining in this article, we can assume  $V_{IO}$  is negligible, although for precision Schmitt triggers it must be taken into account.

One thing we cannot ignore, however, is the effect of input bias currents. Ideally, an op.amp’s input terminals would have an infinitely large impedance, such that they would draw no current from an input voltage source. In practice, all op.amps exhibit an “input bias current” which, as the name suggests, is the current necessary to bias the input transistors.

Usually denoted  $I_B$ , the input bias current may flow into or out of the input, depending on the op.amp type, and tends to be larger for devices fabricated using a bipolar process.

For example, the inputs of bipolar op.amps like the LM358 and MC33078 draw bias currents of a few tens or hundreds of nanoamperes. Devices fabricated using JFET or MOSFET technology, on the other hand, exhibit much smaller bias currents. The TLC271, for example, has a MOSFET input stage with typical input bias currents of just 0.7 picoampere at room temperature. More about input bias currents later.

### POWER SUPPLIES

The diagram in Fig.2.1a shows the op.amp connected to positive and negative power rails,  $+V_S$  and  $-V_S$ , respectively. Typically, dual supplies like this may range from  $\pm 5\text{V}$  to  $\pm 15\text{V}$ , depending on the application, although some op.amps and comparators can operate on rails as low as  $\pm 1\text{V}$ .

For dual rail (sometimes called “split supply”) circuits, it’s important to remember that there is a third power supply connection, namely 0V (or “ground”). Although the op.amp is not usually connected directly to 0V, the power supply, the input voltage source(s) and the output load usually are connected to 0V in some way, and the input and output voltages are almost always measured with respect to 0V.

A slight variation on this arrangement is found in “single rail” applications, where the negative rail is omitted and the op.amp’s negative supply terminal is connected to 0V. Single rail circuits are increasingly used in applications where an analogue signal of some kind must interface with digital logic operating on a single rail, typically +5V or +3.3V. The Schmitt trigger provides an extremely powerful way of interfacing analogue and digital circuits, and we shall look at single rail Schmitt triggers later.

### COMMON MODE

We’ve mentioned that the op.amp amplifies *differential* signals: ideally, any *common-mode* voltage will be totally rejected and will have no effect on the output. A common-mode voltage is one which appears in common to both inputs.

Suppose, for example, we shorted both inputs together and connected them to +2.5V (with respect to 0V), the common-mode

voltage would be +2.5V. If we then connected one input to -1V and the other to -2V, the differential voltage would be 1V, and the common-mode voltage would be the mean voltage between the inputs, in this case -1.5V.

In practical circuits, op.amps do not provide total rejection of the common-mode voltage, although the *common-mode rejection* (the degree to which the common-mode signal is rejected) is usually so good that common-mode effects can be ignored.

Still on the subject of common-mode signals, the “common-mode input voltage range” defines the range of common-mode voltages that can be tolerated by a given op.amp. This is not usually the same as the “differential voltage range” which defines the range of voltage that can appear between the inputs without causing malfunction or damage.

Both of these parameters depend on the supply voltage. The LM741, for example, has a maximum differential input voltage rating of  $\pm 30V$ . Exceeding this limit could cause permanent damage. When operating on  $\pm 15V$  supply rails, the common-mode input voltage range is typically  $\pm 13V$ , which means that the voltage at each input must not go within 2V of either supply rail or the op.amp might not function properly.

The LM358, however, is specifically intended for single rail applications. For example, when operating on a single +5V rail, the common-mode input voltage may go as high as +3.5V and may go all the way down to 0V. Modern op.amps and comparators frequently offer “rail-to-rail” performance. This means that the input voltage range, or output voltage range, or sometimes both, may cover the entire range from one supply rail to the other.

The LMC6482, for example, is a “Rail-to-Rail Input and Output” op.amp. When operated on, say,  $\pm 5V$  rails, the input voltage may be permitted to take any value between -5V and +5V, and the output voltage will typically swing to within 20mV of each rail (i.e.,  $\pm 4.98V$ ) for load resistances greater than 100k $\Omega$ .

When used in “linear” applications (i.e., applications in which *negative* feedback is applied to keep the op.amp within its linear range), the op.amp’s input voltage ratings are often not excessively taxed. However, when used in Schmitt trigger circuits, the *positive* feedback frequently forces the inputs to cover a wide range, resulting in large common-mode and differential voltages.

Consequently, it’s essential to check the worst-case, maximum input voltage range for a given application to ensure the op.amp or comparator will function correctly.

## POSITIVE FEEDBACK

Having discussed basic op.amp theory, we can now return to Fig.2.1a and examine the operation of the inverting Schmitt trigger.

To simplify the analysis, assume the reference voltage  $V_{REF}$  is zero (i.e., R1 connected to 0V) and that  $V_{IN}$  is at some negative voltage, such that the voltage at the op.amp’s inverting input is lower (more negative) than that at the non-inverting input, denoted  $V+$ . If the resulting positive differential input voltage is greater than a few millivolts, the op.amp’s output will be in positive saturation,  $V_{SAT+}$ , i.e., the output will be at its maximum positive level.

The non-inverting input voltage,  $V+$ , will sit at a value determined by the ratio of R1 and R2, and by the value of  $V_{SAT+}$ . If  $V_{IN}$  now rises above the level of  $V+$ , the differential input voltage becomes negative forcing  $V_{OUT}$  also to go negative. This causes  $V+$  to go negative, which increases the negative differential voltage, and ultimately forces  $V_{OUT}$  into negative saturation,  $V_{SAT-}$ .

As with the discrete Schmitt triggers described in Part One, the positive feedback via R2 causes *regenerative* behaviour which reinforces the switching action, causing a rapid transition from one output state to the other.

The value of  $V_{IN}$  required to “trigger” this change of state is denoted the “upper threshold voltage”,  $V_{TU}$ , and is given by:

$$\text{Upper Threshold Voltage, } V_{TU} = \frac{R1 \times V_{SAT+}}{R1 + R2} \quad (\text{volts})$$

Since  $V_{OUT}$  has gone into negative saturation,  $V+$  now sits at a negative voltage. If  $V_{IN}$ , and hence the inverting input terminal, is now taken more negative than  $V+$ , the differential voltage will again become positive and regenerative action will force  $V_{OUT}$  into positive saturation,  $V_{SAT+}$ . The value of  $V_{IN}$  required to initiate this opposite change of state is denoted the “lower threshold voltage”,  $V_{TL}$ , and is given by:

$$\text{Lower Threshold Voltage, } V_{TL} = \frac{R1 \times V_{SAT-}}{R1 + R2} \quad (\text{volts})$$

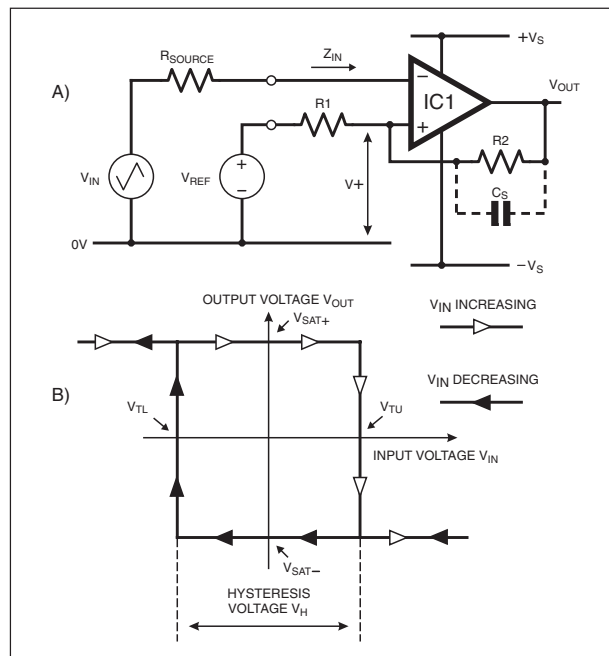


Fig.2.1. Circuit diagram for an Inverting Schmitt Trigger (a) and its voltage transfer characteristic (b).

Note that when  $V_{IN}$  goes positive and crosses the upper threshold, the output goes negative, hence the term *inverting* Schmitt trigger. We can see at a glance that the circuit is *inverting* because  $V_{IN}$  is applied to the op.amp’s inverting input terminal.

The diagram in Fig.2.1b shows the circuit’s “voltage transfer characteristic”, i.e., the relationship between input and output voltage. Starting at the top left-hand corner and following the white arrows as the input voltage increases, we see that the output remains at  $V_{SAT+}$  until  $V_{IN}$  crosses the upper threshold,  $V_{TU}$ , at which point the output rapidly changes state and goes into negative saturation,  $V_{SAT-}$ .

Further increases in  $V_{IN}$  have no effect on  $V_{OUT}$ . As  $V_{IN}$  decreases (shown by the black arrows),  $V_{OUT}$  remains at  $V_{SAT-}$  until  $V_{IN}$  crosses the lower threshold,  $V_{TL}$ , where  $V_{OUT}$  abruptly changes state and goes back into positive saturation.

The transfer characteristic shown assumes that  $V_{SAT+}$  is equal and opposite to  $V_{SAT-}$  and that  $V_{TU}$  is equal and opposite to  $V_{TL}$ , resulting in a “hysteresis loop” that is symmetrical about the origin. However, this is not always the case: depending on the application, it may be necessary to make the magnitude of the thresholds unequal, or to make them both positive or both negative. Also, as we shall see shortly,  $V_{SAT+}$  is not always equal and opposite to  $V_{SAT-}$ .

The thresholds can be varied by appropriate choice of R1 and R2, and by introducing a non-zero reference voltage (so far, we have assumed that  $V_{REF} = 0$ ).

Referring again to Fig.2.1a, assume we apply a positive value of  $V_{REF}$ : whatever the value of  $V_{OUT}$ , this will result in  $V+$  becoming more positive. The effect of making  $V_{REF}$  positive is to shift the thresholds “upward”, i.e., more positive. Similarly, making  $V_{REF}$  negative would shift the thresholds negative. To incorporate the effect of  $V_{REF}$ , the threshold equations become:

$$\text{Upper Threshold Voltage, } V_{TU} = \frac{(V_{REF} \times R2) + (R1 \times V_{SAT+})}{R1 + R2} \quad (\text{volts})$$

and:

$$\text{Lower Threshold Voltage, } V_{TL} = \frac{(V_{REF} \times R2) + (R1 \times V_{SAT-})}{R1 + R2} \quad (\text{volts})$$

The “hysteresis” voltage is the difference between the thresholds:

$$\text{Hysteresis voltage, } V_H = V_{TU} - V_{TL} = \frac{R1 \times (V_{SAT+} - V_{SAT-})}{R1 + R2} \quad (\text{volts})$$

Note that  $V_H$  is completely independent of  $V_{REF}$ : this is an important aspect of the circuit, since it allows the thresholds to be shifted by varying  $V_{REF}$  *without* affecting the hysteresis voltage.

The circuit’s response to a triangle wave input voltage is shown in Fig.2.2a.  $V_{REF}$  has been set to a sufficiently large positive voltage, such that both thresholds are also positive; in Fig.2.2b, a negative value of  $V_{REF}$  has shifted both thresholds negative.

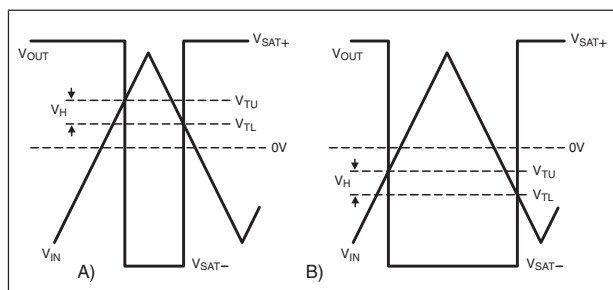


Fig.2.2. Response to a triangle wave input for positive (a) and negative (b)  $V_{REF}$ .

Varying  $V_{REF}$  allows the thresholds to be shifted over a wide range of positive and negative values. This can be a particularly useful feature: having chosen R1 and R2 to set the desired hysteresis voltage,  $V_{REF}$  may then be selected to set the mid point of the hysteresis band equal to the quiescent value of the input signal, such that the circuit can accommodate small-amplitude input signals whilst providing maximum noise immunity.

## INPUT IMPEDANCE

Our analysis of the circuit has ignored the effects of input offset voltage,  $V_{IO}$ : this is a reasonable approach provided the circuit does not demand absolute precision. However, the op.amp's input impedance cannot always be neglected.

Generally, the impedance  $Z_{IN}$  seen "looking into" the inverting input can be represented by the same kind of model introduced in Part One, namely a parallel combination of resistance, capacitance, and a current sink (or source) to represent the input bias current.

At low frequencies we can usually ignore the effects of input capacitance, and if we assume the input resistance is large (several megohms) we can concentrate on the effects of input bias current.

For example, consider the LM6171, a high speed op.amp capable of operation at frequencies in excess of 10MHz. The input bias current,  $I_B$ , is typically  $1\mu A$ , but can be as high as  $3\mu A$ . If the input voltage source resistance,  $R_{SOURCE}$ , is very small,  $I_B$  will have negligible effect.

However, for a source resistance of, say, 100k $\Omega$ , a bias current of  $2\mu A$  would drop 0.2V across  $R_{SOURCE}$ , resulting in significant errors in the threshold levels.

Even if  $R_{SOURCE}$  is zero, we must still consider the effects of  $I_B$  at the non-inverting input: if R1 and R2 are relatively large, the input bias current will cause a voltage drop across them which again will offset the threshold levels. To avoid these problems, either use small values for R1 and R2, or select an op.amp (or comparator) that has very small input bias currents.

## TESTING THE CIRCUIT'S PERFORMANCE

To demonstrate the circuit's performance, it was decided to use an LF351 op.amp. As well as offering fast response, the LF351 has a JFET input stage with typical input bias currents of just 50 picoamperes, allowing it to accommodate large resistance values without affecting the thresholds.

With  $R1 = 10k\Omega \pm 1\%$ ,  $R2 = 100k\Omega \pm 1\%$ , and with the supply rails set to precisely  $\pm 15.00V$ , the circuit's response to a 100Hz triangle wave input voltage was measured. It was found that the op.amp's output saturation levels were  $V_{SAT+} = +14.25V$  and  $V_{SAT-} = -13.55V$ .

Therefore, with  $V_{REF} = 0$ , the thresholds should be  $V_{TU} = +1.30V$  and  $V_{TL} = -1.23V$ . The actual, measured values were  $V_{TU} = +1.31V$  and  $V_{TL} = -1.21V$ . Pretty good!

Next, a reference voltage was introduced. With  $V_{REF} = +5.00V$ , the thresholds were  $V_{TU} = +5.88V$  and  $V_{TL} = +3.36V$ , very close to their theoretical values of  $V_{TU} = +5.84V$  and  $V_{TL} = +3.31V$ .

Finally, with  $V_{REF} = -5.00V$ , the thresholds were  $V_{TU} = -3.26V$  and  $V_{TL} = -5.80V$ , again in close agreement with their theoretical values of  $V_{TU} = -3.25V$  and  $V_{TL} = -5.78V$ .

Note that for each value of  $V_{REF}$ , the hysteresis voltage,  $V_H$ , remains fairly constant at  $\approx 2.5V$ .

## ZENER CLAMP OUTPUT SCHEME

We see from the previous example that the output saturation levels are not equal in magnitude, i.e.,  $|V_{SAT+}| \neq |V_{SAT-}|$ , which results in an asymmetry in the thresholds. Furthermore, the output saturation levels may change from part to part, and may also vary with temperature and load.

Since  $V_{TU}$  and  $V_{TL}$  depend directly on  $V_{SAT+}$  and  $V_{SAT-}$ , this can make it difficult to establish the thresholds precisely and repeatably. To some extent, this problem can be resolved by using an op.amp (or comparator) with rail-to-rail output swing, but even then the saturation levels would be affected by any variation in the supply voltages.

In Fig.2.3 are shown two methods which can be used to establish greater control over the output voltage levels. In Fig.2.3a, a back-to-back Zener "clamp" has been added to the output and feedback is now taken from the clamp via R2, rather than from the op.amp's output.

The Zener clamp is "bi-directional": as the op.amp output swings between its positive and negative saturation levels, the output voltage,  $V_{OUT}$ , at the junction of R3 and ZD1 also swings positive and negative. We can define these levels  $V_{Z+}$  and  $V_{Z-}$ , such that  $V_{Z+} = V_{Z1} + V_{D2}$  and  $V_{Z-} = V_{Z2} + V_{D1}$ , where  $V_{Z1}$  and  $V_{Z2}$  are the reverse Zener voltages, and  $V_{D1}$  and  $V_{D2}$  are the Zeners' forward diode drops.

If the Zeners are well matched, i.e., if  $V_{Z1} = V_{Z2}$  and  $V_{D1} = V_{D2}$ , the magnitude of  $V_{Z+}$  and  $V_{Z-}$  will be equal.

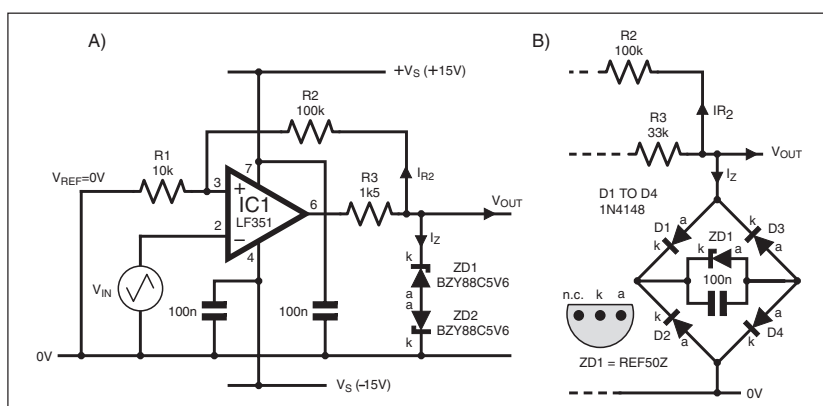


Fig.2.3. Two methods which can be used to give greater control over output voltage levels, (a) using a back-to-back Zener clamp and (b) using a diode bridge.

For example, using 5.6V Zeners as shown in Fig.2.3a, it was found that the voltage at  $V_{OUT}$  was perfectly symmetrical at  $\pm 6.60V$ , and with  $R1 = 10k\Omega \pm 1\%$  and  $R2 = 100k\Omega \pm 1\%$  as before, and with  $V_{REF} = 0$ , the thresholds were also symmetrical at  $\pm 0.63V$ .

Note that R3 must be small enough to provide adequate current,  $I_Z$ , to bias the Zeners properly, and must also provide the feedback current,  $I_{R2}$ , that flows in R2. Provided R3 is chosen carefully, this technique will provide a relatively constant, symmetrical bipolar voltage swing at  $V_{OUT}$ .

## A STABLE BRIDGE

The output clamp method can be improved still further using the scheme shown in Fig.2.3b. Here, the D1-D4 diode bridge maintains a positive potential at the cathode of regulator diode ZD1 for both positive and negative swings at  $V_{OUT}$ . If we assume the forward voltage drops across each of the bridge diodes are equal and denoted  $V_D$ , the output voltage swing is  $V_{OUT} = \pm(2V_D + V_Z)$ , where  $V_Z$  is ZD1's reverse voltage.

Although ZD1 could be a Zener, even better performance can be obtained using a precision shunt voltage reference diode. Here a choice was made to use the REF50Z, a micropower 5.0V reference diode, although other devices such as the REF12Z (1.26V) and REF25Z (2.5V) could be used to provide different clamping voltages.

Note that R3 has been increased from 1.5k $\Omega$  to 33k $\Omega$ , since the REF50Z requires much less bias current than the back-to-back Zeners.

This "reference-in-a-bridge" approach generated an output voltage swing of  $\pm 6.02V$ , and with  $R1 = 10k\Omega \pm 1\%$ ,  $R2 = 100k\Omega \pm 1\%$  and  $V_{REF} = 0$  as before, the thresholds were  $V_{TU} = \pm 0.575V$  and  $V_{TL} = -0.570V$ .



## USING COMPARATORS AND SINGLE RAILS

The examples so far have focused on a circuit using an op.amp working on dual supply rails. However, in many applications, it may be better to take advantage of the superior switching qualities offered by a comparator (see panel “Comparator Essentials”). We must also consider the biasing requirements of single rail applications and the use of “open-collector” (or “open-drain”) outputs.

In Fig.2.4a is shown an inverting Schmitt trigger using one half of the popular LM393 comparator. Although the LM393 can work on dual supplies from  $\pm 1\text{V}$  to  $\pm 18\text{V}$ , it is particularly suited to single rail operation since the common-mode input range goes all the way down to the negative rail (0V for single rail applications).

The reference voltage is generated by the potential divider comprising resistors R1a, R1b and the positive supply:

$$V_{\text{REF}} = \frac{+V_S \times R1b}{R1a + R1b} \quad (\text{volts})$$

For dual rail applications, a negative reference may be generated by connecting R1a to  $-V_S$ .

Since the LM393 has an open-collector output, pull-up resistor  $R_{\text{PU}}$  is required to pull the output voltage up toward  $+V_S$  when the output transistor turns off. However,  $R_{\text{PU}}$  must be included in the expression for  $V_{\text{TU}}$  since it effectively appears in series with R2.

The thresholds are given by:

Upper Threshold Voltage,

$$V_{\text{TU}} = \frac{V_{\text{REF}} \times (R2 + R_{\text{PU}}) + R_{\text{TH}} \times (+V_S)}{R_{\text{TH}} + R2 + R_{\text{PU}}} \quad (\text{volts})$$

and: Lower Threshold Voltage,

$$V_{\text{TL}} = \frac{(V_{\text{REF}} \times R2) + (R_{\text{TH}} \times V_{\text{SAT-}})}{R_{\text{TH}} + R2} \quad (\text{volts})$$

$R_{\text{TH}}$  is the Thévenin equivalent resistance of the R1a-R1b potential divider:

$$R_{\text{TH}} = \frac{R1a \times R1b}{R1a + R1b} \quad (\text{ohms})$$

Note that the expression for  $V_{\text{TU}}$  is only true for a lightly loaded output (for example, driving a CMOS logic gate). For heavier loads which prevent  $R_{\text{PU}}$  pulling the output all the way up to  $+V_S$ , the expression must be modified by removing  $R_{\text{PU}}$  and replacing  $+V_S$  with  $V_{\text{SAT+}}$ , the maximum positive output voltage, which must be determined for the particular application.

## CUT THE CHATTER

A problem sometimes encountered when comparators are misapplied is “chatter” at the output. With slowly varying input signals, comparators tend to produce multiple output transitions when the input signal crosses the reference potential.

As the input traverses the linear region, the comparator behaves as a very high gain, open-loop amplifier. The slightest noise on the input is amplified by the enormous gain of the comparator causing “chatter” at the output.

For example, the LM393 has a typical open-loop voltage gain of 200V/mV (i.e., 200,000), so to cause a 5V output transition requires an input noise amplitude of only  $5/200,000 = 25\mu\text{V}$ .

Stray capacitances around the comparator can result in a.c. feedback from output to input causing oscillation around the threshold, another source of output chatter.

Fortunately, hysteresis may be used to eliminate these problems. Usually, applying just a little positive feedback, say a few millivolts, may be enough to prevent the chatter. Naturally, for signals with larger noise content, the hysteresis, and hence the positive feedback, must be increased.

Chatter can sometimes be difficult to spot on an oscilloscope, but causes unacceptable errors in counting circuits.

## SINGLE RAIL TESTS

A single rail version of the circuit in Fig.2.4a was built by connecting the comparator's negative supply terminal (pin 4) to 0V. Resistance values were selected for  $R1a = R1b = 36\text{k}\Omega \pm 1\%$  to give  $R_{\text{TH}} = 18\text{k}\Omega \pm 1\%$ . With  $R2 = 100\text{k}\Omega \pm 1\%$ ,  $R_{\text{PU}} = 10\text{k}\Omega \pm 1\%$ , and  $+V_S = +5.00\text{V}$ , the “negative” saturation voltage,  $V_{\text{SAT-}}$ , was measured as  $+50\text{mV}$ . The thresholds were  $V_{\text{TU}} = 2.82\text{V}$  and  $V_{\text{TL}} = 2.10\text{V}$ , in close agreement with the theoretical values, namely  $V_{\text{TU}} = 2.85\text{V}$  and  $V_{\text{TL}} = 2.13\text{V}$ .

The value of  $V_{\text{SAT-}}$  is so small that it can almost be ignored and eliminated from the expression for  $V_{\text{TL}}$  which reduces to:

$$V_{\text{TL}} = (V_{\text{REF}} \times R2) / (R_{\text{TH}} + R2)$$

Bear in mind, however, that  $V_{\text{SAT-}}$  will tend to increase as  $R_{\text{PU}}$  is reduced. For example, if  $R_{\text{PU}}$  is reduced to, say,  $1\text{k}\Omega$ , the LM393's output transistor will sink around  $4\text{mA}$  when it turns on, and the corresponding saturation voltage may be as large as  $400\text{mV}$ .

## HIGH FREQUENCY RESPONSE

So far, we've looked at circuit response using low frequency signals, on the order of  $100\text{Hz}$ . However, at high frequencies, where the input signal has a very fast rate of change, the comparator's response time causes an apparent shift in the thresholds.

The waveforms in Fig.2.5 illustrate those obtained from the single rail LM393 circuit when a  $250\text{kHz}$  triangle wave input was applied. Initially, the non-inverting input,  $V+$ , sits at a potential equal to  $V_{\text{TU}}$ , but when  $V_{\text{IN}}$  crosses this threshold the output does not change state immediately. Instead, there is a delay denoted  $t_{\text{PD-}}$  (for “negative-going propagation delay”) before the output leaves its positive saturation level and starts to head negative.

However, it cannot change from positive to negative saturation instantaneously, but takes a finite time to “slew” from  $V_{\text{SAT+}}$  to  $V_{\text{SAT-}}$ . The combined effects of propagation delay and slew rate constitute the response time, and result in the *apparent* value of  $V_{\text{TU}}$  being significantly higher than the real value of  $V_{\text{TU}}$ .

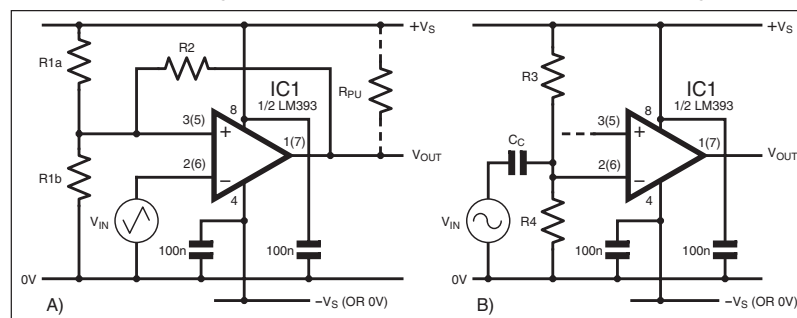


Fig.2.4. A single rail Schmitt trigger circuit using an “open-collector” comparator.

A similar effect occurs when the input signal crosses the lower value of  $V+$ , i.e.,  $V_{\text{TL}}$ . Again, there is a delay denoted  $t_{\text{PD+}}$  (for “positive-going propagation delay”) before the output leaves its negative saturation level and starts to move positive. However, this time, the slew-rate effects are more pronounced since the open-collector output depends on the pull-up resistor to swing the output positive.

Since the resistor must charge the comparator's output capacitance plus any stray and load capacitance, the output waveform now acquires an exponential shape. By the time the output waveform crosses the input signal, the *apparent* value of  $V_{\text{TL}}$  is considerably lower than the real level of  $V_{\text{TL}}$ .

At low frequencies, where the input signal changes at a relatively slow rate, the effects of comparator response time are usually negligible. However, you should be aware of these effects at high frequencies since they limit the Schmitt trigger's ability to respond to rapidly changing signals.

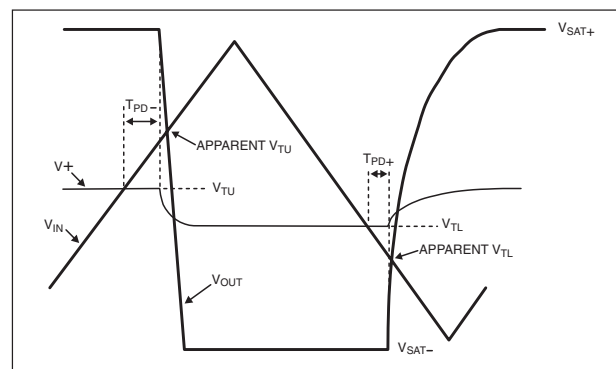


Fig.2.5. Effects of comparator response time on apparent thresholds.

# Comparator Essentials

Although op.amps can be used to compare one voltage level with another, the *voltage comparator* is often the better choice. Like the op.amp, the comparator is essentially a high-gain differential amplifier, in that a very small differential input voltage will drive the output into positive or negative saturation.

However, by enhancing certain characteristics such as gain and slew rate, the comparator is optimised for non-linear applications in which the main function is to compare rather than to amplify voltages.

An important comparator a.c. parameter is *response time*, the time delay between an input step voltage and the resulting large-scale change in output voltage. Response time includes the propagation delay through the i.c. and the effects of output slew rate, and varies considerably from one type of comparator to another. For example, the typical response time for the National Semiconductor LM393 is 1.3µs, whereas for the LM360 it is just 14ns.

Comparators are expected to be operated with non-zero differential voltages; this is not necessarily so with op.amps which are mainly intended to be operated "closed-loop" where the differential voltage is close to zero. For example, the TLC372 dual comparator has a differential input range equal to the supply voltage (which can be as high as 18V), whereas the OP97 precision op.amp has input protection diodes which limit the differential input voltage to just ±1V. Always read the data sheet thoroughly to check that a given device is being used properly.

## OUTPUT STAGE

Although comparators occasionally feature "push-pull" output stages like op.amps, they often have "open-collector" (or "open-drain") outputs. For example, the NE521 (a high speed, dual comparator) has a push-pull output stage, which means the output voltage is constrained to lie between ground (0V) and the positive supply.

The dual LM393, on the other hand, has an open-collector output (emitter connected to ground), which allows it to drive loads connected to rails higher than its own supply voltage.

The output stage of the LM311 is even more flexible, since both the collector and emitter of the output transistor are "floating", such that it can drive loads referred to ground, to the positive supply or to the negative supply. With the emitter grounded, the collector can drive loads connected to voltages as high as 40V and can sink currents up to 50mA.

Open-collector outputs can be very flexible when interfacing to logic devices, and are also suited to "wired-OR" operation, rather like open-collector TTL gates.

## INPUT PARAMETERS

Input bias current,  $I_B$ , can vary considerably from one comparator type to another. For example, the LM393 has  $I_B = 25nA$  (typical) at 25°C, whereas the TLC393 (dual, open drain) has  $I_B = 5pA$  (typical) at 25°C – five thousand times less! Also, note that the TLC393 supply current is approximately one-twentieth that of the LM393, even though the devices are functionally equivalent.

For certain devices, bias current can vary with differential input voltage. The LM311, for example, has a typical input bias current of 100nA at 25°C for zero differential input voltage, but this can vary by ±75nA if the differential input is taken beyond ±8V. Note that 100nA will drop 10mV across a 100kΩ input resistance.

Always check the common-mode input range: this is not necessarily equal to the supply voltages, and is often significantly less. For example, when working on ±15V supplies, the LM311's input voltage range is -14.5V to +13.0V.

## WIDE VARIETY

Like op.amps, comparators come in a many different "flavours". Speed (response time), input offset voltage and bias current are some of the parameters to be considered when choosing a suitable device, although supply current, output type and cost can often be equally important. Table 1 lists some of the most popular comparators and details some of the main parameters. Note that this is not an exhaustive list and there are many others to choose from!

If you would rather use an op.amp as a comparator, consider its speed (bandwidth and slew-rate), its ability to drive loads, and its output swing (especially if interfacing to logic circuits). Lastly, remember that comparators are not meant to be operated in linear mode, and so are not internally frequency compensated. Generally, therefore, comparators do not make good op.amps and should not be used as such!

Table 1: Popular Comparators and Their Main Characteristics

Part Number	Manufacturer	Single/Dual/Quad	$t_R$ typ.	$I_B$ max.	$V_{IO}$ max. (mV)	$I_S$ max.	Total Supply Voltage (V)		Single Rail Operation?	Output Type	Comments
							min	max			
CA3290	Harris	D	1.2µs	40pA	20	3mA	5	36	Yes	OC	BiMOS design
LM311	National Semiconductor	S	200ns	250nA	7.5	7.5mA	5	36	Yes	OC	popular: inexpensive; flexible output stage
LM319	National Semiconductor	D	80ns	1µA	8	12.5mA	5	36	Yes	OC	fast, but input current is high
LM339	National Semiconductor	Q	1.3µs	250nA	5	2.5mA	2	36	Yes	OC	popular: inexpensive; very low operating voltage
LM361	National Semiconductor	S	14ns	30µA	5	20mA	11	30	No	PP	very fast, but input and supply currents are high; differential output may be strobed
LM393	National Semiconductor	D	1.3µs	250nA	5	2.5mA	2	36	Yes	OC	popular: inexpensive; dual version of LM339
LMC6762	National Semiconductor	D	10µs	0.04pA (typ.)	15	20µA	2.7	15	Yes	PP	input and output voltage range is rail-to-rail; very low power; extremely low input current
LT1016	Linear Technology	S	10ns	10µA	3	35mA	5	10	Yes	PP	very fast, but power hungry; differential outputs may be latched.
LT1017	Linear Technology	D	20µs	15nA	1	90µA	1.2	40	Yes	PP	micropower: very low operating voltage
LT1018	Linear Technology	D	6µs	75nA	1	250µA	1.2	40	Yes	PP	low power; very low operating voltage
MAX931	Maxim	S	12µs	1nA	10	3.2µA	2.5	11	Yes	PP	micropower; includes 1.18V bandgap voltage reference; comparator has adjustable hysteresis
MAX941	Maxim	S	80ns	300nA	2	700µA	2.7	6	Yes	PP	fast; low power; rail-to-rail input voltage range
NE521	Philips Semiconductors	D	10ns	20µA	7.5	35mA	9	11	No	PP	very fast; outputs may be strobed
NE529	Philips Semiconductors	S	15ns	20µA	6	25mA	10	20	No	PP	very fast; differential outputs may be strobed
TLC372	Texas Instruments	D	650ns	5pA	5	300µA	2	18	Yes	OD	low power; very low supply voltage and input current
TLC393	Texas Instruments	D	2.5µs	5pA	5	40µA	3	16	Yes	OD	micropower; very low supply voltage and input current; compare with LM393
TLC3702	Texas Instruments	D	2.7µs	5pA	5	40µA	3	16	Yes	PP	push-pull output version of TLC393
TLC3704	Texas Instruments	Q	2.7µs	5pA	5	80µA	3	16	Yes	PP	quad version of TLC3702

NOTES: All specifications are given for an operating temperature of +25°C.  $t_R$  = Response Time (depends on input overdrive).  $I_B$  = Input Bias Current  
 $V_{IO}$  = Input Offset Voltage.  $I_S$  = Supply Current. Total Supply Voltage = difference between positive and negative supply rails.  
 OC = Open Collector; OD = Open Drain; PP = Push-Pull.

## A.C. COUPLING

We've seen how the Schmitt trigger's reference voltage can be set to match the mid-point of the hysteresis band to the quiescent, or average, voltage level of the input signal. However, for signals that lie outside the common-mode range of the comparator, a.c. coupling can be used to remove the d.c. level and thus bring the a.c. content of the signal within the comparator's input range.

The circuit diagram in Fig.2.4b shows how the single rail Schmitt trigger can be modified for a.c. coupling. Resistors R3 and R4 establish a suitable d.c. potential at the comparator's inverting input. Usually, it is best to make this potential equal to the mid-point of the comparator's common-mode input range.

For example, when operating on a single +5V rail, the LM393's common-mode input range is zero to 3.5V, so R3 and R4 would be selected to set the d.c. level at the inverting input to 1.75V. The a.c. signal is capacitively coupled via  $C_C$  to the inverting input, allowing the circuit to accept a.c. signals up to  $\pm 1.75V$  in amplitude, or 3.5V peak-to-peak.

Resistors R1a and R1b would be chosen to set the mid point of the hysteresis band equal to 1.75V, and by selecting R2 and  $R_{PU}$  to set the hysteresis voltage just less than the minimum peak-to-peak amplitude of the input signal, the Schmitt trigger will provide maximum noise immunity.

A word of warning, though. When dealing with a.c. signals such as pulse trains whose duty cycle can vary enormously, capacitive coupling can cause problems: as the duty cycle changes, so, too, does the average d.c. level of the waveform, such that the waveform at the inverting input tends to shift up and down. If this shift is excessive, the signal fails to cross one of the thresholds, and the circuit doesn't trigger. Always check that the circuit will respond properly at the extremes of the input signal's duty cycle.

## NON-INVERTING SCHMITT TRIGGER

By swapping over the input voltage and reference voltage connections of the inverting Schmitt trigger (Fig.2.1), we obtain the non-inverting Schmitt trigger shown in Fig.2.6a.

The voltage  $V_+$  at the non-inverting input now depends not only on  $V_{OUT}$ , R1 and R2, but also on  $V_{IN}$ . We can understand the circuit's operation by referring to the voltage transfer characteristic in Fig.2.6b, which shows the case for  $V_{REF} = 0$  and assumes  $V_{SAT+}$  is equal and opposite to  $V_{SAT-}$ .

Starting at the bottom left-hand corner, where  $V_{IN}$  is at its most negative value, the output is in negative saturation and so  $V_+$  is also a negative voltage. As  $V_{IN}$  increases (shown by the white arrows) it eventually reaches a positive level where  $V_+$  just rises above 0V, causing the comparator output to change state. The value of  $V_{IN}$  where the output rapidly changes from  $V_{SAT-}$  to  $V_{SAT+}$  is the upper threshold voltage,  $V_{TU}$ .

If  $V_{IN}$  is now reduced (shown by the black arrows), the output remains in positive saturation until  $V_{IN}$  has gone sufficiently negative to make  $V_+$  go just below 0V. At this point, where  $V_{IN} = V_{TL}$ , the output abruptly changes from positive to negative saturation,  $V_{SAT-}$ .

Notice how the hysteresis loop moves in an "anti-clockwise" direction, whereas that of the inverting Schmitt trigger (Fig.2.1b) follows a clockwise path.

By introducing the reference voltage,  $V_{REF}$ , we can shift the thresholds up or down: when  $V_{REF}$  is positive, the thresholds are moved in a positive direction, and vice-versa. The expressions for the thresholds (assuming  $R_{SOURCE} = 0$ ) are:

Upper Threshold Voltage,

$$V_{TU} = \frac{V_{REF} \times (R1 + R2) - (R1 \times V_{SAT-})}{R2} \quad (\text{volts})$$

and:

Lower Threshold Voltage,

$$V_{TL} = \frac{V_{REF} \times (R1 + R2) - (R1 \times V_{SAT+})}{R2} \quad (\text{volts})$$

The "hysteresis" voltage, the difference between the thresholds, is:

Hysteresis voltage,

$$V_H = V_{TU} - V_{TL} = \frac{R1 \times (V_{SAT+} - V_{SAT-})}{R2} \quad (\text{volts})$$

Again, like the inverting Schmitt trigger, we see that  $V_H$  is completely independent of  $V_{REF}$ .

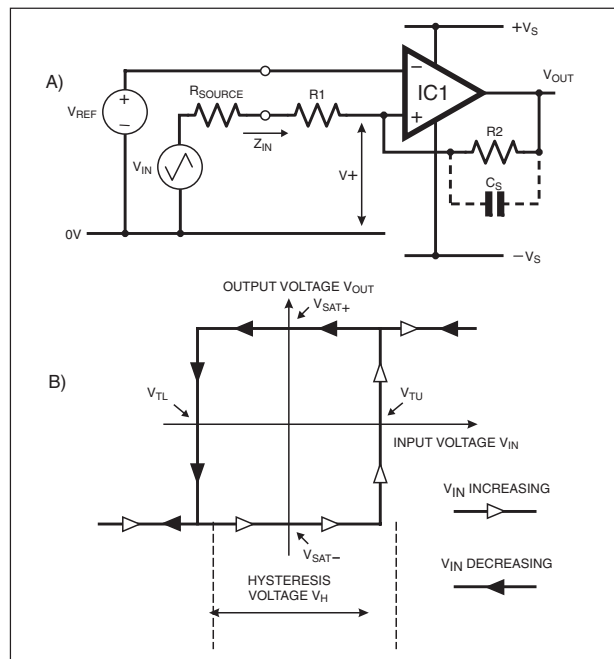


Fig.2.6. Circuit for a non-inverting Schmitt trigger (a) and its voltage transfer characteristic (b).

## POSITIVE AND NEGATIVE RESISTANCE

We saw that the inverting Schmitt trigger's input impedance was dominated by the input bias current of the op.amp or comparator. For the non-inverting circuit, the impedance  $Z_{IN}$  seen by the voltage source depends largely on R1, R2 and  $V_{OUT}$ , and appears as either a positive or negative resistance.

For example, when  $V_{IN}$  is above  $V_{TU}$ ,  $V_{OUT}$  is in positive saturation and current flows from IC1's output, through R2 and R1 and into  $V_{IN}$ . Thus,  $Z_{IN}$  appears as a *negative* resistance.

On the other hand, when  $V_{IN}$  is below  $V_{TL}$ ,  $V_{OUT}$  is in negative saturation, and current flows from  $V_{IN}$ , through R1 and R2 and into IC1's output, such that  $Z_{IN}$  now behaves like a *positive* resistance.

If  $R_{SOURCE}$ , the output resistance of the voltage source, is very small or zero, the changing nature of  $Z_{IN}$  has negligible effect on circuit behaviour. However, if  $R_{SOURCE}$  is similar, or greater, in size to R1 and R2, the changing input current will cause a changing voltage drop across it, causing the apparent thresholds to shift relative to their nominal values.

In these circumstances, it is necessary to modify the threshold and hysteresis voltage equations by replacing R1 with  $(R_{SOURCE} + R1)$ , since  $R_{SOURCE}$  effectively appears in series with R1.

## NON-INVERTING DESIGN PROCEDURE

The values for  $V_{SAT+}$  and  $V_{SAT-}$  can be obtained from the data sheet or determined from in-circuit measurements: the latter can often be more accurate, especially where saturation levels are heavily dependent on output loading.

For a desired hysteresis voltage, R1 and R2 can be selected by rearranging the expression for  $V_H$ :

$$R2 = R1 \times (V_{SAT+} - V_{SAT-}) / V_H$$

Then, knowing the desired value for  $V_{TU}$ , the appropriate reference voltage may be evaluated from:

Reference Voltage,

$$V_{REF} = \frac{V_{TU} \times (V_{SAT+} - V_{SAT-}) + (V_H \times V_{SAT-})}{V_H + V_{SAT+} - V_{SAT-}} \quad (\text{volts})$$

We'll follow a design example based on the LM6482, a dual, rail-to-rail input and output op.amp. Let's assume we require a hysteresis voltage of 1.0V and  $V_{TU} = 1.5V$ , and the circuit is to run on a single 5V supply.

With the output lightly loaded, it was found from in-circuit measurements that  $V_{SAT+} = 5.00V$  and  $V_{SAT-} = 20mV$ . Using the above equations, we find that  $R2 = 4.98 \times R1$ , and  $V_{REF} = 1.253V$ .



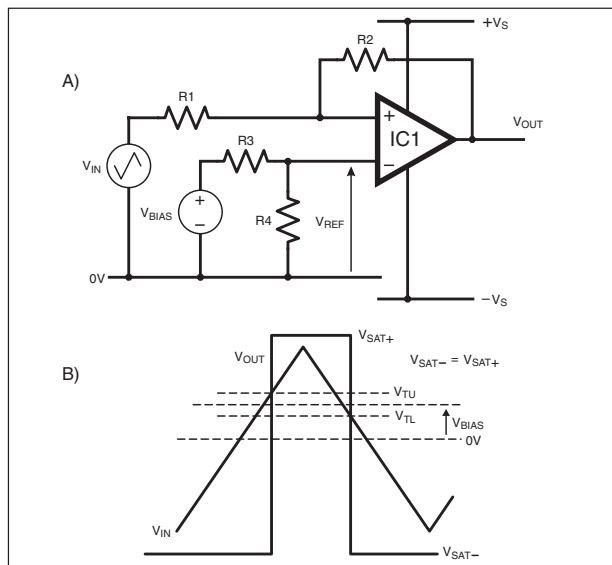


Fig.2.7. Using a bias voltage to control the mid-hysteresis level.

Using  $R1 = 20k\Omega \pm 1\%$ ,  $R2 = 100k\Omega \pm 1\%$ , and with the supply voltage set to precisely 5.00V and  $V_{REF}$  set to 1.25V, measurements showed the upper threshold voltage as  $V_{TU} = 1.53V$  and the hysteresis voltage as  $V_H = 1.06V$ .

Note that these results were obtained using a 200Hz triangular input waveform. It was found that performance was good up to around 2kHz: at higher frequencies, the op.amp's response time started to affect the thresholds in the manner described earlier.

For example, with  $V_{REF}$  increased to 2.5V, the nominal thresholds are  $V_{TL} = 2.00V$  and  $V_{TU} = 3.00V$ . At 2kHz, the measured values were  $V_{TL} = 1.87V$  and  $V_{TU} = 3.09V$ , whereas at 20kHz the apparent thresholds were  $V_{TL} = 1.50V$  and  $V_{TU} = 3.45V$ . Clearly, if accurate performance were to be required at frequencies above 2kHz, it would be necessary to use a faster op.amp.

## MID-HYSTERESIS LEVEL

We saw earlier that the hysteresis voltage  $V_H = R1 \times (V_{SAT+} - V_{SAT-}) / R2$ . If we can arrange for the output saturation levels to be equal and opposite, i.e., if  $V_{SAT+} = -V_{SAT-}$ , the expression can be written  $V_H = (2 \times R1 \times V_{SAT+}) / R2$ .

Now, the mid-point of the hysteresis band is simply the lower threshold plus half of the hysteresis voltage, or  $V_{TL} + (V_H/2)$ . So, for the case when  $V_{SAT+} = -V_{SAT-}$  (and assuming  $R_{SOURCE} = 0$ ), we find that:

$$\text{Mid-point of Hysteresis Voltage} = V_{TL} + (V_H/2) = \frac{V_{REF} \times (R1 + R2) - (R1 \times V_{SAT+})}{R2} + \frac{(R1 \times V_{SAT+})}{R2} \quad (\text{volts})$$

which simplifies nicely to:

$$V_{TL} + (V_H/2) = V_{REF} \times \frac{(R1 + R2)}{R2} \quad (\text{volts})$$

If we apply a d.c. bias voltage,  $V_{BIAS}$ , to the inverting input using the R3-R4 potential divider as shown in Fig.7a, we see that  $V_{REF} = (V_{BIAS} \times R4) / (R3 + R4)$ , and so:

$$V_{TL} + (V_H/2) = V_{BIAS} \times \frac{R4}{(R3 + R4)} \times \frac{(R1 + R2)}{R2} \quad (\text{volts})$$

Therefore, if we make the ratio of  $R2 / R1 = R4 / R3$ , we get:

$$V_{TL} + (V_H/2) = V_{BIAS}$$

In other words, the mid-point of the hysteresis band will equal the bias voltage  $V_{BIAS}$ , as shown in Fig.2.7b for a positive value of  $V_{BIAS}$ .

This technique can be useful where the average level of the a.c. input signal changes unpredictably, a problem that can make it difficult or impossible to set appropriate thresholds using the simple Schmitt trigger of Fig.2.6.

By using the circuit of Fig.2.7a, and by arranging for  $V_{BIAS}$  to track the average level of the input signal, the thresholds will shift automatically such that the hysteresis band will always be centred

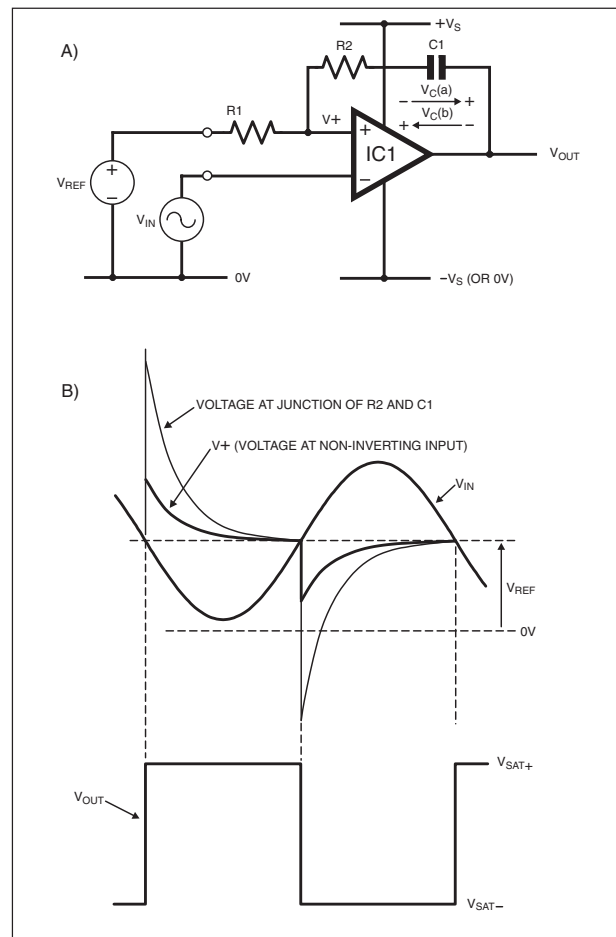


Fig.2.8. Using capacitive feedback provides temporal hysteresis.

on the a.c. signal. Remember, however, that this technique can only be used when the output saturation levels are equal and opposite.

## SINGLE THRESHOLD VOLTAGE

For applications that demand only a single threshold voltage and yet still require noise rejection, we must find a way of introducing hysteresis without having two separate thresholds. This apparent paradox is achieved using "temporal" hysteresis, usually implemented with capacitive positive feedback as shown in the inverting Schmitt trigger of Fig.2.8a. The circuit works as follows:

Assume that  $V_{IN}$  is lower than  $V+$ , the voltage at the non-inverting terminal, such that  $V_{OUT}$  is in positive saturation. Capacitor C1 charges via R1 and R2 until its voltage,  $V_C(a)$  equals  $(V_{SAT+} - V_{REF})$ .

When C1 is fully charged, no current flows through R1 and so  $V+ = V_{REF}$ . If  $V_{IN}$  now rises above  $V+$ ,  $V_{OUT}$  abruptly changes state from  $V_{SAT+}$  to  $V_{SAT-}$ , causing the voltage at the R2-C1 junction to go to  $V_{SAT-} - V_C(a) = V_{SAT-} - V_{SAT+} + V_{REF}$ .

Thus,  $V+$  is suddenly pulled down to a voltage lower than  $V_{REF}$ , resulting in the regenerative action needed for proper Schmitt trigger operation. (The actual voltage that  $V+$  goes to depends on the ratio of R1 and R2).

However,  $V+$  does not stay at this low level because C1 starts to charge via R1 and R2 until its voltage,  $V_C(b)$  equals  $(V_{REF} - V_{SAT-})$ . Once C1 is fully charged,  $V+$  again settles back to equal  $V_{REF}$ .

If  $V_{IN}$  now falls below  $V+$ ,  $V_{OUT}$  snaps into positive saturation, and  $V+$  is rapidly pulled to a voltage greater than  $V_{REF}$ . Once again, positive feedback causes the required regenerative action. C1 now charges until its voltage,  $V_C(a)$  equals  $(V_{SAT+} - V_{REF})$ , at which point  $V+$  again falls back to equal  $V_{REF}$ .

The waveforms in Fig.2.8b are those typically occurring in response to a sinusoidal input voltage, where  $V_{REF} = V_{SAT+} / 2$  and  $V_{SAT-} = 0$  (i.e., a single rail application).

Notice that when  $V_{IN}$  crosses the  $V_{REF}$  threshold,  $V+$  jumps above or below  $V_{REF}$  and then decays back to a level equal to  $V_{REF}$ . Provided the  $(R1 + R2) \times C1$  time constant is less than one-tenth the period of  $V_{IN}$ ,  $V+$  will always return to  $V_{REF}$  before  $V_{IN}$  next crosses the  $V_{REF}$  threshold.

Knowing the maximum input signal frequency, the appropriate  $(R1 + R2) \times C1$  time constant may be determined. Then, having chosen  $C1$ , the ratio of  $R1$  and  $R2$  must be selected to maximise the voltage swing at the non-inverting input (thereby maximising the circuit's noise rejection properties) whilst ensuring that  $V+$  remains within the common-mode input limits for the op.amp or comparator used.

Temporal hysteresis can be demonstrated using the circuit of Fig.2.9, a single rail circuit which again uses one half of an LMC6482 op.amp (although other op.amps or comparators with rail-to-rail input and output capability could be used).

Making  $R1a$  and  $R1b$  both equal to  $100k\Omega$  sets  $V_{REF} = 2.5V$  and provides an effective (Thévenin) value of  $R1 = 50k\Omega$ . With  $R2 = 100k\Omega$  and  $C1 = 6.8nF$ , the feedback network's time constant is  $1ms$ , allowing the circuit to accommodate input signal frequencies as high as  $100Hz$ .

The maximum voltage swing at the non-inverting input is  $V_{REF} \pm 1.7V$ , i.e.,  $0.8V$  to  $4.2V$ , well within the op.amp's common-mode input limits.

The circuit's response to a noisy input signal is illustrated in Fig.2.10. The top trace shows the input signal, a sine wave containing over 30 per cent of "triangular" noise. The middle trace is the output of the circuit in Fig.2.9. Notice how there is only one transition each time the sinusoid crosses the  $2.5V$  reference threshold.

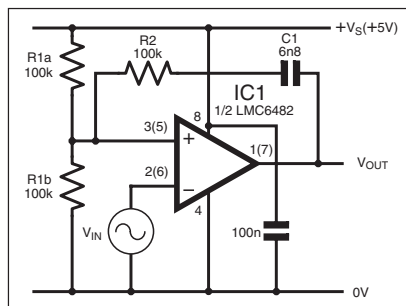


Fig.2.9. Single rail Schmitt trigger with temporal hysteresis.

The bottom trace shows the circuit's output with  $R2$  and  $C1$  removed (i.e., no positive feedback at all). The circuit now

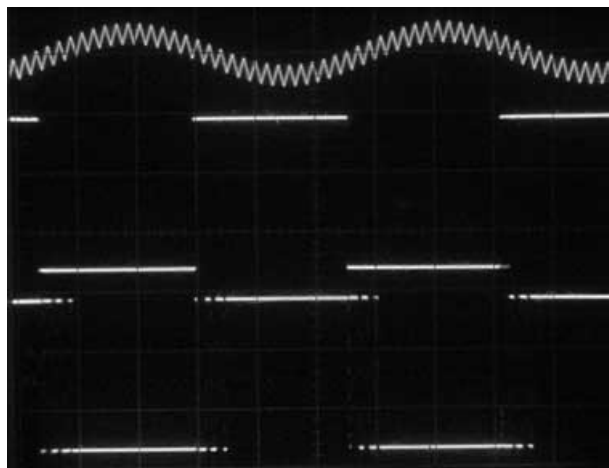


Fig.2.10. Waveforms showing that temporal hysteresis provides noise rejection. Top trace:  $V_{IN}$  (5V/div.). Middle trace: Output waveform of circuit with temporal hysteresis (2V/div.). Bottom trace: Output waveform with no positive feedback (2V/div.). Timebase: 2ms/div.

behaves as a simple comparator, such that its input is triggered each time the noise crosses the  $2.5V$  reference: the multiple transitions caused by the noise can clearly be seen on the output wave-form.

## PRECISION AND VERSATILITY

In Part Three of this series, we'll examine methods for improving the Schmitt trigger's precision and flexibility. We'll also see how this versatile circuit element is used as the basis for other circuit functions, such as oscillators and pulse generators.

## SHOP TALK

with David Barrington

### PIC-Monitored Dual PSU

We have a minor problem concerning the metal case for the *PIC-Monitored PSU*. The original one used in the author's model is no longer stocked. However, although the dimensions are not exactly the same, our investigations have thrown up two possibilities and they are both RS types.

The first one measures  $305mm \times 178mm \times 177mm$ , is coded 223-972 and listed at £19.55. The other one is coded 671-242, measures  $254mm \times 197mm \times 159mm$  and is listed at £40.21. Readers should be able to order these through any bona-fide RS stockists in their area. Alternatively, they can be ordered through **Electromail** (☎ 01536 304555 or <http://rswwww.com>), their mail order outlet. No doubt, readers will have their own ideas regarding the case.

The 50VA mains transformer, code 805-142, and the L272 dual power op.amp, code 635-167, also came from the above source.

Regarding the monitor section. The alphanumeric 2-line 16-character per line liquid display module used in the prototype has an integral cable and connector. It was purchased from **Magenta Electronics** (☎ 01283 565435 or [www.magenta2000.co.uk](http://www.magenta2000.co.uk)). Other advertisers will no doubt be able to offer something similar, without cable.

For those readers unable to program their own PICs, a ready-programmed PIC16F877-4P can be purchased from Magenta (see above) for the inclusive price of £10 (overseas readers add £1 for postage). Software for the *PIC-Monitored Dual PSU* is available on a 3.5in. PC-compatible disk from the EPE Editorial Office – see *PCB Service* page 946. It is also available free via the EPE web site: <http://epemag.wimborne.co.uk/pubs/PICS/PICmonpsu>.

The two printed circuit boards are available from the *EPE PCB Service*, codes 280 (Power Supply, of which two are needed for the full PSU) and 281 (Monitor).

### Static Field Detector

This month's Starter Project is a low-cost *Static Field Detector* and we do not expect any "sticky" component problems.

The specified TL061CP op.amp has an output stage that will drive both i.e.d.s from fully switched off to fully on, whereas many other op.amps will fail to do this. Therefore, the use of alternative devices is not really recommended. The TL061CP should be readily available from component advertisers.

The printed circuit board for the "Detector" is the Multi-project board available from our *PCB Service*, code 932.

### Motorists' Buzz-Box

Prices for panel meters tend to vary quite considerably and it may pay you to shop around when collecting together parts for the *Motorists' Buzz-Box* project.

The LM334N adjustable current source chip came from Maplin (☎ 0870 264 6000 or [www.maplin.co.uk](http://www.maplin.co.uk)), code WQ32K. They also have a "large"  $50\mu A$  panel

meter, code RX54J, but you will need a larger plastic box for this one. The printed circuit board is available from the *EPE PCB Service*, code 278.

### Festive Fader

The 3VA mains transformer, with twin primary and secondary windings, and the MOC3020 opto-isolated triac for the *Festive Fader* were purchased from **Farnell** (☎ 0113 263 6311 or [www.farnell.com](http://www.farnell.com)), codes 159-438 and 280-320. They also supplied the  $1\mu F$  multilayer ceramic capacitor, but you will probably have to buy in multiples of 5. It is also listed by **Electromail** (☎ 01536 304555 or <http://rswwww.com>), code 264-4977 (packs of 5).

The printed circuit board is available from the *EPE PCB Service*, code 277 (see page 946). The Euro mains connector, with fuseholder, should be widely stocked.

### PICtogram

All of the components called up for the *PICtogram* project appear to be "off-the-shelf" items except, of course, a ready-programmed PIC16F84 microcontroller. The 2mA i.e.d.s certainly seem to be in abundant supply, in various colours.

For those readers unable to program their own PICs, the author is able to supply ready-programmed PIC16F84 microcontrollers for the sum of £6 each, inclusive of postage (overseas add £1 per order). Orders should be sent to: **Andy Flind, 22 Holway Hill, Taunton, Somerset, TA1 2HB**. Payments should be made out to A. Flind. For those who wish to program their own PICs, the software is available from the Editorial offices on a 3.5in. PC-compatible disk, see *PCB Service* page 946. It is also available free via the EPE web site: <http://epemag.wimborne.co.uk/pubs/PICS/PICtogram>.

Finally, the printed circuit board is available from the *EPE PCB Service*, code 271 (see page 946).

### Christmas Bubble and Twinkling Star

Regarding the *Christmas Bubble* and *Twinkling Star* projects, both sets of components appear to be "run of the mill" items and should not cause any sourcing problems.

Jumbo i.e.d.s (10mm) should cost you just under £1 on average. You may also be able to buy the standard i.e.d.s at quantity discounts from some advertisers, it's worth trying.

If you must run these two projects using mains adaptors, most of our components advertisers seem to stock good quality, multi-voltage types. The small printed circuit board for the *Twinkling Star* is available from the *EPE PCB Service*, code 276 (see page 946).

### PLEASE TAKE NOTE

#### Anti-Tamper Alarm (Ingenuity Unlimited)

Page 766. The i.c.s should be types 4001 and not as shown on the circuit. Also, note capacitor  $C1$  should be  $10n$  (nano) and not as shown.

Oct '00

#### Versatile Mic/Audio Preamplifier

It would appear that supplies of the SSM2166P mic. preamp chip have now "dried-up". If any readers know of a source please let us know so that we can pass it on.

May '00

**WHETHER ELECTRONICS IS YOUR HOBBY  
OR YOUR LIVELIHOOD . . .  
YOU NEED THE MODERN ELECTRONICS MANUAL  
and the ELECTRONICS SERVICE MANUAL**

## THE MODERN ELECTRONICS MANUAL



**SALE  
40%  
OFF**  
Buy either Manual at 40% off  
regular price.  
Or buy both and save even more.  
**DON'T  
MISS**

**The essential reference  
work for everyone  
studying electronics**

- Over 900 pages
- In-depth theory
- Projects to build
- Detailed assembly instructions
- Full components checklists
- Extensive data tables
- Detailed supply information
- Easy-to-use format
- Clear and simple layout
- Comprehensive subject range
- Professionally written
- Regular Supplements
- Sturdy gold blocked ring-binder

## EVERYTHING YOU NEED TO GET STARTED AND GO FURTHER IN ELECTRONICS!

The revised edition of the Modern Electronics Base Manual contains practical, easy-to-follow information on the following subjects:

**BASIC PRINCIPLES:** Electronic Components and their Characteristics (16 sections from Resistors and Potentiometers to Crystals, Crystal Modules and Resonators), Circuits Using Passive Components (9 sections), Power Supplies, The Amateur Electronics Workshop, The Uses of Semiconductors, Digital Electronics (6 sections), Operational Amplifiers, Introduction to Physics, Semiconductors (6 sections) and Digital Instruments (5 sections).

**CIRCUITS TO BUILD:** There's nothing to beat the satisfaction of creating your own project. From basic principles, like soldering and making printed circuit boards, to circuit-building, the Modern Electronics Manual and its Supplements describe clearly, with appropriate diagrams, how to assemble radios, loudspeakers,

amplifiers, car projects, computer interfaces, measuring instruments, workshop equipment, security systems, etc. The Base Manual describes 13 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 turn to the glossary included in the Manual and you'll find a comprehensive definition in plain English.

The Manual also covers **Safety** and **Suppliers**. The most comprehensive reference work ever produced at a price you can afford, the revised edition of **THE MODERN ELECTRONICS MANUAL** provides you with all the **essential** information you need.

## THE MODERN ELECTRONICS MANUAL

**Revised Edition of Basic Work:** Contains over 900 pages of information. Edited by John Becker.

**Regular Supplements:** Approximately 160-page Supplements of additional information which, if requested, are forwarded to you immediately on publication (four times a year). These are billed separately and can be discontinued at any time.

**Presentation:** Durable looseleaf system in large A4 format

**Price of the Basic Work:** ~~£39.95~~ **SALE PRICE £23.97** (to include a recent Supplement **FREE**)

### Guarantee

Our 30 day money back guarantee gives you **complete peace of mind**. If you are not entirely happy with either Manual, for whatever reason, simply return it to us in good condition within 30 days and we will make a **full refund of your payment** – no small print and no questions asked.  
(Overseas buyers do have to pay the overseas postage charge)

Wimborne Publishing Ltd., Dept Y12, Allen House, East Borough, Wimborne, Dorset BH21 1PF. Tel: 01202 881749. Fax: 01202 841692.



# ELECTRONICS SERVICE MANUAL

## EVERYTHING YOU NEED TO KNOW TO GET STARTED IN REPAIRING AND SERVICING ELECTRONIC EQUIPMENT

**SAFETY:** Be knowledgeable about Safety Regulations, Electrical Safety and First Aid.

**UNDERPINNING KNOWLEDGE:** Specific sections enable you to Understand 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 regular Supplements include vital guidelines on how to Service Audio Amplifiers, Radio Receivers, TV Receivers, Cassette Recorders, Video Recorders, Personal Computers, etc.

**TECHNICAL NOTES:** Commencing with the IBM PC, this section and the regular Supplements deal with a very wide range of specific types of equipment – radios, TVs, cassette recorders, amplifiers, video recorders etc..

**REFERENCE DATA:** Detailing vital parameters for Diodes, Small-Signal Transistors, Power Transistors, Thyristors, Triacs and Field Effect Transistors. Supplements include Operational Amplifiers, Logic Circuits, Optoelectronic Devices, etc.

## The essential work for servicing and repairing electronic equipment

- Around 900 pages
- Fundamental principles
- Troubleshooting techniques
- Servicing techniques
- Choosing and using test equipment
- Reference data
- Easy-to-use format
- Clear and simple layout
- Vital safety precautions
- Professionally written
- Regular Supplements
- Sturdy gold blocked ring-binder

## ELECTRONICS SERVICE MANUAL

**Basic Work:** Contains around 900 pages of information. Edited by Mike Tooley BA

**Regular Supplements:** Approximately 160-page Supplements of additional information which, if requested, are forwarded to you immediately on publication (four times a year). These are billed separately and can be discontinued at any time.

**Presentation:** Durable looseleaf system in large A4 format

**Price of the Basic Work:** ~~£39.95~~ **SALE PRICE £23.97** (to include a recent Supplement **FREE**)

## ORDER BOTH MANUALS TOGETHER AND SAVE ANOTHER £8

*A mass of well-organised and clearly explained information is brought to you by expert editorial teams whose combined experience ensures the widest coverage*  
*Regular Supplements to these unique publications, each around 160 pages, keep you abreast of the latest technology and techniques if required*

### REGULAR SUPPLEMENTS

Unlike a book or encyclopedia, these Manuals are living works – continuously extended with new material. If requested, Supplements are sent to you approximately every three months. Each Supplement contains around 160 pages – all for only £23.50+£2.50 p&p. You can, of course, return any Supplement (within ten days) which

you feel is superfluous to your needs. You can also purchase a range of past Supplements to extend your Base Manual on subjects of particular interest to you.

### RESPONDING TO YOUR NEEDS

We are able to provide you with the most important and popular, up to date, features in our

Supplements. Our unique system is augmented by readers' requests for new information. Through this service you are able to let us know exactly what information you require in your Manuals.

You can also contact the editors directly in writing if you have a specific technical request or query relating to the Manuals.

**PLEASE** send me

☐ THE MODERN ELECTRONICS MANUAL plus a **FREE SUPPLEMENT**

☐ ELECTRONICS SERVICE MANUAL plus a **FREE SUPPLEMENT**

I enclose payment of £23.97 (for one Manual) or £39.94 for both Manuals (saving another £8 by ordering both together) plus postage if applicable.

I also require the appropriate Supplements four times a year. These are billed separately and can be discontinued at any time. *(Please delete if not required.)*

Should I decide not to keep the Manual/s I will return it/them to you within 30 days for a full refund.

FULL NAME .....  
(PLEASE PRINT)

ADDRESS .....

.....POSTCODE .....

SIGNATURE .....

☐ I enclose cheque/PO payable to Wimborne Publishing Ltd.

☐ Please charge my Visa/Mastercard

Card No. .... Card Exp. Date .....

### ORDER FORM

Simply complete and return the order form with your payment to the following address:

**Wimborne Publishing Ltd, Dept. Y12, Allen House, East Borough, Wimborne, Dorset BH21 1PF**

**We offer a 30 day MONEY BACK GUARANTEE**

– if you are not happy with either Manual simply return it to us in good condition within 30 days for a full refund.

Overseas buyers do have to pay the overseas postage – see below.

### POSTAGE CHARGES

Postal Region	Price PER MANUAL	
	Surface	Air
Mainland UK	FREE	–
Scottish Highlands, UK Islands & Eire	£5.50 each	–
Europe (EU)	–	£20 each
Europe (Non-EU)	£20 each	£26 each
USA & Canada	£25 each	£33 each
Far East & Australasia	£31 each	£35 each
Rest of World	£25 each	£45 each

Please allow four working days for UK delivery.

NOTE: Surface mail can take over 10 weeks to some parts of the world. Each Manual weighs about 4kg when packed.

esm2

# New Technology Update

*Inkjet and optical technologies combine to provide greater comms bandwidth. Ian Poole reports.*

**T**HE telecommunications industry is one of the major growth areas in today's business arena. Increasing amounts of information are required and they are needed faster than ever before. Much of this has been fuelled by the phenomenal growth of the Internet, with applications like e-commerce and the transmission of audio and video providing ever-increasing levels of traffic.

Such is the growth that it has been predicted that the capacity required will have risen by a factor of thirty-six in the eight years from 1995.

## Optical Data Rates

Many of the transmission paths use optical technologies. New techniques like Dense Wavelength Division Multiplexing (DWDM) are being used more widely. In this, a single fibre is used to carry several channels, each having a different wavelength.

Optical fibre data rates are also increasing, with transmission speeds set to quadruple in the next two years. This will enable network builders to move from the existing backbones running at 10 Gigabits per second to 40 Gigabits.

To ensure that the required speeds can be met, many organisations are moving to all-optical networks. This alleviates a number of the problems found in mixed technology systems. It also gives additional levels of flexibility, for example allowing operators to lease a wavelength, whereby the entire wavelength channel is leased out to a user.

This gives the potential of desk-top to desk-top optical communications, which can be very attractive to the system provider as there could be many thousands of optical channels available within a single fibre.

## Switched Solution

To achieve these goals, optical devices need to be developed further. At the moment many are very expensive, but there are a number of developments that are under way that are likely to resolve many of the problems being encountered.

One of these areas is in optical switching, where Agilent (formerly the non-computer related areas of Hewlett Packard) have developed an optical switch. This uses a combination of inkjet activators and optical planar waveguides to give a simple and scalable optical switch with no moving parts.

Agilent's new switch is the N3565A, which provides a  $32 \times 32$  photonic switching platform. It innovatively uses inkjet printer technology, combined with planar

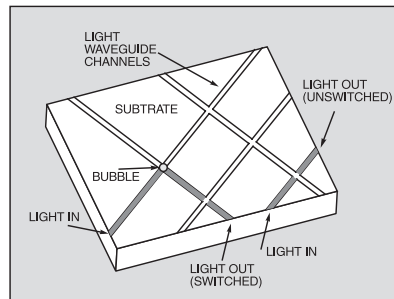


Fig.1. The light waveguide switching platform.

lightwave circuit technologies.

The switch consists of intersecting silica waveguides as shown in Fig.1. At each intersection a trench is etched into the waveguide. This is filled with a fluid that has a refractive index matching that of the light path, and accordingly it allows unimpeded transmission of the light across the intersection.

When a command to switch is issued, A bubble is created at the intersection and this causes the light to be reflected down the intersecting light path by total internal reflection (Fig.2). It is this bubble that is formed using inkjet printer technology.

## Switching Technique

Switching is performed using the piezo-electric actuators that are based on those found in inkjet printers. These are solid state devices that are comprised of a pump chamber, inlet mechanism and a bubble nozzle. When a voltage is applied to the piezo-electric actuator, it contracts and

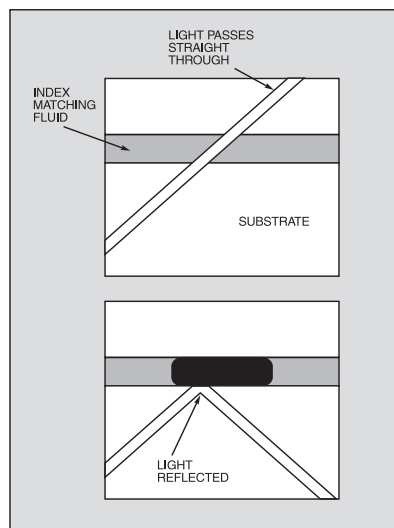


Fig.2. Principle of switching.

then relaxes when the voltage is removed. This action increases and then reduces the pump chamber volume, drawing in liquid and ejecting droplets under pulsed control.

Using this system, switching can occur in less than ten milliseconds, and this is sufficiently fast for the systems on which it is anticipated the switch will be used.

The absence of moving parts is the key to the reliability of the system. The inkjet elements have been switched many millions of times in tests and have been shown to be exceedingly reliable. Additionally, the fluid that is used is non-corrosive and stable, which are key elements in the reliability of the whole system.

## System Aspects

The basic principle can be used to create very large switching matrices that enable a considerable amount of flexibility to be introduced into optical data systems. Whilst there is about 5dB of loss from one fibre, through the switch, into the output fibre, for what is termed a wavelength selective cross-connect, this is quite acceptable, especially when it is compared to other technologies.

Crosstalk is surprisingly low at -50dB, demonstrating the very high level of isolation that is achieved. This is particularly important where large numbers of optical paths are switched, because if the levels were higher then it would also lead to high levels of interfering noise that would result in data errors.

## Future

This development is likely to achieve widespread use. It is flexible, cheap and effective. It shows that optical technology for data transmission can now be used even in small installations.

The development is also indicative of the growing use of optical technology. It has several advantages, even for the small user. Not only are much higher data rates possible than for an electrical wire system, but it also has greater immunity to electrical noise. For those interested in security, the optical fibres do not radiate the signals in the same way that wired systems do, thereby making eavesdropping much more difficult.

In view of all these advantages, many commentators anticipate that optical technology will grow considerably in importance in the coming years.

Further information about these optical switches can be found on the Agilent website at [www.agilent.com](http://www.agilent.com).

Information about radio and electronics in general can be found at [www.radio-](http://www.radio-)

# INTERFACE

Robert Penfold



## EXTENDED TEMPERATURE PC INTERFACE SOFTWARE

As pointed out in the past, this series is primarily concerned with the hardware side of add-on projects for PCs. However, without software the projects are of no use, and the software topics have to be considered from time to time.

Interestingly, it is the software that tends to bring the most feedback from readers. Over the last year software matters seem to have generated three or four times as many letters and E-mails as hardware related topics.

Some of the letters contain suggestions for better ways of doing things. Thanks to those who have made suggestions, some of which have been incorporated into the software featured in recent months.

Others are interested in using improved software to extend the capabilities of the projects featured in this series. Arrays and data logging is a topic that turns up from time to time, and is one that has not been covered significantly in this series.

### Arrays

Usually the software has to do nothing more than take a reading from a port, do some simple arithmetic on the returned value, and then display the value on the screen. This is achieved by storing the reading in a variable, doing any necessary mathematics with the result being stored back in the variable, and then writing the contents of the variable to the screen via a label or text box.

Data logging is more complex in that it requires what could be hundreds or even thousands of readings to be taken and stored in the computer's memory. The results can then be read via a text box, printed out, or presented on the screen in some graphic form.

Arrays are used to store blocks of data, and each element of an array is just a special form of variable. The exact way in which arrays are handled varies slightly from one programming language to another, but here we will consider the Visual BASIC 6 version, which is fairly typical.

Each element in an array has the same name, but a number in parentheses (brackets) follows this name. This number gives each element in the array a unique identity. In the normal scheme of things the numbering starts at 0 and goes up to the number that is specified when the array is dimensioned. In Visual BASIC you can declare variables or simply make them up as you go along.

This same flexibility is not available when using arrays, and they must be declared and dimensioned before they are used. By telling the programming

language the type of variable used in the array and the number of elements, it is then able to reserve a suitably sized block of memory to store the data.

### Going Public

When declaring variables and arrays in Visual BASIC it has to be borne in mind that there are public and private variables. If the declaration is made within a subroutine, the variable can only be used within that routine.

This can be very useful, but with interfacing software it is often the public version that is of more use. By declaring a variable outside a subroutine it becomes a public type that can be accessed by any part of the program. The following line, for example, would declare an array containing 100 elements, with each element an integer:

Dim Reading(99) As Integer

Note that there are 100 and not 99 cells in this array, because the numbering starts at 0 and not 1. In order to read a set of data into an array a loop is used, together with a variable that acts as a counter. For example, the followings routine would read the printer port data lines at address 888 one hundred times, placing the readings in the elements of the array called Reading:

Dim Reading(99) As Integer

Out 890,32

For Counter = 0 To 99

Reading(Counter) = Inp(888)

Next Counter

The first line dimensions the array, and the second one sets the printer port data

### Listing 1: Extended Temperature Interface Program

```
Dim Port1 As Integer
Dim Port2 As Integer
Dim Port3 As Integer
Dim Reading As Integer
Dim Counter As Integer
Dim Readings(99) As Integer

Private Sub Command1_Click()
    Port1 = 632
    Port2 = 633
    Port3 = 634
    Timer1.Enabled = True
End Sub

Private Sub Command2_Click()
    Port1 = 888
    Port2 = 889
    Port3 = 890
    Timer1.Enabled = True
End Sub

Private Sub Command3_Click()
    Label1.Caption = Readings(Text1.Text)
End Sub

Private Sub Form_Load()
    Counter = 0
End Sub

Private Sub Timer1_Timer()
    Out Port3, 1
    Out Port3, 3
    Out Port3, 2
    For D = 1 To 2000
        Next D
        Dta = Inp(Port2) And 8
        If Dta = 8 Then Reading = 128
        Else Reading = 0
        Out Port3, 3
        Out Port3, 2
        Dta = Inp(Port2) And 8
        If Dta = 8 Then Reading = Reading + 64
        Out Port3, 3
        Out Port3, 2
        Dta = Inp(Port2) And 8
        If Dta = 8 Then Reading = Reading + 32
        Out Port3, 3
        Out Port3, 2
        Dta = Inp(Port2) And 8
        If Dta = 8 Then Reading = Reading + 16
        Out Port3, 3
        Out Port3, 2
        Dta = Inp(Port2) And 8
        If Dta = 8 Then Reading = Reading + 8
        Out Port3, 3
        Out Port3, 2
        Dta = Inp(Port2) And 8
        If Dta = 8 Then Reading = Reading + 4
        Out Port3, 3
        Out Port3, 2
        Dta = Inp(Port2) And 8
        If Dta = 8 Then Reading = Reading + 2
        Out Port3, 3
        Out Port3, 2
        Dta = Inp(Port2) And 8
        If Dta = 8 Then Reading = Reading + 1
        Out Port3, 3
        Out Port3, 1
        Label1.Caption = Reading / 2
        Readings(Counter) = Reading / 2
        Counter = Counter + 1
        If Counter = 100 Then Label1.Caption = "STOPPED"
        If Counter = 100 Then Timer1.Enabled = False
    End Sub
```



lines as inputs. The port must obviously be a bidirectional type for this to work. Note that Visual BASIC does not have built-in Inp and Out commands, and that these must be added using **Inpout32.dll**, as described in previous *Interface* articles. The rest of the routine is a For...Next loop that executes 100 times, incrementing the variable called Counter from 0 to 99 in the process. Counter is used as the element number in the program line that reads the printer port and the result into the array.

Therefore, on the first loop the returned value is read into Reading(0), on the next it is placed into Reading(1), and so on until the value read from the port is placed in Reading(99) on the one hundredth loop.

### Perfect Timing

In practical applications the readings will usually have to be taken at regular intervals, and it may be necessary to have a substantial gap from one reading to the next. This could be achieved by adding a delay routine in the For...Next loop, but



Fig.1. Screen shot showing display text box window and READ "button".

with Visual BASIC the obvious way of handling things is to assign the routine that reads the port to a timer component.

Readings are then taken at whatever interval is used for the timer. The method used to obtain readings might be more complex than simply reading a port, but the basic method outlined here can still be applied.

Program Listing 1 is an extension of the thermometer program featured in the previous *Interface* article. It takes 100 temperature readings at one-second intervals and places them in an array. See the October 2000 issue for details of the Temperature Interface.

As in the original program, operating either the button marked H278 or the one captioned H378 selects the required base address and starts the timer. The routine that reads the analogue-to-digital converter is relatively long because the data is read one bit at a time and then reconstituted into an 8-bit value. However, once the final value has been obtained it is displayed on Label1 and placed in the array.

### Numbers Count

A variable called Counter is used to provide the element number, and this

variable is incremented by one each time the routine is performed. Eventually the value of Counter reaches 100, and the last line in the routine then switches off the timer so that no further readings are taken and stored. The penultimate line prints STOPPED on Label1 so that you know that things have come to a halt.

Once the data has been safely stored in an array the PC can manipulate it in a variety of ways. This program simply has a third button and a text box that enable individual samples to be displayed on the screen. Just type a number from 0 to 99 into the text box and then press the READ button. The relevant reading will then be displayed on Label1, as in the screen dump

that is shown in Fig.1.

There are plenty of other possibilities. The PC can be used to find and display the maximum and minimum readings, calculate and display various types of mean reading, and so on.

### Graphics

A modern PC is also well equipped to display various types of graph and chart. The following routine can be applied to a fourth command button, and it draws a simple graph on the screen once a set of readings have been taken. The form must be large enough to accommodate the graph, and the middle section that the graph occupies must be left free of other components.

```
Private Sub Command4_Click()
Counter = 0
T1 = 600
T2 = 660
For Loops = 0 To 98
Lft = Readings(Counter)
Counter2 = Counter + 1
Rght = Readings(Counter2)
Lft = Lft * 30
```

```
Rght = Rght * 30
Lft = Lft + 1000
Rght = Rght + 1000
Lft = 5000 - Lft
Rght = 5000 - Rght
Line (T1, Lft) - (T2, Rght)
Counter = Counter + 1
T1 = T1 + 60
T2 = T2 + 60
Next Loops
End Sub
```

An enlarged version of the program in action is depicted in the screen dump of Fig.2. Some simple calibration marks have been added to make it easier to interpret results.

The routine starts by setting three variables at their initial values. T1 and T2 are variables used to provide the X1 and X2 co-ordinates for each section of the graph. Counter is used to select the required element of the array, and is initially set at 0. The routine then goes into a For...Next loop that actually draws the graph.

The first and second readings are used to provide the Y1 and Y2 co-ordinates for the first section of the graph. Both require some mathematical manipulation in order to match up with the Visual BASIC co-ordinate system. Incidentally, the graphics area extends from 600,4000 at the bottom left corner to 6600,10000 at the top right hand corner.

A Line command is then used to actually draw the line, and this operates in much the same way as the QBASIC Line command. Counter is then incremented by 1, and T1 plus T2 are incremented by 60 (one second's worth of co-ordinates). The loop causes this process to be repeated a further 98 times until all 99 sections of the graph have been completed.

The routines provided here are quite basic, and do not contain any error trapping for example. However, they do demonstrate that reading data into an array is very straightforward. Processing the captured data and displaying it on the screen in various ways is then just a matter of using conventional programming techniques.

### On Disk

Should you wish to experiment with them, the source files for the graph program are available on the *EPE* web site, as is the compiled version of the program. It is also available on the *EPE Interface* Disk 1, see *EPE PCB Service* page elsewhere in this issue for details.



*Our*  
**Hot  
 Rods**  
*won't burn a hole  
 in your pocket*

**ANTEX**

**NOT JUST ANY OLD IRON**

Antex have a great track record of offering high quality soldering irons at a low price. So race off with a 'fixed temperature' iron or take the 'In Handle' temperature controlled model for a burn.

Both offer total safety with a choice of a PVC or burn-proof silicone lead, and every model has been manufactured in the UK and meets CE conformity.

And with Antex you get loads of extras from a wide variety of long life bits to state-of-the art soldering stations.

So visit our web site or your electronics retailer and take one for a test drive



**YOU CAN NOW BUY ANTEX EQUIPMENT ON-LINE**  
 ALL SOLDERING IRONS PURCHASED ON-LINE BEFORE  
 CHRISTMAS WILL RECEIVE A FREE DESOLDER PUMP

**www.antex.co.uk**



**A COMPLETE RANGE OF  
 INVERTERS**

**150W TO 1000W - 12V & 24V**

A Complete range of regulated inverters to power 220V and 240V AC equipment via a car, lorry or boat battery. Due to their high performance (>90%) the inverters generate very little heat. The high stability of the output frequency (+/-1%) makes them equally suitable to power sensitive devices.

These inverters generate a modified sine wave, which are considerably superior to the square waves which are produced by most other inverters. Due to this superior feature they are capable of powering electrical equipment such as TV's, videos, microwave ovens, electrical lamps, pumps, battery chargers, etc.

**Low Battery Alarm**

The inverters give an audible warning signal when the battery voltage is lower than 10.5V (21V for the 24V version). The inverter automatically shuts off when the battery voltage drops below 10V (20V for the 24V version). Fuse protected input circuitry.

Order Code	Power	Voltage	Price
651.581	150W Continuous	12V	£38.49
651.578	150W Continuous	24V	£38.49
651.582	300W Continuous	12V	£54.36
651.585	300W Continuous	24V	£54.36
651.583	600W Continuous	12V	£118.42
651.593	600W Continuous	24V	£118.42
651.587	1000W Continuous	12V	£174.60
651.597	1000W Continuous	24V	£174.60

**All prices are inclusive of V.A.T. Carriage £6.00 Per Order**

**Many uses include:-** \* Fetes \* Fairgrounds \* Airshows \* Picnics \* Camping \* Caravans \* Boats \* Carnivals \* Field Research and \* Amateur Radio field days.



**ILLUSTRATION SHOWN IS 651.583 600W VERSION**

**DELIVERY CHARGES ARE £6.00 PER ORDER. OFFICIAL ORDERS FROM SCHOOLS, COLLEGES, GOVT. BODIES, PLC'S ETC. PRICES ARE INCLUSIVE OF V.A.T. SALES COUNTER. VISA AND ACCESS ACCEPTED BY POST, PHONE OR FAX, OR EMAIL US AT SALES@BKELEC.COM ALTERNATIVELY SEND CHEQUE OR POSTAL ORDERS MADE PAYABLE TO BK ELECTRONICS.**



**B.K. ELECTRONICS**



UNIT 1, COMET WAY, SOUTHEND-ON-SEA, ESSEX. SS2 6TR  
 TEL.: +44(0)1702-527572 FAX.: +44(0)1702-420243

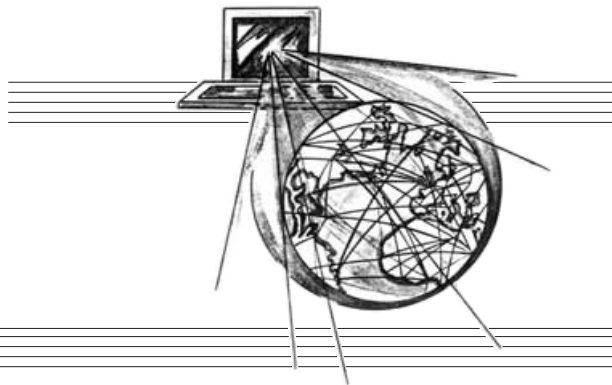
**For Full Specifications View our web site at:-**

**WWW.BKELEC.COM/INVERTERS.HTM**

# SURFING THE INTERNET

## NET WORK

ALAN WINSTANLEY



ONE of the downsides of writing a column dated several months ahead of reality is that it doesn't half make time fly. Here I am in early October already writing for the December 2000 issue, with the year 2001 arriving "next month"! This year started on an optimistic note, with promises of unmetered Internet access and broadband services wetting our appetites. Spring 2000 saw the attempt by Alta Vista UK to pre-empt the market by promising an unmetered package. Other unmetered tariffs have come and gone since then, all of them proving a financial drain for their operators, or in the case of Ezesurf, ruining them altogether.

Freeserve ([www.freeserve.net](http://www.freeserve.net)) was amongst the very first to offer BT Surftime unmetered tariffs in Summer 2000, but has gone underground with its advertising, apparently having been heavily subscribed, even more so when other users, finding themselves turfed off other failed unmetered packages, migrated to Freeserve instead. Users were soon complaining of slow connections, engaged tones and poor bandwidth as the networks creaked under the strain.

### On the Hog

Predictably, a minority of Freeserve incumbents decided to hog some lines to themselves, therefore spoiling the show for everyone else. More than 750 customers have since been served with a month's written notice because of their disproportionate drain – said to be up to 10% – on Freeserve's bandwidth.

The UK Consumer's Association said in October: "ISPs offering an unmetered service have seemed more interested in increasing their customer numbers than in delivering the services that consumers were originally promised when they signed up."

"Recent press reports suggesting that Freeserve would withdraw its unmetered access service from heavy users seems like another example of an unmetered offer that can't live up to the hype. If Freeserve has found itself caught out by the heavy usage of its customers it should accept its share of the blame."

"The ISPs have got themselves into a mess" says the CA. "Rather than luring consumers in and then kicking them off schemes, what is needed on their part is better planning, realistic projections of customer usage and clearer advertising for new schemes."

However, no ISP can reasonably cater for, say, a quarter of a million users all suddenly commandeering a cheap leased line 24x7, because the capacity just isn't there and probably never will be. Expectations are still running unrealistically high on both sides: consumers demand "excessive" levels of bandwidth on the cheap, and ISPs hope their customers will show restraint when using it.

### The times are a'changing

I decided the time was ripe to review my Internet provision, if only to see what could be done to bring the cost down from its interstellar trajectory. I soon saw that confusion marketing reigned supreme. I started by checking my regular ISP, Demon Internet, who pioneered the flat-rate "TAM" (tenner-a-month) account in the early 1990's. Recently Demon felt sufficiently moved to incorporate a BT Surftime package, the idea being that the BT portion of the cost would be charged directly to your phone bill to provide for unmetered tariffs.

Under Surftime the standard TAM account will then benefit from reduced call costs – 2p/minute daytimes, 0-6p evenings, 0-5p weekends. For its proposed evenings and weekends package, Demon offers the standard Surftime £5.99 monthly rate paid direct to BT. This provides 100 per cent discount on all evening and weekend Internet calls, remembering Demon's £11.75 monthly subscription is extra.

Demon also proposes an enhanced package called *Premier Connect Plus* which costs nearly twice the standard account rate.

For a monthly sum of £19.99, the Surftime numbers can be used throughout the working day as well as during evenings and weekends. Under this package, call costs drop to 1p/min. weekday daytimes, 0-6p evenings and 0-5p weekends.

Demon continues: "Again, if you make a fixed extra payment to BT (a further £19.99 per month) you can get a 100 per cent discount on some or all of your Surftime calls so that they become 'free'. . . or you can pay £5.99 per month to cover evening and weekend calls only." Demon puts a price of £119.94 (\$167) per quarter on 100 per cent unmetered access. This service was due to roll out on 9 October.

This typifies the sort of stuff most users have to grapple with when comparing the best deals. Your cable operator may have packages comparable with any BT service (*ntl* hasn't replied to my query about cable modems). Personally, I sought a credible Surftime ISP offering a reasonable compromise to help slash daytime access costs, and maybe provide free calls in the evening and weekends.

As mentioned in previous columns, the choice of Surftime-enabled ISPs listed on BT's web site is meagre. A glitch with my Demon dial-in access – Demon changed their access software which rendered my modem obsolete – finally caused me to start shopping around.

Enter an ISP which bowed out from offering unmetered access earlier this year: LineOne ([www.lineone.net](http://www.lineone.net)). Their new Surftime tariff is simple and to the point: for a fee of £9.99 added to your phone bill – £5.99 is BT's Surftime evening and weekend portion, £4 is LineOne's ISP subscription – I could enjoy 1p a minute during the business daytime and completely free access during the evenings and weekends.

LineOne's on-line sign-up was soon completed and three days later an E-mail confirmed that my BT account had been updated for LineOne Surftime. This will cost £29.97 per quarter including VAT. Quickly dialling in via the new 0844 number, I was soon in business at 1p/minute or completely free altogether, and have high hopes of dramatically cutting costs. Note that LineOne telephone support costs 50p/minute, whilst Demon's is free, but this won't worry proficient users.

### On your bike, ET

I was feeling quite pleased at this point. However, there's just enough room left this month to describe a perverse coincidence which rained on my parade. On the very same day I started to celebrate new lower prices, I spied a BT engineer shinning up the telegraph pole outside. In giving a neighbour a second line, the engineer did something to my own Internet access line which has resulted in my line speed being crippled to 33-6Kbps maximum, and it now takes several noisy attempts of my new modem to access any ISP at all, and connection speeds are suddenly 40 per cent slower.

This has all the makings of having a phone line "DACSeD" (Digital Access Carrier Service), multiplexing two signals down a copper wire where no new circuits are available, to channel two phone lines down one wire. It's a common BT trick.

A maximum line speed of 33-6K every time is a dead give-away that something is wrong, but my problem makes no sense as two separate properties are involved. I have already had the "we don't guarantee any modem speeds down a voice line" argument with several unsympathetic BT reps.

I am therefore, at a single stroke, back to the sort of line speed I endured half a decade ago. British Telecom uses E.T. the Extra Terrestrial as their TV advertising mascot and I can tell you that at the time of writing, I am more incandescent than E.T.'s finger-end.

You can E-mail me at [alan@epemag.demon.co.uk](mailto:alan@epemag.demon.co.uk). See you next month.



# Constructional Project

# MOTORISTS'

# BUZZ-BOX



**TERRY de VAUX-BALBIRNIE**

*A multi-purpose test instrument for the intrepid car owner.*

It also provides a "crank test". This gives a battery "goodness" check by measuring the voltage under the heavy load over the starter motor.

**T**HIS easy-build Buzz-Box is a test instrument having six useful functions. It would be ideal for anyone involved with fitting car accessories and for checking bulbs, fuses, switches, ignition leads and "earth" points. Since the unit receives power from the car electrical system, it does not need any internal batteries so will always be ready to use.

One particular advantage of this circuit is that most of the tests are provided by audible signals. This means that the user can concentrate on the task in hand without having to look at a display!

## NEGATIVE ONLY

The Buzz-Box is suitable only for vehicles having a 12V *negative earth* system. That is, the negative terminal of the car battery is connected directly to the vehicle's metal structure ("earth" or "ground"). It is usual for the car body to provide the return path for the various circuits and this saves a lot of wiring.

Practically all cars in use today use the negative earth system although certain old models are "positive earth" (where the positive terminal of the battery is connected to the chassis). It is a simple matter to check this point if in doubt. **Damage will be caused to the unit if it is connected with incorrect polarity.**

## OVERVIEW

The instrument is built in a small plastic box. On top there is a meter, a rotary control with scale, a pair of terminals, pair of sockets and two metal contact "rails" (see photograph). On the side, there is a further socket which accepts a test meter type probe. A long piece of twin wire is used to connect the unit to the car cigar lighter socket for powering it.

The Buzz-Box provides the following functions:

**1. Earth Test.** When the probe is applied to some point which has a small resistance with respect to the car chassis, an internal buzzer will emit a short bleep. This will be found useful for finding a good "earth" point when wiring an accessory or for checking the quality of an existing connection. Rust at a securing screw is a common problem and will result in increased resistance.



**2. 12V Test.** When the probe is touched on to some point which is within approximately 300mV of supply voltage (nominally 11.7V), the buzzer will emit a long bleep.

**3. Low Resistance Test (20 $\Omega$ ).** When the terminals of a low-resistance component bridge the test rails, the buzzer will sound continuously providing its resistance lies between zero and 20 ohms approximately. Several items associated with the car electrical system have near-zero resistance. Examples include fuses, pieces of wire and "closed" switch contacts.

However, the "cold" resistance of a low-power bulb may exceed ten ohms. A facility for giving a bleep with a resistance less than 20 ohms or thereabouts is therefore useful. This may be used as a quick "continuity" check on any low-resistance item.

**4. Ignition Lead Test (Hi-R).** The lead is connected to the Hi-R (high resistance) test position. The knob on the rotary control is turned until the buzzer just sounds and the resistance read off on a scale from ten kilohms (10k $\Omega$ ) to 50 kilohms (50k $\Omega$ ).

**5. Battery Voltmeter.** While the unit is connected to the car system, a narrow-scale analogue meter gives a read-out of the battery voltage from 10V to 14V. This may be used to check the charge state of the battery.

**6. Loudspeaker Test.** When loudspeaker leads are connected to the terminals, the loudspeaker will emit an audible tone. This is useful when it is not known which set of loudspeaker leads is which. It will also identify faulty units and connections. *Note that this test does not determine how well the loudspeaker is working.*

In order to set up the voltmeter section at the end of construction, you will need brief access to a good-quality test meter.

Since the circuit receives current from the car system, the 0V line will be automatically connected to the car chassis through the low resistance of the feed wire. The positive line will be at whatever voltage exists across the car battery terminals. This will be approximately 12V but will vary to some extent depending on the state of charge of the battery.

## HOW IT WORKS

The full circuit diagram for the Motorists' Buzz-Box is shown in Fig.1. In the descriptions which follow, the supply voltage is assumed to be 12V. However, it turns out that the exact value of the voltage (within operating limits) does not matter and this point will be explained later.

Note that there is *no* reverse-polarity protection provided. This would introduce

a voltage drop which would interfere with correct operation of the circuit.

However, providing the unit is correctly wired to the cigar lighter plug, the circuit cannot be connected incorrectly. Fuse FS1 provides some protection against overheating if a short-circuit were to occur. However, it does not provide any protection against reverse-polarity.

## DOWN TO EARTH

The "earth test" centres around IC1a which is one section of quad op.amp (operational amplifier), IC1. This contains four identical units – the other three are associated with other tests.

The non-inverting input (pin 3) of IC1a is connected to a potential divider having fixed resistor R1 as the top arm. Resistor R2 appears in series with the resistance between the probe and the 0V line. This is labelled "R" (the "earth resistance") in Fig.1. Resistor R2 and R form the lower arm of the potential divider.

It will be noted that resistors R7 and R8 connected in series, appear in parallel with

R. When the probe is connected to an earth point there will be only a very small resistance between itself and the 0V line so the effect of resistors R7 and R8 (having a combined resistance much higher than R) is negligible.

When the probe is left unconnected, the non-inverting input (pin 3) will be at 9.7V approximately. This is due to the potential divider which now consists of resistor R1 in the top arm and R2 in series with R7 and R8 in the lower one.

When the probe is connected to an "earth" point, R will have a very low value. Assume for the moment that this is zero. The upper and lower arms of the potential divider connected to IC1a non-inverting input will now be equal. The voltage here will then be one-half that of the supply – that is, 6V approximately.

However, if the earth resistance was, say, 0.5 ohm the lower arm would have a greater resistance than the upper one. In this case, calculation shows that the voltage at IC1a non-inverting input would be 6.03V, 30mV more than before.

## POTENTIALLY MORE

The inverting input of IC1a (pin 2) is also connected to a potential divider. This comprises resistor R3 (the top arm) and the network of resistors R4, R5 and preset potentiometer VR1 connected in series (the bottom one). When preset VR1 is set to minimum, the voltage at the inverting input will be 5.8V and when at maximum, 6.1V approximately.

By adjusting preset VR1 at the end of construction, the inverting input voltage can be made to exceed that at the non-inverting one when R is between zero and some chosen value. The op.amp will then have its output (pin 1) low.

Some adjustment is needed to provide the required "low" point taking account of component tolerances and the resistance already existing in the connecting wires. In the prototype unit, the low point was set at 0.3 ohm approximately.

With the probe unconnected, the voltage at IC1a pin 3 (9.7V) exceeds that at pin 2 (6V approx.) so the op.amp output is high. This has no further effect.

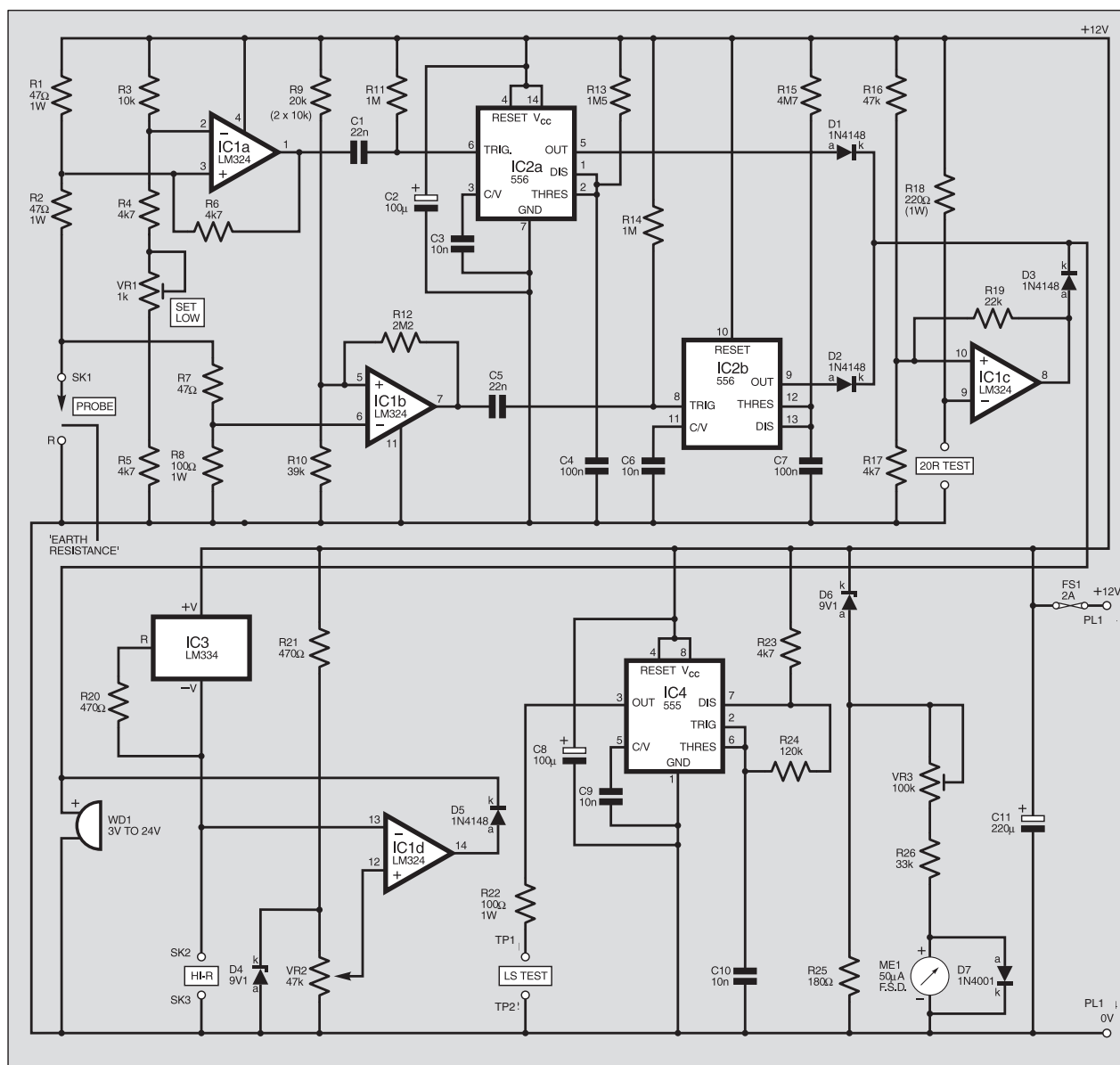


Fig.1. Complete circuit diagram for the Motorists' Buzz-Box. Note that some resistors must be rated at 1W.

## GOOD ENOUGH!

When the probe detects a sufficiently "good" (that is, low resistance) earth point, the low logic state of IC1a output (pin 1) applies a short duration low pulse to IC2a pin 6 (the trigger input) via capacitor C1. IC2 is a dual timer with both sections, IC2a and IC2b configured as monostables.

In the case of IC2a, the time period is set by the value of resistor R13 and capacitor C4 and with those used here, it will be rather less than 0.2 second. During this time, the output (pin 5) goes high then reverts to low. While high, current flows through diode D1 to buzzer WD1, which gives a *short* bleep.

Resistor R11 maintains IC2a pin 6 in a high state in the absence of a trigger pulse and this prevents false operation. Resistor R6 applies a little positive feedback to the op.amp (IC1a) system and this sharpens the switching action.

## 12 VOLT TEST

For the 12V Test, op.amp IC1b (another section of quad op.amp, IC1) and IC2b (the other section of dual timer IC2) are used. It will be noted that the same probe is used for both the "Earth" and "12V" tests and this is particularly convenient when making checks.

The action of the 12V test is best described by considering what voltage exists at IC1b inverting input (pin 6) when the probe is (a) connected to a point at +12V, (b) unconnected and (c) when connected to 0V (that is, while performing an earth test).

In the case of (a), IC1b pin 6 may be considered to be connected to a potential divider having resistors R7 in the upper arm and R8 in the lower one (remembering that the top end of R7 is now connected to +12V). This gives a voltage of 8.16V.

In the case of (b) pin 6 is connected to the potential divider comprising resistors R1, R2 and R7 in series in the upper arm and R8 in the lower one. This provides a voltage of almost 5V. In the case of (c) the top end of R7 and the bottom end of R8 are both connected to 0V so the voltage at pin 6 is zero.

## MORE POTENTIAL

The non-inverting input of IC1b is connected to another potential divider comprising resistor R9 in the upper arm and R10 in the lower one. With the values specified, the voltage applied to this input will be 7.93V.

If the probe is touched on a point within about 0.3V of the positive supply voltage, the inverting input voltage will exceed the non-inverting one. The output at pin 7 will then go low. This low state is applied, via capacitor C5, to the trigger input (pin 8) of the monostable based on IC2b.

The time period of this section is related to the values of resistor R15 and capacitor C7, and with those specified it will be 0.5 second approximately. During this time, the output at pin 9 goes high and current passes via diode D2 to the buzzer. This then emits a *long* bleep.

The trigger input at pin 8 of IC2b is maintained in a normally-high state using resistor R14. Resistor R12 provides a little positive feedback to op.amp IC1b and this sharpens the switching action.

## COMPONENTS

Approx. Cost  
Guidance Only  
excluding case & meter

£15

### Resistors

R1, R2	47Ω 1W (2 off)
R3	10k
R4 to R6,	
R17, R23	4k7 (5 off)
R7	47Ω
R8, R22	100Ω 1W (2 off)
R9	20k (2 off 10k units – see text).
R10	39k
R11, R14	1M (2 off)
R12	2M2
R13	1M5
R15	4M7
R16	47k
R18	220Ω 1 watt
R19	22k
R20, R21	470Ω (2 off)
R24	120k
R25	180Ω
R26	33k

Plus 0.22W test resistor – see test. Also 10kΩ and 47kΩ test resistors.

All resistors, apart from the 0.22Ω test resistor, are of the 1% metal film type. Unless otherwise indicated, they should be rated at 0.6W. The 0.22Ω test resistor may be of any type.

### Potentiometers

VR1	1k min. preset, vert.
VR2	47k min. rotary carbon, lin.
VR3	100k min. preset, vert.

### Capacitors

C1, C5	22n polyester, 5mm pin spacing (2 off)
C2, C8	100μ radial elect. 25V (2 off)

See  
SHOP  
TALK  
page

C3, C6	
C9, C10	10n polyester, 5mm pin spacing (4 off)
C4, C7	100n polyester, 5mm pin spacing (2 off)
C11	220μ radial elect. 25V

### Semiconductors

D1 to D3,	1N4148 signal diode (4 off)
D5	
D4, D6	9V1 Zener diode (2 off)
D7	1N4001 50V 1A rect. diode
IC1	LM324N dual op.amp
IC2	556N dual timer
IC3	LM334N adjustable current source
IC4	555 timer

### Miscellaneous

ME1	50μA full-scale deflection (f.s.d.), moving coil panel meter – see text
SK1, SK2,	4mm chassis sockets (3 off) matching plugs (2 off) – see text.
SK3	
TP1, TP2	small terminal posts (2 off)

Printed circuit board available from the *EPE PCB Service*, code 278; plastic box, size 150mm x 100mm x 60mm external; 8-pin d.i.l. socket; 14-pin d.i.l. socket (2 off); test meter probe to fit SK1; screw terminals (2 off); 5A terminal block (2 sections); 5A flexible twin wire (or ready-made cigar lighter extension lead (PL1)) – see text; materials for test rails; strain relief bush; control knob for VR2; self-adhesive p.c.b. stand-off pillar (2 off); solder etc.

## TWENTY OHM TEST

The 20 Ohm Test or "low resistance test" is centred on IC1c, the third section of quad op.amp IC1. The non-inverting input (pin 10) is held at a potential of just over 1V due to the potential divider R16/R17. The inverting input (pin 9) is held at +12V due to resistor R18.

The metal rails on top of the unit form the "20R test" position. When a low-resistance item bridges the rails, this becomes the lower arm of a potential divider with resistor R18 as the upper one.

If the component on test has a resistance less than 22 ohms approximately, the inverting input voltage will fall below that at the non-inverting one. The output at IC1c pin 8 will then go high. The high state will pass, via diode D3, to the buzzer, which will sound.

When the test position is not occupied, the inverting input voltage exceeds the non-inverting one and the output will be low. This state is blocked by diode D3 and has no effect.

Timer IC2 is a robust bipolar device. It needs small-value capacitors connected between the control voltage pins (pin 3 and pin 11) and the 0V line (C3 and C6 respectively). Also, because momentary large current "spikes" occur on the supply rails, capacitor C2 is included to provide a charge reservoir.

In the Earth Test, 12V Test and 20 Ohm Test, both inputs of the op.amp involved

have applied voltages which are derived from potential dividers. These are connected to the same supply lines. Thus, as the supply voltage rises or falls, the voltages at both op.amp inputs will rise or fall in sympathy. It, therefore, does not matter what battery voltage actually exists within operating limits.

## TAKING THE LEAD

Ignition leads have a relatively high resistance and this is built into the design to suppress RFI (radio-frequency interference). This would otherwise cause severe noise in the loudspeaker connected to audio equipment and it would even affect radios in nearby cars.

The voltage used in the ignition system is very high (tens of kilovolts) so the relatively high resistance of the leads still enables sufficient current to flow to provide an effective spark at each plug gap.

However, if the resistance rises too much mis-firing occurs. This usually varies with factors such as engine speed and load. If the lead becomes open-circuit, the corresponding cylinder will not fire at all. Any such faults will play havoc with a catalytic converter.

Unfortunately, problems with ignition leads are fairly common so some means of quickly measuring their resistance is useful. This enables the user to check how the resistance of the various leads compare and to determine whether or not they fall within



manufactures' tolerances if this data is available. By "wiggling" the leads as the tests are made, it is possible to check for intermittent faults.

The High Resistance test is centred on IC1d, the fourth section of the quad op.amp. The lead is connected between the inverting input, pin 13, and the 0V line. A fixed current is now passed through it from the adjustable current source device IC3. This is programmed using resistor R20 and with the specified value, will be some  $140\mu\text{A}$ .

With a constant current flowing through the lead, the voltage across its ends will be proportional to its resistance. It turns out that with a resistance of  $64\text{k}\Omega$ , the voltage across it will be nearly 9V and, of course, with zero ohms it is 0V. With no lead connected, virtually no current flows so IC3 obviously cannot maintain its regulation. However, this is of no consequence.

## RESISTANCE TRACKING

Operational amplifier IC1d non-inverting input (pin 12) is connected to the sliding contact of panel-mounted potentiometer VR2. The track is connected in series with fixed resistor R21 across the supply.

Zener diode D4 operates in conjunction with R21 to provide a stable 9.1V (regarded as 9V) across VR2 track despite changes in supply voltage (down to around 9.5V). The difference between these two voltages appears across resistor R21. Since VR2 is a linear device, its angle of rotation will be approximately proportional to the voltage at the sliding contact rising from zero to 9V.

With the ignition lead in "Hi-R" position, VR2 control knob is slowly rotated. At some point, the voltage at the non-inverting input will exceed that at the inverting one. The output at pin 14 of IC1d will then go high and provide a feed to the buzzer WD1 through diode D5.

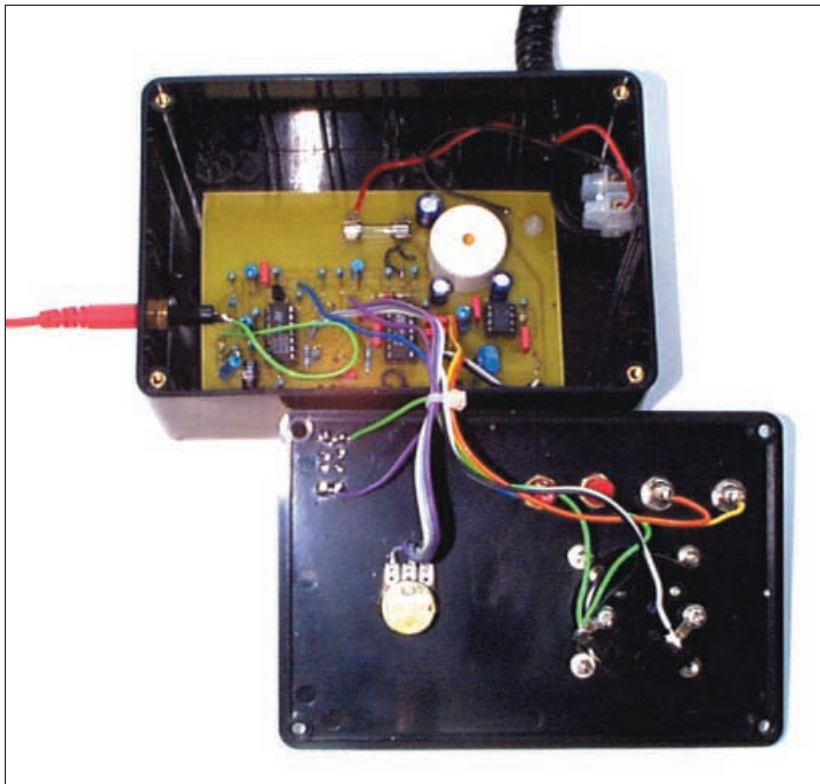
By adjusting the control knob, the position can be found where the buzzer just sounds. The resistance of the lead may then be read off a scale. Marking the scale 0 to  $50\text{k}\Omega$  (50 kilohms) is a simple matter and will be carried out at the end.

## LOUDSPEAKER TEST

For the Loudspeaker Test a single 555 timer, IC4, is used. This is of the same type as the dual unit used for IC2. However, here it is configured as an astable. Thus, as long as a supply exists, the output at pin 3 of IC4 will provide a continuous train of on-off pulses.

The output from IC4 pin 3 is connected to one of the loudspeaker terminals (TP1), via resistor R22, while the other one (TP2) is connected to 0V. Providing the pulse frequency lies within the audible range, a loudspeaker connected to the terminals will produce a sound. Remembering the description of IC2, capacitor C9 is the control voltage capacitor and C8 provides a charge reservoir.

The components which determine the pulse frequency are resistors R23, R24 and capacitor C10. Using the specified values, this frequency will be 600Hz approximately. The ears are sensitive to this frequency and the loudspeaker will reproduce the sound well.



Layout of components inside the plastic box and wiring to components mounted on the lid.

Because the signal is a simple square wave, the power has been kept low to prevent possible damage. This is the reason for including resistor R22 in series with the output. This limits the peak current to 120mA or thereabouts.

*This is not a precision signal designed to assess the performance of the loudspeaker. It is used simply to find which pair of leads is which and to identify non-working units, loose connections and so on.*

## VOLTMETER

The read-out of the supply voltage is provided by panel meter ME1. This is scaled 0 to  $50\mu\text{A}$  but it is modified to show a d.c. range voltage from 10V to 14V.

The supply is connected to a 9.1V (regarded as 9V) Zener diode, D6, connected in series with fixed resistor R25. As long as the supply is a little more than the Zener breakdown voltage, the diode will conduct and this voltage will appear across it. The difference between the supply voltage and 9V will then appear across R25.

If the supply voltage is less than the Zener breakdown voltage, the diode will not conduct and therefore the voltage across resistor R25 will be zero. With a supply voltage of 14V (the maximum value in practice), the voltage across R25 will be 5V.

Meter ME1 operates in conjunction with preset potentiometer VR3 and fixed resistor R26 to provide a voltmeter having a full-scale reading of 14V. With an applied voltage less than about 9.5V, it will read zero.

The region between 9V and 10V must be regarded as a "grey area". This depends on exactly when the Zener diode begins to conduct. Also, at the beginning it does not do this sharply.

Values below 10V are therefore not known with any accuracy. At 10V the Zener diode will be behaving as it should and the scale after that will be more-or-less linear (equal changes in voltage producing equal steps on the scale). This is why there is space between the rest position of the pointer and 10V (see photograph).

## METER CHOICE

The values of components have been chosen for a meter having a full-scale deflection of  $50\mu\text{A}$  (although a  $100\mu\text{A}$  unit would also work). Preset VR3 will be adjusted to give the correct full-scale reading at the end of construction. The internal resistance of the meter itself will be a few kilohms. However, the exact value does not matter because it is taken into account when VR3 is adjusted.

Diode D7 is connected in parallel with the meter movement as a protection device. Thus, if due to a fault an excessive current would otherwise flow through the meter, the voltage across it would be limited to 0.7V approximately (the forward voltage drop).

Normally, a smaller voltage than this exists across the meter (with the specified device carrying  $50\mu\text{A}$  it is about 0.2V). Under normal conditions, therefore, the diode will have no effect. Under fault conditions, the current will be around  $200\mu\text{A}$  but the meter will probably not be damaged.

## CONSTRUCTION

Construction is based on a single-sided printed circuit board (p.c.b.). The topside component layout and full size underside copper track foil master are shown in Fig. 2. This board is available from the EPE PCB Service, code 278.

Begin construction by drilling the two fixing holes then solder the sockets for IC1, IC2 and IC4 in position (but do not insert the i.c.s themselves yet). Solder the fuse clips in place. If these are not available, you could use a small fuse block instead. If necessary, this could be mounted off board and hard-wired to the FS1 points on the p.c.b. later. Solder in position the single link wire, just above IC2 socket.

Add all resistors and the preset potentiometers. Note that some of the fixed resistors *must* have a power rating of one watt minimum. This is because they can become quite warm in prolonged tests.

Although five per cent tolerance would be sufficient for some of the resistors, some must have a tolerance of one per cent. To avoid confusion, one per cent tolerance resistors have therefore been specified throughout.

Resistor R9 must have a value of 20k $\Omega$ . It will probably be easier to use two 10k $\Omega$  units connected in series. Space has been left for two such resistors on the p.c.b. Note that they are *both* labelled R9 on the component layout, Fig.2.

Solder the capacitors in place. It is essential to place the electrolytic

capacitors – C2, C8 and C11 – with the correct polarity. Solder all diodes in position taking care over their polarity, noting particularly the orientation of Zener diodes (D4 and D6). Add the audible warning device (WD1), taking note of its polarity (which is marked on top).

Next, solder 15cm pieces of light-duty stranded connecting wire to the following points on the p.c.b.: +12V; 0V; ME1 (2 off); VR2 (3 off); Probe; TP1; TP2; HI-R and 20 $\Omega$ . By using different coloured wires (pieces of “rainbow” ribbon cable), problems will be avoided later.

Solder IC3 in position (the flat face is towards the left-hand side of the p.c.b.) keeping its end leads at least 5mm in length. Solder it quickly to avoid damage. If necessary, use a simple heat shunt – this may be nothing more than a pair of fine-nose pliers. These are used to grip each lead between the body of the device and the p.c.b. as it is soldered.

### BOXING-UP

Begin the boxing-up procedure by making the holes for the meter. Mark out the large one and the small fixing ones using

the template supplied with it. The large hole can be made by drilling a series of small holes around the outline. These are then joined together using a small hacksaw blade. The holes will be covered by the meter face so there is no point in trying to make a perfect job.

Place the p.c.b. in position on the base of the box. Mark through the fixing holes. Remove the p.c.b. and drill these through.

Decide on positions and drill holes for VR2 bush, also for terminals TP1/TP2 (for the loudspeaker test) and sockets SK2/SK3 (for the Hi-R test). Place the control knob on the potentiometer spindle and measure how much needs to be cut off. Mark this, remove the knob and cut off the excess using a small hacksaw.

While doing this, hold the spindle (not the potentiometer body) in the vice. *Gripping the body of the device is likely to damage it.* File the cut edge smooth.

Place the potentiometer bush through its hole and secure it loosely. Mark a suitable position for the anti-rotation lug on the inside. Remove the potentiometer again and drill a small hole to be a tight fit with the lug.

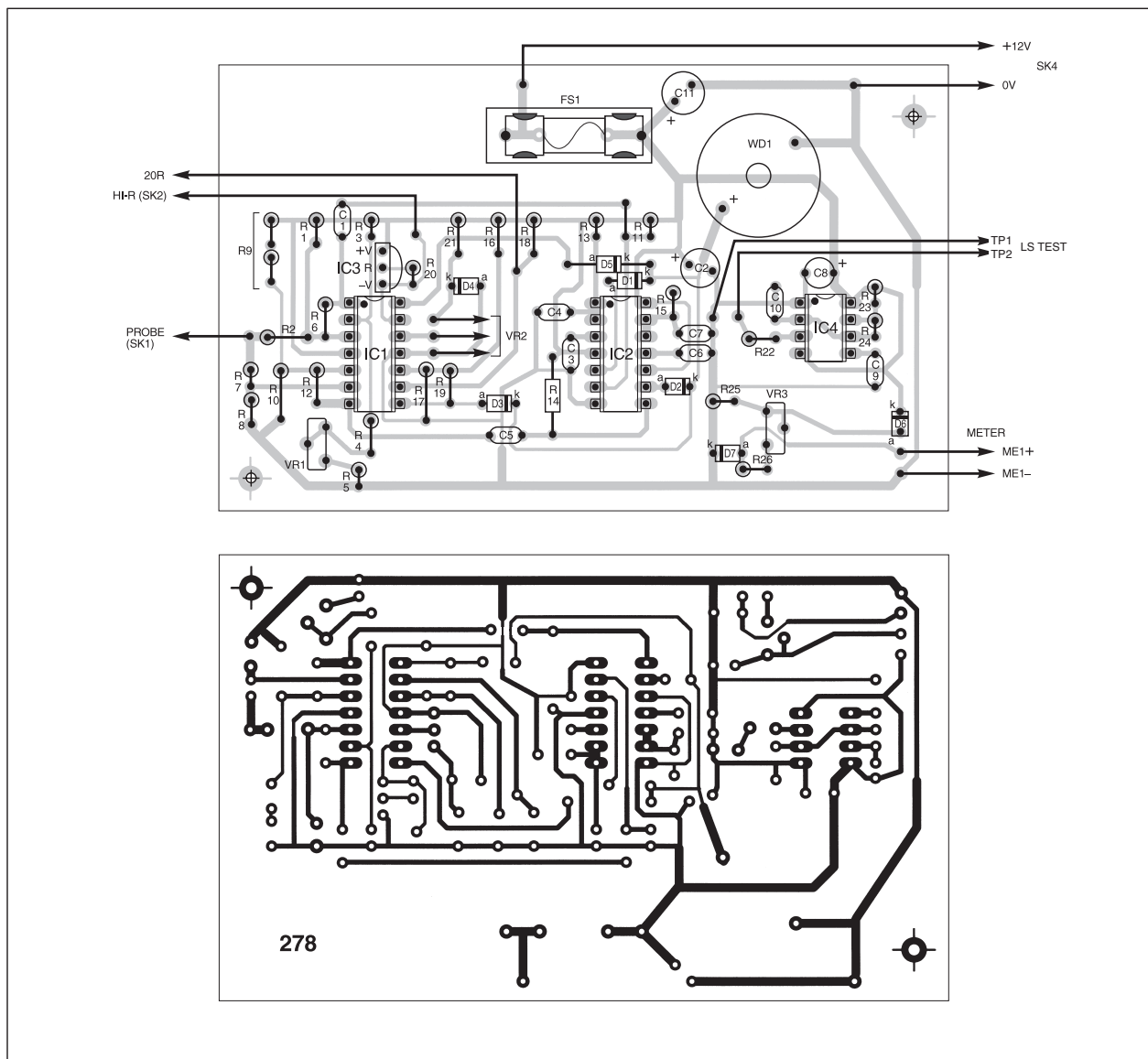
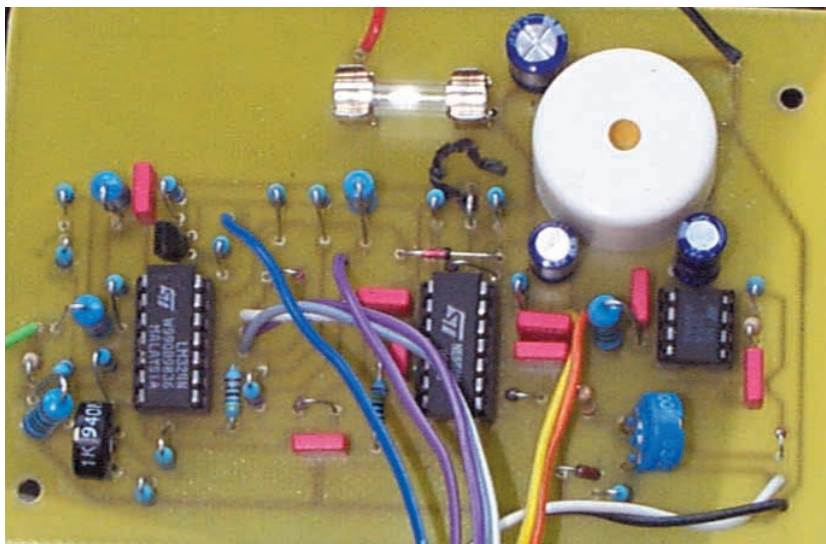


Fig.2. Printed circuit board topside component layout and full-size copper foil master for the Motorists' Buzz-Box.



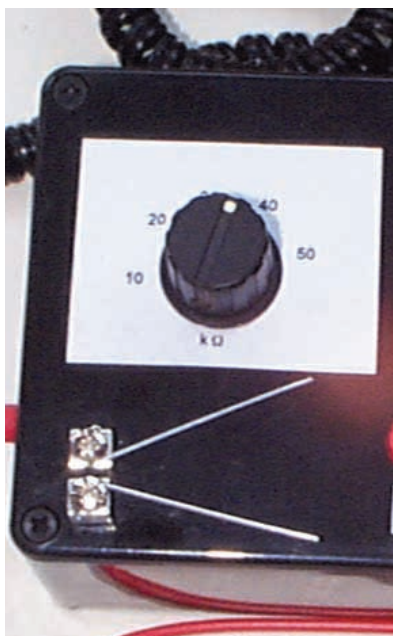
Completed prototype circuit board. Use different coloured wires (rainbow ribbon cable) to ease identification.

Drill the hole for probe the socket, SK1, in one side panel of the box and attach it. Drill a hole in the rear of the box for entry of the input wire. This must be large enough to accommodate the strain relief grommet.

## ON THE RAILS

Refer to the photographs and make the test "Rails". In the prototype unit, these were constructed using paper clips which were secured in place using screw terminals of the type shown. This method gives a neat finish and also allows the rail wires to be easily replaced if they become damaged in use.

The screw terminals used in the prototype were of the p.c.b. mounting type. These had four lugs which were made to be pushed through holes in a panel and soldered into position. However, if tight holes are drilled in the box, the lugs may be pushed through then secured by bending them slightly.



The "test" rails made from paper clips and the cardboard "resistance" scale.

The narrow end of the rails should be only a few millimetres apart (to allow for the testing of small bulbs) and about 35mm apart at the other end to enable testing of 1¼in fuses. The suggested method raises the rails above the top face of the case and this allows for the easy testing of small bulbs.

Attach potentiometer VR2 securely with the anti-rotation lug engaged in its hole. This lug prevents the body from possibly rotating in service (due to harsh use or loosening of the fixing nut). This would

result in incorrect readings and could even snap off the connecting wires. Mount the p.c.b. on short plastic spacers and all remaining components.

Refer to Fig.3 and complete all the interwiring between the p.c.b. and off-board components. This should be done slowly to avoid errors in view of the fact that there are several components involved. Note particularly which wire from the p.c.b. connects to which VR2 tag (the diagram gives a rear view). Only if they are correct will the high resistance (Hi-R) section work properly with clockwise rotation corresponding with increasing resistance.

## SUPPLY LEAD

The cable used for the supply voltage input lead **must be rated at 5A minimum**. This will avoid excessive voltage drops due to resistance. In the prototype, a ready-made "curly" extension lead was used with the line socket end cut off.

Fit the 2-core cable wire through the strain relief bush. **Make sure it is secure.** Leaving a little slack, connect the ends to a 2-section piece of screw terminal block mounted inside the case. Connect the p.c.b. wires to this making certain that the polarity is correct.

Adjust preset VR1 fully clockwise (with respect to the left-hand side of the p.c.b.) and preset VR3 to approximately mid-track position.

## TESTING

**Double-check that the polarity to the circuit is correct before plugging in.**

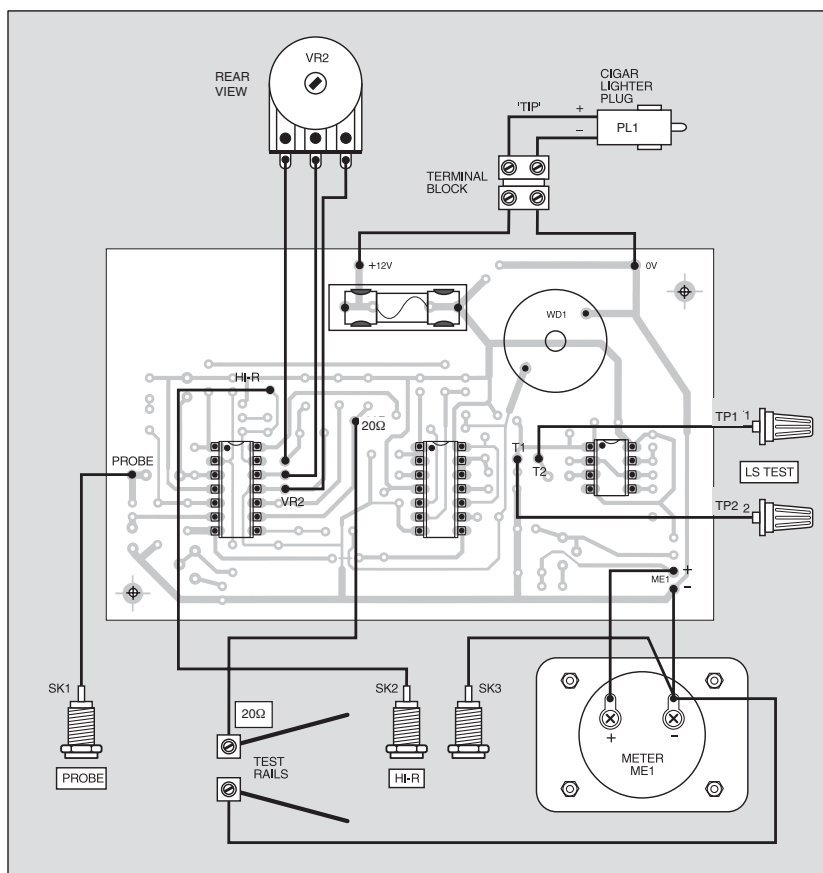


Fig.3. Interwiring from the printed circuit board to off-board components. The general layout within the case can be seen in the photographs.



Connect the unit to the lighter socket. In some cars the ignition must be switched on for this to operate. The monostables will probably self-trigger and the buzzer give a bleep. The meter should read somewhere on the scale. Adjust preset VR3 slightly if necessary.

Plug the probe into socket SK1. Touch this on an "earth" point. The buzzer should give a short bleep. If not, adjust preset VR1 so that it does. Touch the probe on a point at positive supply voltage. The buzzer should give a longer bleep.

Check that the 20 $\Omega$  test works by bridging the rails with a piece of wire. The buzzer should sound continuously.

## METER SCALE

Remove the front cover from the meter by *gently* pulling or careful levering using a thin knife blade. Exercising great care, remove the scale fixing screws using a small screwdriver. Slide out the scale taking care not to touch the pointer.

Cut out a paper scale to glue on top of the existing one. By pressing them in contact, you will see through sufficiently to mark with a pencil the positions of 10 $\mu$ A, 20 $\mu$ A, 30 $\mu$ A, 40 $\mu$ A and 50 $\mu$ A. Mark these 10V, 11V, 12V, 13V and 14V respectively using dry print lettering. Put a light pencil dot at the zero position.

You can, if you wish, "Tippex" or white-out the old scale (so that it does not show through the paper). Glue the new scale over it and re-assemble the meter. Attach the front taking care that the adjustment peg engages with the fork in the movement.

Check that the pointer rests at the zero dot. If not, adjust the screw on the top face until it does.

## MAKING ADJUSTMENTS

Start the adjustment procedure with the Voltmeter. If you have access to a variable voltage power supply unit, you could use that to set VR3 to give a full-scale reading when 14V is applied. You will then find that the other markings correspond fairly well. Adjust preset VR3 to give the best compromise on these figures.

However, if you do not have access to a suitable power supply, plug the unit into the cigar lighter, measure the battery terminal voltage and adjust preset VR3 to correspond. The whole of the scale will then be reasonably accurate.

## GOOD OLE' EARTH

To adjust the Earth Test low point, take the 0-22 ohm test resistor (or some other chosen value) and connect the probe to one end of this. Connect the other end to the negative terminal of the battery or a good earth point. Adjust preset VR1 until the buzzer just sounds.

## R-SCALE CALIBRATION

Now for potentiometer VR2's front panel "resistance" scale and calibration. Make a thin cardboard scale and secure it temporarily behind the control knob. Pencil in the zero position (knob turned full anti-clockwise).

There is no point in marking the scale with great accuracy. It may be assumed that this is linear – that is, equal increases in resistance correspond with equal steps.



Testing an ignition (plug) lead. The new meter scaling can also be seen here.

Take the 10k $\Omega$  test resistor and connect it to the Hi-R test position. Rotate VR2 control knob to the point where the buzzer just sounds. Make a pencil mark. Repeat using the 47k $\Omega$  (regarded as 50k $\Omega$ ) test resistor, again, making a mark.

Remove the scale and, by measurement, make marks for each 10k $\Omega$  step from 10 to 50. Mark these permanently. Label the scale "k $\Omega$ " then attach the scale in its original position. Check that the "zero" point is still correct.

## USING THE BUZZ-BOX

There are several points to observe when using the test probe. *This must be applied with care and with reference to the car wiring diagram. It may be used on items which carry supply current direct to some accessory (e.g. at a fuse, switch or connector) or an earth point. Do not probe around indiscriminately.*

*On no account use it inside pieces of electronic equipment. If, for example, it was used inside an electronic control unit severe damage could result to the control unit.*

*Do not apply it to any connector associated with an engine management system, ABS unit or any other electronic system or sensor. Do not apply it to any wires inter-connecting such circuits.*

*Do not apply it to points on any diagnostic socket. Do not use it in the engine compartment with the engine running.*

When using the loudspeaker test, disconnect **both** of the wires involved *before* connecting them to the unit.

## CRANK TEST

The unit is not really designed to be used with the engine running except for a "crank test". To do this, watch the voltmeter as the starter motor is operated. If the needle drops immediately below 10V and the battery is known to be well charged, it is likely to be at the end of its useful life.

It would be worth checking the battery connectors (for tightness and lack of corrosion) and the connection of the earth strap to the car chassis since trouble here could produce a similar result. A good battery should be capable of maintaining a voltage of 10V or more for a few seconds until the engine fires.

## STATE OF CHARGE

The charge state of the battery is found by measuring the voltage but this needs some interpretation. It will only be meaningful if the battery has not been charged for a few hours before the test is made.

A terminal voltage less than 11.5V indicates a battery which is "flat" (possibly irreversibly so). A voltage of 12.5V or more indicates a good state of charge and near 13V indicates full charge.

Take great care to avoid touching the probe on a +12V point and the car chassis or other earth point at the same time. *If you did, there would be a short circuit and damage could be caused.* In the prototype unit, the end of the probe was insulated using heat-shrinkable sleeving so that only a little bare tip remained. This reduced the likelihood of causing a short circuit.

## UP TO YOU

Ignition leads could be connected to the test position in various ways. The method used in the prototype was to solder short pieces of stiff wire to the 4mm plugs. The other ends of the wire were bent into a loop to make contact with the connectors when inserted in the ends of the leads (see photograph).

Several ignition leads were tested and these had a resistance between 5k $\Omega$  and 20k $\Omega$ . Without specific data, compare the resistances of the leads. If one has a markedly higher value than the rest, it should be replaced and, preferably, the whole set renewed.  $\square$

# QUASAR ELECTRONICS LIMITED

Unit 14 Sunningdale, BISHOPS STORTFORD, Herts. CM23 2PA

TEL: 01279 306504 FAX: 07092 203496

ADD £2.00 P&P to all orders (or 1st Class Recorded £4, Next day (Insured £250) £7, Europe £4.00, Rest of World £6.00). We accept all major credit cards. Make cheques/P.O.s payable to Quasar Electronics. Prices include 17.5% VAT. MAIL ORDER ONLY FREE CATALOGUE with order or send £2 x 1st class stamps (refundable) for details of over 150 kits & publications.



## PROJECT KITS

Our electronic kits are supplied complete with all components, high quality PCBs (NOT cheap Tripad strip board!) and detailed assembly/operating instructions

- **2 x 25W CAR BOOSTER AMPLIFIER** Connects to the output of an existing car stereo cassette player, CD player or radio. Heatsinks provided. PCB 76x55mm. **1046KTT £27.95**
- **3-CHANNEL WIRELESS LIGHT MODULATOR** No electrical connection with amplifier. Light modulation achieved via a sensitive electret microphone. Separate sensitivity control per channel. Power handling 400W/channel. PCB 54x112mm. Mains powered. Box provided. **6014KT £27.95**
- **12 RUNNING LIGHT EFFECT** Exciting 12 LED light effect ideal for parties, discos, shop-windows & eye-catching signs. PCB design allows replacement of LEDs with 220V bulbs by inserting 3 TRIACS. Adjustable rotation speed & direction. PCB 54x112mm. **1026KT £17.95; BOX (for mains operation) 2026BX £10.00**
- **DISCO STROBE LIGHT** Probably the most exciting of all light effects. Very bright strobe tube. Adjustable strobe frequency: 1-60Hz. Mains powered. PCB: 60x88mm. Box provided. **6037KT £31.95**

- **ANIMAL SOUNDS** Cat, dog, chicken & cow. Ideal for kids farmyard toys & schools. **SG10M £6.95**
- **3 1/2 DIGIT LED PANEL METER** Use for basic voltage/current displays or customise to measure temperature, light, weight, movement, sound levels, etc. with appropriate sensors (not supplied). Various input circuit designs provided. **3061KT £13.95**
- **IR REMOTE TOGGLE SWITCH** Use any TV/VCR remote control unit to switch onboard 12V/1A relay on/off. **3058KT £10.95**
- **SPEED CONTROLLER** for any common DC motor up to 100V/5A. Pulse width modulation gives maximum torque at all speeds. 5-15VDC. Box provided. **3067KT £12.95**
- **3 x 8 CHANNEL IR RELAY BOARD** Control eight 12V/1A relays by Infra Red (IR) remote control over a 20m range in sunlight. 8 relays turn on only, the other 2 toggle on/off. 3 operation ranges determined by jumpers. Transmitter case & all components provided. Receiver PCB 76x89mm. **3072KT £52.95**

## PRODUCT FEATURE

### 4 WATT FM TRANSMITTER

Small but powerful 4 Watt 88-108MHz FM transmitter with an audio preamplifier stage and 3 RF stages. Accepts a wide variety of input sources – the electret microphone supplied, a tape player or for more professional results, a separate audio mixer (like our 3-Input Mono Mixer kit 1052). Can be used with an open dipole or ground plane antenna. Supply: 12-15V DC/0-5A. PCB: 45 x 145mm.

**ORDERING INFO:** Kit 1028KT £24.95.  
**OPTIONAL EXTRAS:** 3-Input Mono Mixer Kit 1052KT £17.95. AS1028 £39.95.



- **SOUND EFFECTS GENERATOR** Easy to build. Create an almost infinite variety of interesting/unusual sound effects from birds chirping to sirens. 9VDC. PCB 54x85mm. **1045KT £9.95**
- **ROBOT VOICE EFFECT** Make your voice sound similar to a robot or Darlek. Great fun for discos, school plays, theatre productions, radio stations & playing jokes on your friends when answering the phone! PCB 42x71mm. **1131KT £9.95**
- **AUDIO TO LIGHT MODULATOR** Controls intensity of one or more lights in response to an audio input. Safe, modern opto-coupler design. Mains voltage experience required. **3012KT £8.95**
- **MUSIC BOX** Activated by light. Plays 8 Christmas songs and 5 other tunes. **3104KT £7.95**
- **20 SECOND VOICE RECORDER** Uses non-volatile memory - no battery backup needed. Records/replay messages over & over. Playback as required to greet customers etc. Volume control & built-in mic. 6VDC. PCB 50x73mm. **3131KT £12.95**
- **TRAIN SOUNDS** 4 selectable sounds: whistle blowing, level crossing bell, 'clackety-clack' & 4 in sequence. **SG01M £6.95**

- **PC CONTROLLED RELAY BOARD** Convert any 286 upward PC into a dedicated automatic controller to independently turn on/off up to eight lights, motors & other devices around the home, office, laboratory or factory using 8 240VAC/12A onboard relays. DOS utilities, sample test program, full-featured Windows utility & all components (except cable) provided. 12VDC. PCB 70x200mm. **3074KT £31.95**
- **2 CHANNEL UHF RELAY SWITCH** Contains the same transmitter/receiver pair as 30A15 below plus the components and PCB to control two 240VAC/10A relays (also supplied). Ultra bright LEDs used to indicate relay status. **3082KT £27.95**
- **TRANSMITTER RECEIVER PAIR** 2-button keyboard style 300-375MHz Tx with 30m range. Receiver encoder module with matched decoder IC. Components must be built into a circuit like kit 3082 above. **30A15 £14.95**
- **PC DATA ACQUISITION/CONTROL UNIT** Use your PC to monitor physical variables (e.g. pressure, temperature, light, weight, switch state, movement, relays, etc.), process the information & use results to control physical devices like motors, sirens, relays, servo & stepper motors. Inputs: 16 digital & 11 analogue. Outputs: 8 digital & 1 analogue. Plastic case with printed front/rear panels, software utilities, programming examples & all components (except sensors & cable) provided. 12VDC. **3093KT £95.95**
- **PIC 16C71 FOUR SERVO MOTOR DRIVER** Simultaneously control up to 4 servo motors. Software & all components (except servos/control pots) supplied. 5VDC. PCB 50x70mm. **3102KT £15.95**
- **PC SERIAL PORT ISOLATED I/O BOARD** Provides eight 240VAC/10A relay outputs & 4 optically isolated inputs. Designed for use in various control & sensing applications e.g. load switching, external switch input sensing, contact closure & external voltage sensing. Controlled via serial port & a terminal emulator program (built into Windows). Can be used with ANY computer/operating system. Plastic case with printed front/rear panels & all components (except cable) provided. **3108KT £54.95**
- **UNIPOLAR STEPPER MOTOR DRIVER** for any 5/6/8 lead motor. Fast/slow & single step rates. Direction control & on/off switch. Wave, 2-phase & half-wave step modes. 4 LED indicators. PCB 50x65mm. **3109KT £14.95**
- **CONTROLLED STEPPER MOTOR DRIVER** Control two unipolar stepper motors (3A max. each) via PC printer port. Wave, 2-phase & half-wave step modes. Software accepts 4 digital inputs from external switches & will single step motors. PCB fits in D-shell case provided. **3113KT £17.95**
- **12-BIT PC DATA ACQUISITION/CONTROL UNIT** Similar to kit 3093 above but uses a 12 bit Analogue-to-Digital Converter (ADC) with internal analogue multiplexer. Reads 8 single ended channels or 4 differential inputs or a mixture of both. Analogue inputs read 0-4V. Four TTL/CMOS compatible digital input outputs. ADC conversion time <10µs. Software (C, QB & Win), extended D shell case & all components (except sensors & cable) provided. **3119KT £52.95**

## X-FACTOR PUBLICATIONS

### THE EXPERTS IN RARE & UNUSUAL INFORMATION!

Full details of all X-FACTOR PUBLICATIONS can be found in our catalogue. N.B. Minimum order charge for reports and plans is £5.00 PLUS normal P&P.

- **SUPER-EAR LISTENING DEVICE** Complete plans to build your own parabolic dish microphone. Listen to distant voices and sounds through open windows and even walls! Made from readily available parts. **R002 £3.50**
- **TELEPHONE BUG PLANS** Build your own micro-beetle telephone bug. Suitable for any phone. Transmits over 250 metres - more with good receiver. Made from easy to obtain, cheap components. **R006 £2.50**
- **LOCKS** - How they work and how to pick them. This fact filled report will teach you more about locks and the art of lock picking than many books we have seen at 4 times the price. Packed with information and illustrations. **R008 £3.50**
- **RADIO & TV JOKER PLANS** We show you how to build three different circuits for disrupting TV picture and sound plus FM radio! May upset your neighbours & the authorities!! DISCRETION REQUIRED. **R017 £3.50**
- **INFINITY TRANSMITTER PLANS** Complete plans for building the famous Infinity Transmitter. Once installed on the target phone, device acts like a room bug. Just call the target phone & activate the unit to hear all room sounds. Great for home/office security! **R019 £3.50**
- **THE ETHER BOX CALL INTERCEPTOR PLANS** Grabs telephone calls out of thin air! No need to wire-in a phone bug. Simply place this device near the phone lines to hear the conversations taking place! **R025 £3.00**
- **CASH CREATOR BUSINESS REPORTS** Need ideas for making some cash? Well this could be just what you need! You get 40 reports (approx. 800 pages) on floppy disk that give you information on setting up different businesses. You also get valuable reproduction and duplication rights so that you can sell the manuals as you like. **R030 £7.50**

# SURVEILLANCE

High performance surveillance bugs. Room transmitters supplied with sensitive electret microphone & battery holder/cip. All transmitters can be received on an ordinary VHF-FM radio between 88-108MHz. Available in Kit Form (KT) or Assembled & Tested (AS).

## ROOM SURVEILLANCE

- **MTX - MINIATURE 3V TRANSMITTER** Easily to build & guaranteed to transmit 300m @ 3V. Long battery life. 3-5V operation. Only 45x18mm. **3007KT £6.95**
- **AS3007 £11.95**
- **MTX - MINIATURE 9V TRANSMITTER** Our best selling bug. Super sensitive, high power - 500m range @ 9V (over 1km with 18V supply and better aerial). 45x19mm. **3018KT £7.95**
- **AS3018 £12.95**
- **HPXT - HIGH POWER TRANSMITTER** High performance, 2 stage transmitter gives greater stability & higher quality reception. 1000m range 6-12V DC operation. Size 70x15mm. **3032KT £9.95**
- **AS3032 £18.95**
- **MMTX - MICRO-MINIATURE 9V TRANSMITTER** The ultimate bug for its size, performance and price. Just 15x25mm. 500m range @ 9V (Good stability, 6-18V operation). **3051KT £8.95**
- **AS3051 £14.95**
- **VTX - VOICE ACTIVATED TRANSMITTER** Operates only when sounds detected. Low standby current. Variable trigger sensitivity. 500m range. Peaking circuit suppresses RF output. On/off switch 6V operation. Only 63x38mm. **3028KT £12.95**
- **AS3028 £21.95**
- **HARDWIRED BUG/TWO STATION INTERCOM** Each station has its own amplifier, speaker and mic. Can be set up as either a hard-wired bug or two-station intercom. 10m x 2-core cable supplied. 9V operation. **3021KT £15.95** (kit 115x19mm. **3013KT £9.95** **AS3013 £21.95**)
- **TRVS - TAPE RECORDER VOX SWITCH** Used to automatically operate a tape recorder (not supplied) via its REMOTE socket when sounds are detected. All conversations recorded. Adjustable sensitivity & turn-off delay. 115x19mm. **3013KT £9.95** **AS3013 £21.95**



## TELEPHONE SURVEILLANCE

- **MTTX - MINIATURE TELEPHONE TRANSMITTER** Attaches anywhere to phone line. Transmits only when phone is used! Tune-in your radio and hear both parties. 300m range. Uses line as aerial & power source. 20x45mm. **3016KT £8.95**
- **AS3016 £14.95**
- **TRI - TELEPHONE RECORDING INTERFACE** Automatically records all conversations. Connects between phone line & tape recorder (not supplied). Operates recorders with 1.5-12V battery systems. Powered from line. 50x33mm. **3033KT £9.95** **AS3033 £18.95**
- **TPA - TELEPHONE PICK-UP AMPLIFIER/WIRELESS PHONE BUG** Place pick-up coil on the phone line or near phone earpiece and hear both sides of the conversation. **3055KT £11.95**
- **AS3055 £20.95**
- **1 WATT FM TRANSMITTER** Easy to construct. Delivers a crisp, clear signal. Two-stage circuit. Kit includes microphone and requires a simple open dipole aerial. 8-30VDC. PCB 42x46mm. **1006KT £14.95**
- **4 WATT FM TRANSMITTER** Comprises three RF stages and an audio preamplifier stage. Piezoelectric microphone supplied or you can use a separate preamplifier circuit. Antenna can be an open dipole or Ground Plane. Ideal project for those who wish to get started in the fascinating world of FM broadcasting and want a good basic circuit to experiment with. 12-18VDC. PCB 44x146mm. **1028KT £24.95** **AS1028 £39.95**
- **15 WATT FM TRANSMITTER (PRE-ASSEMBLED & TESTED)** Four transistor based stages with Philips BLY 88 in final stage. 15 Watts RF power on the air. 88-108MHz. Accepts open dipole, Ground Plane, 5/8 J, or YAGI configuration antennas. 12-18VDC. PCB 70x220mm. SWS meter needed for alignment. **1021KT £74.95**
- **SIMILAR TO ABOVE BUT 25W Output.** **1031KT £84.95**

- **LIQUID LEVEL SENSOR/RAIN ALARM** Will indicate fluid levels or simply the presence of fluid. Relay output to control a pump & remove water when it reaches a certain level. **1080KT £6.95**
- **STEREO VU METER** shows peak music power using 2 rows of 10 LEDs (mixed green & red) moving bar display. 0-30db. **3089KT £11.95**
- **AM RADIO KIT 1** Tuned Radio Frequency front-end, single chip AM radio IC & 2 stages of audio amplification. All components inc. speaker provided. PCB 32x102mm. **3063KT £10.95**
- **DRILL SPEED CONTROLLER** Adjust the speed of your electric drill according to the job at hand. Suitable for 240V AC mains powered drills up to 700W power. PCB: 48mm x 65mm. Box provided. **6074KT £18.95**
- **3 INPUT MONO MIXER** Independent level control for each input and separate bass/treble controls. Input sensitivity: 240mV. 18V DC. PCB: 60mm x 185mm **1052KT £17.95**
- **NEGATIVE/POSITIVE ION GENERATOR** Standard Cockcroft-Walton multiplier circuit. Mains voltage experience required. **3057KT £10.95**
- **LED DICE** Classic intro to electronics & circuit analysis. 7 LEDs simulate dice roll, slow down & land on a number at random. 555 IC circuit. **3003KT £9.95**
- **STAIRWAY TO HEAVEN** Tests hand-eye co-ordination. Press switch when green segment of LED lights to climb the stairway - miss & start again! Good intro to several basic circuits. **3005KT £9.95**
- **ROULETTE LED** 'Ball' spins round the wheel, slows down & drops into a slot. 10 LEDs. Good intro to CMOS decade counters & Op-Amps. **3006KT £10.95**
- **9V XENON TUBE FLASHER** Transformer circuit steps up 9V battery to flash a 25mm. Xenon tube. Adjustable flash rate (0.25-2 Sec's). **3022KT £11.95**
- **LED FLASHER 1** 5 ultra bright red LED's flash in 7 selectable patterns. **3037MKT £5.95**
- **LED FLASHER 2** Similar to above but flash in sequence or randomly. Ideal for model railways. **3052MKT £5.95**
- **INTRODUCTION TO PIC PROGRAMMING.** Learn programming from scratch. Programming hardware, a P16F84 chip and a two-part, practical, hands-on tutorial series are provided. **3081KT £22.95**
- **SERIAL PIC PROGRAMMER** for all 818/28/40 pin DIP serial programmed PICs. Sharingware software supplied limited to programming 256 bytes (registration costs £14.95). **3096KT £13.95**
- **PICALL SERIAL & PARALLEL PIC PROGRAMMER** for all 818/28/40 pin DIP parallel AND serial PICs. Includes fully functional & registered software (DOS, W3.1, W95/8). **3117KT £59.95**
- **ATMEL 89C051 PROGRAMMER** Simple-to-use yet powerful programmer for the Atmel 89C1051, 89C2051 & 89C4051 uCs. Programmer does NOT require special software other than a terminal emulator program (built into Windows). Can be used with ANY computer/operating system. **3121KT £24.95**
- **3V/1.5V TO 9V BATTERY CONVERTER** Replace expensive 9V batteries with economic 1.5V batteries. IC based circuit steps up 1 or 2 'AA' batteries to give 9V/18mA. **3035KT £5.95**

- **STABILISED POWER SUPPLY 3-30V/2.5A** Ideal for hobbyist & professional laboratory. Very reliable & versatile design at an extremely reasonable price. Short circuit protection. Variable DC voltages (3-30V). Rated output 2.5 Amps. Large heatsink supplied. You just supply a 24VAC/3A transformer. PCB 55x112mm. Mains operation. **1007KT £18.95**
- **STABILISED POWER SUPPLY 2-30V/5A** As kit 1007 above but rated at 5Amp. Requires a 24VAC/5A transformer. **1096KT £32.95**
- **MOTORBIKE ALARM** Uses a reliable vibration sensor (adjustable sensitivity) to detect movement of the bike to trigger the alarm & switch the output relay to which a siren, bikes horn, indicators or other warning device can be attached. Auto-reset. 6-12VDC. PCB 57x64mm. **1011KT £12.95** Box **2011BX £7.00**
- **CAR ALARM SYSTEM** Protect your car from theft. Features vibration sensor, courtesy/boot light voltage drop sensor and bonnet/boot earth switch sensor. Entry/exist delays, auto-reset and adjustable alarm duration. 6-12V DC. PCB: 47mm x 55mm **1019KT £12.95** Box **2019BX £8.00**
- **PIEZO SCREAMER** 110dB of ear piercing noise. Fits in box with 2 x 35mm piezo elements built into their own resonant cavity. Use as an alarm siren or just for fun! 6-9VDC. **3015KT £10.95**
- **COMBINATION LOCK** Versatile electronic lock comprising main circuit & separate keypad for remote opening of lock. Relay supplied. **3029KT £10.95**
- **ULTRASONIC MOVEMENT DETECTOR** Crystal locked detector frequency for stability & reliability. PCB 75x40mm houses all components. 4-7m range. Adjustable sensitivity. Output will drive external relay/circuits. 9VDC. **3049KT £13.95**
- **PIR DETECTOR MODULE** 3-lead assembled unit just 25x35mm as used in commercial burglar alarm systems. **3076KT £8.95**
- **INFRARED SECURITY BEAM** When the invisible IR beam is broken a relay is tripped that can be used to sound a bell or alarm. 25 metre range. Mains rated relays provided. 12VDC operation. **3130KT £12.95**
- **SQUARE WAVE OSCILLATOR** Generates square waves at 6 preset frequencies in factors of 10 from 1Hz-100KHz. Visual output indicator. 5-18VDC. Box provided. **3111KT £8.95**
- **PC DRIVEN POCKET SAMPLER/DATA LOGGER** Analogue voltage sampler records voltages up to 2V or 20V over periods from milli-seconds to months. Can also be used as a simple digital scope to examine audio & other signals up to about 5KHz. Software & D-shell case provided. **3112KT £18.95**
- **20 MHz FUNCTION GENERATOR** Square, triangular and sine waveform up to 20MHz over 3 ranges using 'coarse' and 'fine' frequency adjustment controls. Adjustable output from 0-2V p-p. A TTL output is also provided for connection to a frequency meter. Uses MAX038 IC. Plastic case with printed front/rear panels & all components provided. 7-12VAC. **3101KT £69.95**

## BARGAIN BUY!!

Great introduction to electronics. Ideal for the budding electronics expert! Build a radio, burglar alarm, water detector, Morse code practice circuit, simple computer circuits, and much more! No soldering, tools or previous electronics knowledge required. Circuits can be built and unassembled repeatedly. Comprehensive 68-page manual with explanations, schematics and assembly diagrams. Suitable for age 10+. Excellent for schools. Requires 2 x AA batteries. **ONLY £14.95** (phone for bulk discounts).

## 30-in-ONE Electronic Projects Lab



**WEB: <http://www.QuasarElectronics.com>**  
**email: [epesales@QuasarElectronics.com](mailto:epesales@QuasarElectronics.com)**

**Secure Online Ordering Facilities**  
**Full Kit Listing, Descriptions & Photos**  
**Kit Documentation & Software Downloads**



# QUASAR KITS REVIEW

ROBERT PENFOLD

*Examining the merits of a dozen electronic kits from Quasar.*



**W**E NORMALLY receive things for review one or two at a time, but no less than a dozen units are under consideration in this review. This is perhaps a slight exaggeration since there are only six different units, but each one has been supplied in kit form and ready-made. All marketed by Quasar Electronics.

It is not practical to consider every device in detail, so we will take a detailed look at one kit and then consider the other units in more general terms. It is kit number 3113, the PC-based dual stepper motor driver that will receive the in-depth coverage.

## STEP-BY-STEP

A stepper motor has two centre-tapped coils, effectively giving four solenoids for the driver circuit to control. By pulsing the solenoids in the correct fashion the motor can be made to rotate in either direction in small steps of typically about 15 degrees.

Stepper motors produce little torque, but are used in applications that require precise positioning rather than high power. One way of driving a stepper motor is to use a special integrated circuit to simplify control. With this method there are two control inputs, one of which controls the direction of rotation. The other input is pulsed each time the motor must be moved on by one step.

The more simple method, and the one adopted in this case, is to control the solenoids from four output lines of the computer. Software is then used to generate the appropriate control pulses for whatever actions are required. This slightly complicates the software side of things, but direct control of a stepper motor is not that difficult.

This dual stepper motor interface is basically just eight open collector driver transistors controlled by the data outputs of a PC printer port, plus an MS-DOS program to make the unit operate as a dual stepper motor driver.

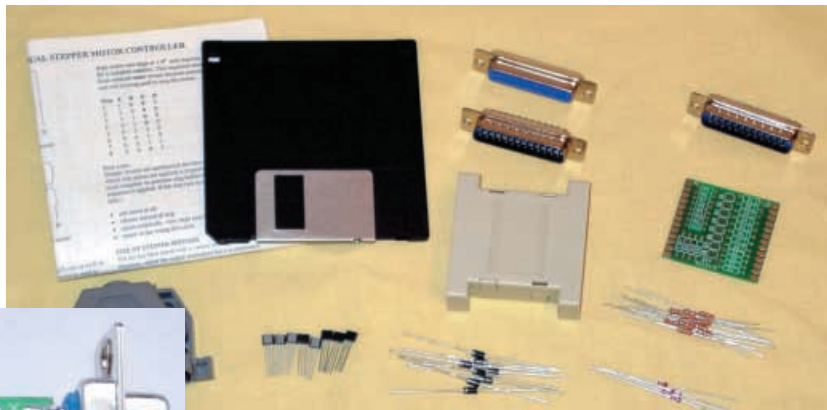
The interface takes the form of a small box having a 25-way D-type connector at each end. The male connector plugs into the PC's printer port, or it can be connected via a "straight" 25-way D connector cable (not supplied). Connections to the motors and power source are by way of the female connector at the other end of the case, and the supplied male connector. You have to supply your own connecting wires. The electronics fits on a tiny printed circuit board that fits between the two D connectors.

## GETTING IT TOGETHER

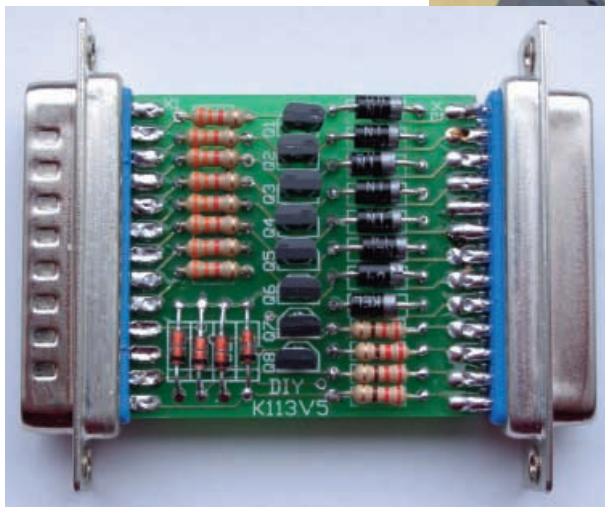
Two A4 size sheets contain the building instructions, notes on use, the circuit diagram, etc. Quite a lot of information is crammed onto these two sheets, and it is definitely advisable to read through them once or twice before starting construction.

The fibreglass printed circuit board is a good quality double-sided type that is printed with a component overlay. Construction starts by fitting the two D connectors, and then the 32 small components are added.

There is no problem in identifying the components, and it is fairly obvious where everything fits. One slight problem is that the board is designed to take eight resistors in the form of a 16-pin



*The contents of the stepper motor driver kit.*



*Completed twin stepper motor driver unit.*

d.i.l. package, but the kit is supplied with eight individual resistors. However, the instruction sheets do point out this discrepancy, and make it clear where the resistors are fitted. (*The p.c.b. has now been redesigned to overcome this – Ed.*)

Having some 32 components squeezed into about nine square centimetres makes construction fiddly rather than difficult. The situation is eased somewhat by the solder resist on the board which helps to avoid accidental short circuits. Also, the board is through-plated so there is no need for any pins to carry connections from one layer to the other.

It is still necessary to take reasonable care to avoid short circuits, and a magnifying glass is as essential as a soldering iron when building this type of board.

The instruction sheets give advice about using the interface with various types of stepper motor. It acknowledges the fact that many



of the motors used by electronics hobbyists are surplus components that are supplied with little or no technical data.

Having sorted out some basic information about the motors it is often a matter of using some trial and error to get everything working properly. I tried the interface with an old Maplin stepper motor for which I did still have the connection data, and I am pleased to say that the unit worked first time.

## SOFTWARE

The only supplied software is a DOS program on a 3.5-inch floppy disk. This did not work properly when run in a DOS window under Windows 98, but it worked fine when the computer was rebooted in DOS mode, or when the computer was booted into DOS from a floppy disk.

The program provides a command line interpreter that can be used to issue various commands to the motors, such as spin, stop, dir (direction) and wait. The commands seem to work well enough, and the program is easy to use.

It is possible to have the software process a series of commands contained in a text file, rather like running a DOS batch file. This enables what is effectively a simple program to be written and executed, but for many purposes something more sophisticated than this will be needed. It should not be too difficult to control the motor using a Windows programming language such as Delphi or Visual BASIC.

The output port of the interface also provides access to four handshake inputs of the printer port, which makes it possible to have control of the motor to some extent dependent on feedback from sensors. However, you are completely on your own with this type of thing.

## CONCLUSION

Although this is a fairly simple kit, it is not really suitable for beginners, and is not aimed at those of limited experience. Constructing the kit is actually quite easy, but a fair amount of technical expertise is needed to get the finished unit do anything worthwhile.

Considering the simplicity of the unit, at a VAT inclusive cost of £17.95 it is not particularly cheap, but the price is reasonable considering the quality of the components. The printed circuit board is as good as any I have seen, and better than most. As the ready-made interface costs some £29.95 including VAT, it seems to be well worthwhile spending half an hour or so building the kit version.

## PIC/ATMEL PROGRAMMERS

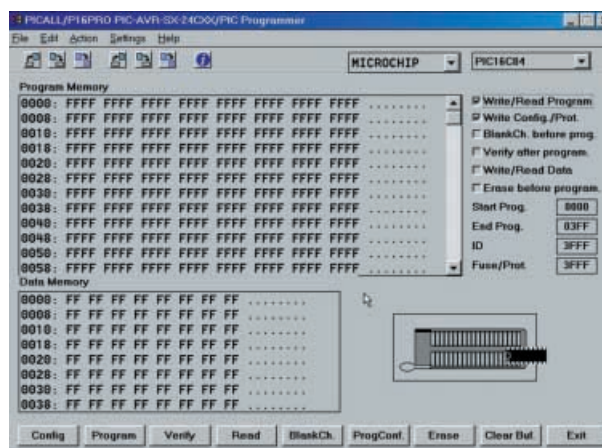
The other kits and ready-made boards received for review are for programming PIC or ATMEL microcontrollers. The Quasar kits seem to be based on designs that are available on the Internet. The original instruction leaflets were quite brief at just one A4 sheet with printing on one side, but these have now been updated and improved. Further assistance is often available from one or more web sites, as are more recent versions of the software. The latter is shareware, although in some cases the full registered version is supplied in the kit price. In general, the kits seem to be quite easy to put together.

The printed circuit boards are good quality fibreglass boards, but are mostly single-sided types that require some link-wires. The boards have a solder resist layer that helps to avoid short circuits due to excess solder, and this makes it much easier to get things working first time.

Some of the kits have attractively low prices, but bear in mind that all you get is a kit of parts to build the board, together with a floppy disk containing the software. The cable to connect the board to the computer and the mains adapter are optional extras at £4.95 and £5.95 each.

The kit versions of the programmers are supplied with an ordinary 40-pin d.i.l. socket, and a universal ZIF socket costs an additional £15.95. The ZIF socket has to be regarded as an essential buy. Apart from other considerations, many PIC chips will simply not fit an ordinary 40-pin holder with its 0.6-inch row spacing.

As already pointed out, there is also a software registration fee with some kits if the full version is required, and this adds a further £14.95 to the cost. These extras can



Windows version of the PICALL software.

substantially boost the basic kit price, although the overall cost still seems to be reasonable.

The programmers are mostly quite easy to use. The P16PRO serial PIC programmer supports a range of PIC microcontrollers and has MS-DOS software, but it is very simple and straightforward to use. The PICALL programmer supports a wide range of PIC microcontrollers, plus a limited range of non-PIC devices, and has the option of MS-DOS or Windows software. The Windows version of the program is easier to use, but the diagram showing how to connect the selected device to the ZIF socket makes things "as clear as mud". It is best to resort to the MS-DOS version for connection details.

## FINAL CONCLUSION

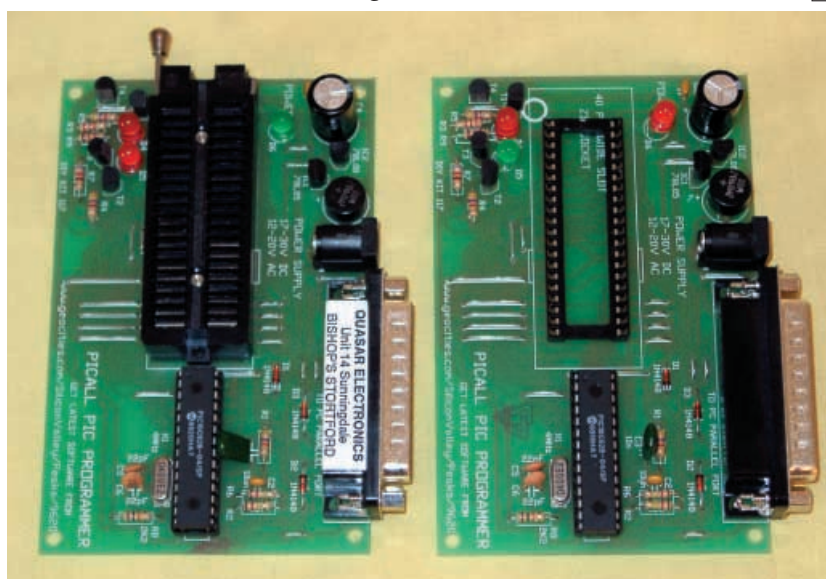
Building any of these kits should not present any major problems for someone who has a small amount of experience at electronic project building. However, none of the kits can really be recommended for beginners, since a fair amount of technical know-how is needed in order to utilize the finished units. For the same reason, the ready-made boards are only suitable for those who know what they are doing.

It is a pity that neither the kits nor the ready-made units are supplied with more documentation as this would substantially broaden their appeal. (*This point has now been addressed with new documents plus an electronic manual that is provided with the software – Ed.*) As things stand, the kits and ready-made units are of excellent quality, represent reasonably good value for money, and represent a worthwhile proposition for someone having the requisite technical expertise and an Internet connection.

For more information contact Quasar Electronics, Unit 14 Sunningdale, Bishop's Stortford, Herts CM23 2PA. Tel: 01279 306504. Fax: 08707 064222.

Email: [epesales@QuasarElectronics.com](mailto:epesales@QuasarElectronics.com).

Web: [www.QuasarElectronics.com](http://www.QuasarElectronics.com).



The ready-made (left) and kit version of the PICALL programmer.

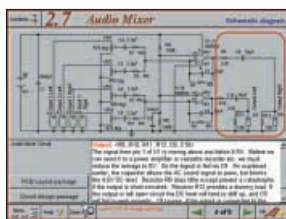
# Everyday Practical Electronics are pleased to be able to offer all readers these **ELECTRONICS CD-ROMS**

**NEW**

## ELECTRONICS PROJECTS



Logic Probe testing

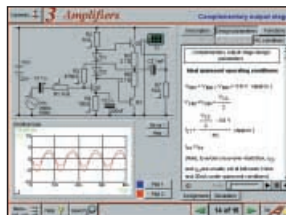


Audio Mixer circuit description

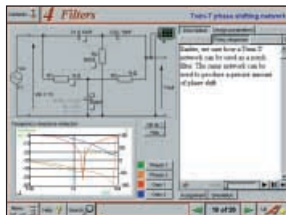
*Electronic Projects* is split into two main sections: **Building Electronic Projects** contains comprehensive information about the components, tools and techniques used in developing projects from initial concept through to final circuit board production. Extensive use is made of video presentations 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.

## ANALOGUE ELECTRONICS



Complementary output stage

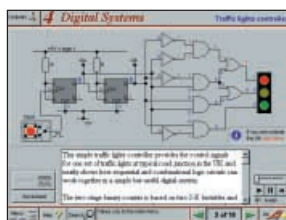


Twin-T phase shifting network

*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



Virtual laboratory – Traffic Lights

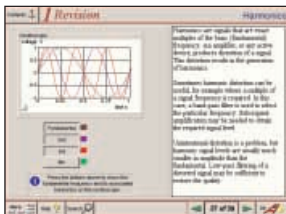


Microprocessor

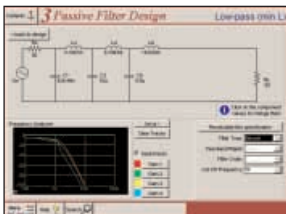
*Digital Electronics* builds on the knowledge of logic gates covered in *Electronic Circuits & Components* (opposite), and takes users through the subject of digital electronics up to the operation and architecture of microprocessors. The virtual laboratories allow users to operate many circuits on screen.

Covers binary and hexadecimal numbering systems, ASCII, basic logic gates and their operation, 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 and their parameters, traffic light controllers, memories and microprocessors – architecture, bus systems and their arithmetic logic units.

## FILTERS



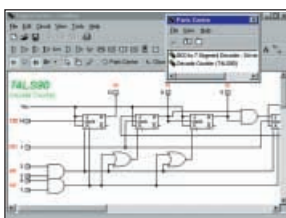
Filter Theory



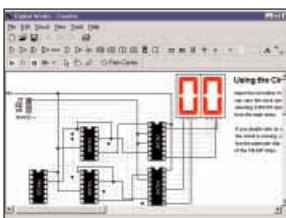
Active filter synthesis

*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.

## DIGITAL WORKS 3.0



Macro screen



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

### PRICES

Prices for each of the CD-ROMs above are:

Hobbyist/Student .....£45 inc VAT  
Institutional (Schools/HE/FE/Industry).....£99 plus VAT  
Institutional 10 user (Network Licence) .....£199 plus VAT

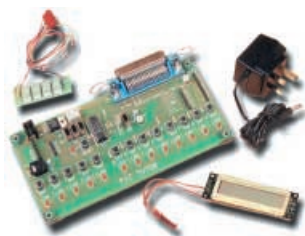
(UK and EU customers add VAT at 17.5% to "plus VAT" prices)



## Interested in programming PIC microcontrollers? Learn with **PICtutor** by John Becker



The Virtual PIC



Deluxe PICtutor Hardware

This highly acclaimed CD-ROM, together with the PICtutor experimental and development board, will teach you how to use PIC microcontrollers with special emphasis on the PIC16x84 devices. The board will also act as a development test bed and programmer for future projects as your programming skills develop. This interactive presentation uses the specially developed **Virtual PIC Simulator** to show exactly what is happening as you run, or step through, a program. In this way the CD provides the easiest and best ever introduction to the subject.

Nearly 40 Tutorials cover virtually every aspect of PIC programming in an easy to follow logical sequence.

### HARDWARE

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

Two levels of PICtutor hardware are available – Standard and Deluxe. The **Standard** unit comes with a battery holder, a reduced number of switches and no displays. This version will allow users to complete 25 of the 39 Tutorials. The **Deluxe** Development Kit is supplied with a plug-top power supply (the **Export** Version has a battery holder), all switches for both PIC ports plus I.C.D. and 4-digit 7-segment I.E.D. displays. It allows users to program and control all functions and both ports of the PIC. All hardware is supplied **fully built and tested** and includes a PIC16F84.

### PICtutor CD-ROM

Hobbyist/Student ..... £45 inc. VAT  
Institutional (Schools/HE/FE Industry) ... £99 plus VAT  
Institutional 10 user (Network Licence) .£199 plus VAT

### HARDWARE

Standard PICtutor Development Kit ..... £47 inc. VAT  
Deluxe PICtutor Development Kit ..... £99 plus VAT  
Deluxe Export Version ..... £96 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

## ELECTRONIC CIRCUITS & COMPONENTS + THE PARTS GALLERY

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. 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. Selections include: **Components, Components Quiz, Symbols, Symbols Quiz, Circuit Technology**

Hobbyist/Student.....£34 inc VAT  
Institutional (Schools/HE/FE/Industry).....£89 plus VAT  
Institutional 10 user (Network Licence).....£169 plus VAT

(UK and EU customers add VAT at 17.5% to "plus VAT" prices)

## MODULAR CIRCUIT DESIGN

This CD-ROM 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.

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

(UK and EU customers add VAT at 17.5% to "plus VAT" prices)

Minimum system requirements for these CD-ROMs: PC with 486/166MHz, VGA+256 colours, CD-ROM drive, 32MB RAM, 10MB hard disk space. Windows 95/98, mouse, sound card, web browser.

Please send me:

- ☐ Electronic Projects
- ☐ Analogue Electronics
- ☐ Digital Electronics
- ☐ Filters
- ☐ Digital Works 3.0
- ☐ PICtutor
- ☐ Electronic Circuits & Components +The Parts Gallery

## CD-ROM ORDER FORM

Version required:

- ☐ Hobbyist/Student
- ☐ Institutional
- ☐ Institutional 10 user

**Note:** The software on each version is the same, only the licence for use varies.

- ☐ PICtutor Development Kit – Standard
- ☐ PICtutor Development Kit – Deluxe

☐ Deluxe Export

**Note:** The PICtutor CD-ROM is not included in the Kit prices.

- ☐ Electronic Components Photos
- ☐ 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: £ .....Card expiry date: .....

Card No: .....

Please supply name and address of cardholder if different to the delivery address.

## 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 country, then add 17½% VAT or provide your official VAT registration number).

**Send your order to:**  
**Direct Book Service**

**Allen House, East Borough, Wimborne Dorset BH21 1PF**

Direct Book Service is a division of Wimborne Publishing Ltd. To order by phone ring

**01202 881749. Fax: 01202 841692**

Goods are normally sent within seven days  
E-mail: [orders@epemag.wimborne.co.uk](mailto:orders@epemag.wimborne.co.uk)



## SMART HIGH QUALITY ELECTRONIC KITS

CAT. NO.	DESCRIPTION	PRICE £
1005	Touch Switch	2.87
1010	5-input stereo mixer with monitor output	
19.31		
1016	Loudspeaker protection unit	3.22
1023	Dynamic head preamp	2.50
1024	Microphone preamplifier	2.07
1025	7 watt hi-fi power amplifier	2.53
1026	Running lights	4.60
1027	NiCad battery charger	3.91
1030	Light dimmer	2.53
1039	Stereo VU meter	4.60
1042	AF generator 250Hz-16kHz	1.70
1043	Loudness stereo unit	3.22
1047	Sound switch	5.29
1048	Electronic thermostat	3.68
1050	3-input hi-fi stereo preamplifier	12.42
1052	3-input mono mixer	6.21
1054	4-input instrument mixer	2.76
1059	Telephone amplifier	4.60
1062	5V 0.5A stabilised supply for TTL	2.30
1064	12V 0.5A stabilised supply	3.22
1067	Stereo VU meter with leads	9.20
1068	18V 0.5A stabilised power supply	2.53
1071	4-input selector	6.90
1080	Liquid level sensor, rain alarm	2.30
1082	Car voltmeter with l.e.d.s	7.36
1083	Video signal amplifier	2.76
1085	DC converter 12V to 6V or 7.5V or 9V	2.53
1093	Windscreen wiper controller	3.68
1094	Home alarm system	12.42
1098	Digital thermometer with l.c.d. display	11.50
1101	Dollar tester	4.60
1102	Stereo VU meter with 14 l.e.d.s	6.67
1106	Thermometer with l.e.d.s	6.90
1107	Electronics to help win the pools	3.68
1112	Loudspeaker protection with delay	4.60
1115	Courtesy light delay	2.07
1118	Time switch with triac 0-10 mins	4.14
1122	Telephone call relay	3.68
1123	Morse code generator	1.84
1126	Microphone preamplifier	4.60
1127	Microphone tone control	4.60
1128a	Power flasher 12V d.c.	2.53
1133	Stereo sound to light	5.26

### DO YOU NEED ALL ROUND AIR MOVEMENT?

A simple fan will move air in one direction only. Even an oscillating fan will only blow just over halfway round, but if you need to blow all round, then our boxer fans, Order Ref: 4P114, could give you just this. Six of these placed as the sketch could be operated from our transformer, Order Ref: 4P24. The fans have their own mounting frames and the transformer has a frame so they could all be assembled on a table-top or plywood base, and if you wanted to blow hot air then a heater could also be placed in the centre. We are making a special offer of six fans and the transformer for **£20 the lot**, including VAT. Order Ref: 20P41.

### ANOTHER USEFUL FAN

This is a 12V d.c. brushless fan. It is very small, infact only just under 60mm square including fixings. Being brushless this fan consumes very little current, in fact it is only 150mA. It is very quiet running and we can supply a transformer and full wave rectifier which would operate it for just £1. Price of the fan £5. Order Ref: 5P291.

### TWO MORE POST OFFICE INSTRUMENTS

Both instruments contain lots of useful parts, including sub-min toggle switch sold by many at £1 each. They are both in extremely nice cases, with battery compartment and flexible carrying handles so if you don't need the instruments themselves, the case may be just right for a project you have in mind.

The first is **Oscillator 87F**. This has an output, continuous or interrupted, of 1KHz. It is in a plastic box size 115mm wide, 145mm high and 50mm deep. Price only £1. Order Ref: 7R1.

The other is **Amplifier Ref. No. 109G**. This is in a case size 80mm wide, 130mm high and 35mm deep. Price £1. Order Ref: 7R2.

### HEAVY DUTY POT

Rated at 25W, this is 20 ohm resistance so it could be just right for speed controlling a d.c. motor or device or to control the output of a high current amplifier. Price £1. Order Ref: 1/33L1.

### STEPPER MOTOR

Made by Philips as specified for the wind-up torch in the Oct '00 Practical Electronics is still available, price £2. Order Ref: 2P457. Sorry, but the other item which Practical Electronics Shop Talk suggests we might supply is the IF Memory Back-up Capacitor, sorry we have no stocks of this item.

## THIS MONTH'S SPECIAL

### IT IS A DIGITAL MULTI-

**TESTER**, complete with backrest to stand it and hands-free test prod holder. This tester measures d.c. volts up to 1,000 and a.c. volts up to 750; d.c. current up to 10A and resistance up to 2 megs. Also tests transistors and diodes and has an internal buzzer for continuity tests. Comes complete with test prods, battery and instructions. Price £6.99. Order Ref: 7P29.



### YOUR CHANCE TO BUY SOME POPULAR LINES AT BARGAIN PRICES

**250W WOOFER.** Made by Challenger, this is 10in. 4 ohm, very high quality make. Our normal price £29, we are reducing to £20, which is almost a third off. Order Ref: 29P7L.

**200W WOOFER.** Again by Challenger, this is 8in. 4 ohm, our normal price £18 but it is reduced to £14 making it a terrific bargain. Order Ref: 18P81.

**9in. PHILIPS MONITOR.** In a Metal frame, made for the OPD computer, our normal price £15, now reduced to £12. Order Ref: 15P1L.

**100A TIME SWITCH.** Ex-electricity board, this is extra useful because it has a mechanism to keep it going should there be a power failure, and although 100A it will operate quite happily on 5A. Regular price £10, now reduced to £8. Order Ref: 10P14L.

**MOTORIZED DISPLAY.** This could control up to 120A of lighting or other equipment. The mains operated motor drives 12 x 10A microswitches, each of which can be set to come on at a different time, so giving running lights or other interesting displays. Regular price £10, reduced to £8. Order Ref: 1P191L.

**BRUSH TYPE MAINS MOTOR.** Probably ¼hp but being brush type it is easily speed controllable. Normal price £5, special offer price £4. Order Ref: 5P275L.

**SOLAR KITS.** To make an old fashioned gramophone which will operate in sunlight or under a light bulb. Normal price £7.50, reduced to £6. Order Ref: 7P16L.

**A SIMILAR SOLAR KIT.** This one makes a mono-plane, again £6. Order Ref: 7P18L.

**MOST USEFUL MAINS TRANSFORMER.** This is a 12V-0-12V 35W rated, has mounting legs so can stand directly on base panel, price £2.50. order Ref: 2.5P15.

**PROJECT BOX BARGAIN.** Colour beige and size approximately 250mm x 130mm wide and 50mm deep. Divides into 2 halves, held together by screws. It has ventilators in the top and bottom corners, but these are quite a decoration and give the box a pleasing look. Price £1. Order Ref: D201.

**5A BRIDGE RECTIFIER FOR 12V or 24V CHARGER.** With heatsink coupler if used on full current, 2 for £1. Order Ref: 1070.

**ENGINEERS BENCH PANEL.** This has 2 x 13A mains sockets which are switched and illuminated, thus saving you having to keep pulling out the plugs. Nicely cased, only £2. Order Ref: 2P461.

**OVEN THERMOSTAT** with knob calibrated so you can set it to cut out at any temperature up to 600 degrees F. Price £3. Order Ref: 3P229.

### BUY ONE GET ONE FREE

**ULTRASONIC MOVEMENT DETECTOR.** Nicely cased, free standing, has internal alarm which can be silenced. Also has connections for external speaker or light. Price £10. Order Ref: 10P154.

**CASED POWER SUPPLIES** which, with a few small extra components and a bit of modifying, would give 12V at 10A. Originally £9.50 each, now 2 for £9.50. Order Ref: 9.5P4.

**3-OCTAVE KEYBOARDS** with piano size keys, brand new, previous price £9.50, now 2 for the price of one. Order Ref: 9.5P5.

**RECHARGEABLE 12V JELLY ACID BATTERIES.** Yuasa 12V 2.3AH. These are 7in. long, 3in. high and 1½in. wide with robust terminals protruding through the top. Price £3.50. Order Ref: 3.5P11.

**DITTO**, but 12V 18AH. This is 7in. long, 7in. high and 3in. wide. Brand new with 12 months guarantee, price £12.50 or pack of 4 for £48, including VAT and carriage. Order Ref: 12.5P3.

Note - This battery will start a car and is ideal for golf trolleys, etc.

**CHARGER** for these batteries and other sealed lead acid batteries, £5. Order Ref: 5P269.

**RECHARGEABLE NICAD BATTERIES.** AA size, 25p each, which is a real bargain considering many firms charge as much as £2 each. These are in packs of 10, coupled together with an output lead so are a 12V unit but easily dividable into 2 x 6V or 10 x 1.2V. £2.50 per pack, 10 packs for £25 including carriage. Order Ref: 2.5P34.

### FOR QUICK HOOK-UPS.

You can't beat leads with a croc clip each end. You can have a set of 10 leads, 2 each of 5 assorted colours with insulated crocodile clips on each end. Lead length 36cm, £2 per set. Order Ref: 2P459.



### 1mA PANEL METER.

Approximately 80mm x 55mm, front engraved 0-100. Price £1.50 each. Order Ref: 1/16R2.

**VERY THIN DRILLS.** 12 assorted sizes vary between 0.6mm and 1.6mm. Price £1. Order Ref: 128.

**EVEN THINNER DRILLS.** 12 that vary between 0.1 and 0.5mm. Price £1. Order Ref: 129.

**TWIN TELEPHONE PLUG.** Enables you to plug 2 telephones into the one socket for all normal BT plugs. Price £1.50. Order Ref: 1.5P67.

**D.C. MOTOR WITH GEARBOX.** Size 60mm long, 30mm diameter. Very powerful, operates off any voltage between 6 and 24 D.C. Speed at 6V is 200 rpm, speed controller available. Special price £3 each. Order Ref: 3P108.

**MOST USEFUL POWER SUPPLY.** Rated at 9V 1A, this plugs into a 13A socket, is really nicely boxed. £2. Order Ref: 2P733.

**BT TELEPHONE EXTENSION WIRE.** This is proper heavy duty cable for running around the skirting board when you want to make a permanent extension. 4 cores properly colour coded, 25m length. Only £1. Order Ref: 1067.

**12V 8A DC POWER SUPPLY.** Totally enclosed with its own cooling fan. Normal mains operation. Price £11. order Ref: 11P6.

**TWIN 13A SWITCHED SOCKET.** Standard in all respects and complete with fixing screws. White, standard size and suitable for flush mounting or in a surface box. Price £1.50. Order Ref: 1.5P61.

**BIG 12V TRANSFORMER.** It is 55VA so that is over 4A which is normal working, intermittently it would be a much higher amperage. Beautiful transformer, well made and very well insulated, terminals are in a plastic frame so can't be accidentally touched. Price £3.50. Order Ref: 3.5P20.

## RELAYS

We have thousands of relays of various sorts in stock, so if you need anything special give us a ring. A few new ones that have just arrived are special in that they are plug-in and come complete with a special base which enables you to check voltages of connections of it without having to go underneath. We have 6 different types with varying coil voltages and contact arrangements. All contacts are rated at 10A 250V AC.

Coil Voltage	Contacts	Price	Order Ref:
12V DC	4-pole changeover	£2.00	FR10
12V DC	2-pole changeover	£1.50	FR11
24V DC	2-pole changeover	£1.50	FR12
24V DC	4-pole changeover	£2.00	FR13
240V AC	1-pole changeover	£1.50	FR14
240V AC	4-pole changeover	£2.00	FR15

Prices include base

**NOT MUCH BIGGER THAN AN OXO CUBE.** Another relay just arrived is extra small with a 12V coil and 6A changeover contacts. It is sealed so it can be mounted in any position or on a p.c.b. Price 75p each, 10 for £6 or 100 for £50. Order Ref: FR16.

### TERMS

Send cash, PO, cheque or quote credit card number - orders under £25 add £3.50 service charge.

**J & N FACTORS**  
**Pilgrim Works (Dept.E.E.)**  
**Stairbridge Lane, Bolney**  
**Sussex RH17 5PA**  
**Telephone: 01444 881965**

# DIRECT BOOK SERVICE



## ELECTRONICS TEACH-IN No. 7 ANALOGUE AND DIGITAL ELECTRONICS COURSE

(published by *Everyday Practical Electronics*)

Alan Winstanley and Keith Dye B.Eng(Tech)AMIEE

This highly acclaimed *EPE Teach-In* series, which included the construction and use of the *Mini Lab* and *Micro Lab* test and development units, has been put together in book form.

An interesting and thorough tutorial series aimed specifically at the novice or complete beginner in electronics. The series is designed to support those undertaking either GCSE Electronics or GCE Advanced Levels, and starts with fundamental principles.

If you are taking electronics or technology at school or college, this book is for you. If you just want to learn the basics of electronics or technology you must make sure you see it. *Teach-In No. 7* will be invaluable if you are considering a career in electronics or even if you are already training in one. The *Mini Lab* and software enable the construction and testing of both demonstration and development circuits. These learning aids bring electronics to life in an enjoyable and interesting way: you will both see and hear the electron in action! The *Micro Lab* microprocessor add-on system will appeal to higher level students and those developing micro-processor projects.

160 pages

Order code TI7

£3.95

## ELECTRONICS PROJECTS USING ELECTRONICS WORKBENCH plus FREE CD-ROM

M. P. Horsey

This book offers a wide range of tested circuit modules which can be used as electronics projects, part of an electronics course, or as a hands-on way of getting better acquainted with Electronics Workbench. With circuits ranging from 'bulbs and batteries' to complex systems using integrated circuits, the projects will appeal to novices, students and practitioners alike.

Electronics Workbench is a highly versatile computer simulation package which enables the user to design, test and modify their circuits before building them, and to plan PCB layouts on-screen. All the circuits in the book are provided as runnable Electronic Workbench files on the enclosed CD-ROM, and a selection of 15 representative circuits can be explored using the free demo version of the application.

Contents: Some basic concepts; Projects with switches, LEDs, relays and diodes; Transistors; Power supplies; Op.amp projects; Further op.amp circuits; Logic gates; Real logic circuits; Logic gate multivibrators; The 555 timer; Flip-flops, counters and shift registers; Adders, comparators and multiplexers; Field effect transistors; Thyristors, triacs and diacs; Constructing your circuit; Index.

227 pages

Order code NE29

£14.99

## A BEGINNER'S GUIDE TO MODERN ELECTRONIC COMPONENTS

R. A. Penfold

The purpose of this book is to provide practical information to help the reader sort out the bewildering array of components currently on offer. An advanced knowledge of the theory of electronics is not needed, and this book is not intended to be a course in electronic theory. The main aim is to explain the differences between components of the same basic type (e.g. carbon, carbon film, metal film, and wire-wound resistors) so that the right component for a given application can be selected. A wide range of components are included, with the emphasis firmly on those components that are used a great deal in projects for the home constructor.

170 pages

Order code BP285

£4.99

FREE  
CD-ROM

## PRACTICAL REMOTE CONTROL PROJECTS

Owen Bishop

Provides a wealth of circuits and circuit modules for use in remote control systems of all kinds; ultrasonic, infra-red, optical fibre, cable and radio. There are instructions for building fourteen novel and practical remote control projects. But this is not all, as each of these projects provides a model for building dozens of other related circuits by simply modifying parts of the design slightly to suit your own requirements. This book tells you how.

Also included are techniques for connecting a PC to a remote control system, the use of a microcontroller in remote control, as exemplified by the BASIC Stamp, and the application of ready-made type-approved 418MHz radio transmitter and receiver modules to remote control systems.

160 pages

Order code BP413

£5.99

## DISCOVERING ELECTRONIC CLOCKS

W. D. Phillips

This is a whole book about designing and making electronic clocks. You start by connecting HIGH and LOW logic signals to logic gates. You find out about and then build and test bistables, crystal-controlled astables, counters, decoders and displays. All of these subsystems are carefully explained, with practical work supported by easy to follow prototype board layouts.

Full constructional details, including circuit diagrams and a printed circuit board pattern, are given for a digital electronic clock. The circuit for the First Clock is modified and developed to produce additional designs which include a Big Digit Clock, Binary Clock, Linear Clock, Andrew's Clock (with a semi-analogue display), and a Circles Clock. All of these designs are unusual and distinctive.

This is an ideal resource for project work in GCSE *Design and Technology: Electronics Product*, and for project work in AS-Level and A-Level *Electronics and Technology*.

194 pages, A4 spiral bound

Order code DEP1

£16.50

## 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

£14.99

## 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

£19.99

## A BEGINNER'S GUIDE TO TTL DIGITAL ICs

R. A. Penfold

This book first covers the basics of simple logic circuits in general, and then progresses to specific TTL logic integrated circuits. The devices covered include gates, oscillators, timers, flip/flops, dividers, and decoder circuits. Some practical circuits are used to illustrate the use of TTL devices in the "real world".

142 pages

Order code BP332

£4.95

## ELECTRONIC MODULES AND SYSTEMS FOR BEGINNERS

Owen Bishop

This book describes over 60 modular electronic circuits, how they work, how to build them, and how to use them. The modules may be wired together to make hundreds of different electronic systems, both analogue and digital. To show the reader how to begin building systems from modules, a selection of over 25 electronic systems are described in detail, covering such widely differing applications as timing, home security, measurement, audio (including a simple radio receiver), games and remote control.

200 pages

Temporarily out of print

## 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-try" 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

£4.99

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 to your door. Full ordering details are given on the last book page.

FOR ANOTHER SELECTION OF BOOKS SEE  
THE NEXT TWO MONTHS' ISSUES.

Note our UK postage costs just £2.00 no matter how  
many books you order!

# Computing & Robotics

## WINDOWS 95 EXPLAINED

P. R. M. Oliver and N. Kantaris

If you would like to get up and running, as soon as possible, with the Windows 95 operating system, then this is the book for you.

The book was written with the non-expert, busy person in mind. It explains the hardware that you need in order to run Windows 95 successfully, and how to install and optimize your system's resources. It presents an overview of the Windows 95 environment.

Later chapters cover how to work with programs, folders and documents; how to control Windows 95 and use the many accessories that come with it; how to use DOS programs and, if necessary, DOS commands and how to communicate with the rest of the electronic world.

170 pages

Order code BP400

£5.95

## 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

£12.99

## 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.

Contents: Don't world changed in 1971; Microprocessors don't have ten fingers; More counting; Mathematical micros; It's all a matter of logic; Registers and memories; A microprocessor based system; A typical 8-bit microprocessor; Programming, High level languages; Micros are getting bigger and faster; The Pentium; The PowerPC; The Alpha 21164 microprocessor; Interfacing; Test equipment and fault finding.

222 pages

Order code NE31

£16.99



## Theory and Reference

### Bebop To The Boolean Boogie

By Clive (call me Max)  
Maxfield

ORDER CODE BEB1

**£24.95**

470 pages. Large format  
*Specially imported by EPE –  
Excellent value*

An Unconventional Guide to  
Electronics Fundamentals,  
Components and Processes

This book gives the "big picture" of digital electronics. This indepth, highly readable, up-to-the-minute guide shows you how electronic devices work and how they're made. You'll discover how transistors operate, how printed circuit boards are fabricated, and what the innards of memory ICs look like. You'll also gain a working knowledge of Boolean Algebra and Karnaugh Maps, and understand what Reed-Muller logic is and how it's used. And there's much, MUCH more (including a recipe for a truly great seafood gumbo!).

Hundreds of carefully drawn illustrations clearly show the important points of each topic. The author's tongue-in-cheek British humor makes it a delight to read, but this is a REAL technical book, extremely detailed and accurate. A great reference for your own shelf, and also an ideal gift for a friend or family member who wants to understand what it is you do all day. . . .

470 pages – large format

Order code BEB1

**£24.95**

**DIGITAL ELECTRONICS – A PRACTICAL APPROACH  
With FREE Software: Number One Systems – EASY-PC  
Professional XM and Pulsar (Limited Functionality)**

Richard Monk

Covers binary arithmetic, Boolean algebra and logic gates, combination logic, sequential logic including the design and construction of asynchronous and synchronous circuits and register circuits. Together with a considerable practical content plus the additional attraction of its close association with computer-aided design including the FREE software.

There is a 'blow-by-blow' guide to the use of EASY-PC Professional XM (a schematic drawing and printed circuit board design computer package). The guide also conducts the reader through logic circuit simulation using Pulsar software. Chapters on p.c.b. physics and p.c.b. production techniques make the book unique, and with its host of project ideas make it an ideal companion for the integrative assignment and common skills components required by BTEC and the key skills demanded by GNVQ. The principal aim of the book is to provide a straightforward approach to the understanding of digital electronics.

Those who prefer the 'Teach-In' approach or would rather experiment with some simple circuits should find the book's final chapters on printed circuit board production and project ideas especially useful.

250 pages

Order code NE28

**£16.99**

**DIGITAL GATES AND FLIP-FLOPS**

Ian R. Sinclair

This book, intended for enthusiasts, students and technicians, seeks to establish a firm foundation in digital electronics by treating the topics of gates and flip-flops thoroughly and from the beginning.

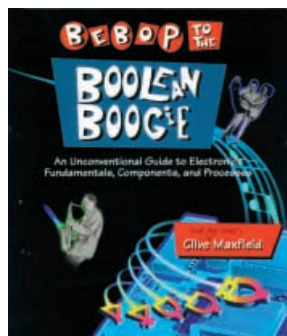
Topics such as Boolean algebra and Karnaugh mapping are explained, demonstrated and used extensively, and more attention is paid to the subject of synchronous counters than to the simple but less important ripple counters.

No background other than a basic knowledge of electronics is assumed, and the more theoretical topics are explained from the beginning, as also are many working practices. The book concludes with an explanation of micro-processor techniques as applied to digital logic.

200 pages

Order code PC106

**£8.95**



### Bebop Bytes Back

By Clive "Max" Maxfield  
and Alvin Brown

ORDER CODE BEB2

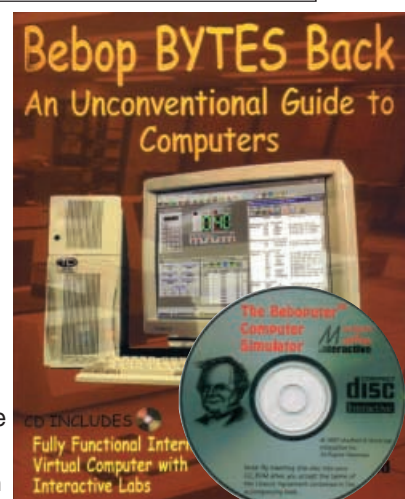
**£29.95**

Over 500 pages. Large  
format

*Specially imported by  
EPE – Excellent value*

An Unconventional Guide  
To Computers

Plus FREE CD-ROM which  
includes: Fully Functional  
Internet-Ready Virtual  
Computer with Interactive  
Labs



FREE  
CD-ROM

This follow-on to *Bebop to the Boolean Boogie* is a multimedia extravaganza of information about how computers work. It picks up where "Bebop I" left off, guiding you through the fascinating world of computer design . . . and you'll have a few chuckles, if not belly laughs, along the way. In addition to over 200 megabytes of mega-cool multimedia, the accompanying CD-ROM (for Windows 95 machines only) contains a virtual microcomputer, simulating the motherboard and standard computer peripherals in an extremely realistic manner. In addition to a wealth of technical information, myriad nuggets of trivia, and hundreds of carefully drawn illustrations, the book contains a set of lab experiments for the virtual microcomputer that let you recreate the experiences of early computer pioneers. If you're the slightest bit interested in the inner workings of computers, then don't dare to miss this one!

Over 500 pages – large format

Order code BEB2

**£29.95**

**NEWNES INTERACTIVE ELECTRONIC CIRCUITS CD-ROM**

**CD-ROM**

Edited by Owen Bishop

An expert adviser, an encyclopedia, an analytical tool and a source of real design data, all in one CD-ROM. Written by leading electronics experts, the collected wisdom of the electronics world is at your fingertips. The simple and attractive Circuits Environment<sup>TM</sup> is designed to allow you to find the circuit or advice notes of your choice quickly and easily using the search facility. The text is written by leading experts as if they were explaining the points to you face to face. Over 1,000 circuit diagrams are presented in a standardised form, and you are given the option to analyse them by clicking on the Action icon. The circuit groups covered are: Amplifiers, Oscillators, Power, Sensing, Signal Processing, Filters, Measurement, Timing, Logic Circuits, Telecommunications.

The analysis tool chosen is SpiceAge for Windows, a powerful and intuitive application, a simple version of which automatically bursts into action when selected.

Newnes Interactive Electronic Circuits allows you to: analyse circuits using top simulation program SpiceAge; test your design skills on a selection of problem circuits; clip comments to any page and define bookmarks; modify component values within the circuits; call up and display useful formulae which remain on screen; look up over 100 electronic terms in the glossary; print and export netlists.

System Requirements: PC running Windows 3.x, 95 or NT on a 386 or better processor. 4MB RAM, 8MB disk space.

Order code NE-CD1

## Audio and Music

**AN INTRODUCTION TO LOUSPEAKERS AND  
ENCLOSURE DESIGN**  
V. Capel

This book explores the various features, good points and snags of speaker designs. It examines the whys and wherefores so that the reader can understand the principles involved and so make an informed choice of design, or even design loudspeaker enclosures for him – or herself. Crossover units are also explained, the various types, how they work, the distortions they produce and how to avoid them. Finally there is a step-by-step description of the construction of the Kapellmeister loudspeaker enclosure.

148 pages

Order code BP256

**£3.99**

**PREAMPLIFIER AND FILTER CIRCUITS**

R. A. Penfold

This book provides circuits and background information for a range of preamplifiers, plus tone controls, filters, mixers, etc. The use of modern low noise operational amplifiers and a specialist high performance audio preamplifier i.c. results in circuits that have excellent performance, but which are still quite simple. All the circuits featured can be built at quite low cost (just a few pounds in most cases). The preamplifier circuit featured includes: Microphone preamplifiers (low

impedance, high impedance, and crystal). Magnetic cartridge pick-up preamplifiers with R.I.A.A. equalisation. Crystal/ceramic pick-up preamplifier. Guitar pick-up preamplifier. Tape head preamplifier (for use with compact cassette systems).

Other circuits include: Audio limiter to prevent overloading of power amplifiers. Passive tone controls. Active tone controls. PA filters (highpass and lowpass). Scratch and rumble filters. Loudness filter. Audio mixers. Volume and balance controls.

92 pages

Order code BP309

**£3.99**

**HIGH POWER AUDIO AMPLIFIER CONSTRUCTION**

R. A. Penfold

Practical construction details of how to build a number of audio power amplifiers ranging from about 50 to 300/400 watts r.m.s. includes MOSFET and bipolar transistor designs.

96 pages

Order code BP277

**£3.99**

**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 in this respect.

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

**£9.95**



# Testing, Theory, Data and Reference

## 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 **Order code NE27** **£19.99**

## 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 (large format) **Order code NE23** **£12.99**

## TRANSISTOR DATA TABLES

Hans-Günther Steidle

The tables in this book contain information about the package shape, pin connections and basic electrical data for each of the many thousands of transistors listed. The data includes maximum reverse voltage, forward current and power dissipation, current gain and forward transmittance and resistance, cut-off frequency and details of applications.

A book of this size is of necessity restricted in its scope, and the individual transistor types cannot therefore be described in the sort of detail that maybe found in some larger and considerably more expensive data books. However, the list of manufacturers' addresses will make it easier for the prospective user to obtain further information, if necessary.

Lists over 8,000 different transistors, including f.e.t.s.

200 pages **Order code BP401** **£5.95**

## ELECTRONIC TEST EQUIPMENT HANDBOOK

Steve Money

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 the instruments are also examined.

Everything from Oscillators, through R, C & L measurements (and much more) to Waveform Generators and testing Zeners.

206 pages **Order code PC109** **£8.95**

## 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** **£2.95**

## NEWNES ELECTRONICS TOOLKIT – SECOND EDITION

Geoff Phillips

The author has used his 30 years experience in industry to draw together the basic information that is constantly demanded. Facts, formulae, data and charts are presented to help the engineer when designing, developing, evaluating, fault finding and repairing electronic circuits. The result is this handy workmate volume: a memory aid, tutor and reference source which is recommended to all electronics engineers, students and technicians.

Have you ever wished for a concise and comprehensive guide to electronics concepts and rules of thumb? Have you ever been unable to source a component, or choose between two alternatives for a particular application? How much time do you spend searching for basic facts or manufacturer's specifications? This book is the answer, it covers resistors, capacitors, inductors, semiconductors, logic circuits, EMC, audio, electronics and music, telephones, electronics in lighting, thermal considerations, connections, reference data.

158 pages **Order code NE20** **£14.99**

## PRACTICAL ELECTRONIC FAULT FINDING AND TROUBLESHOOTING

Robin Pain

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 specialized.

The book covers: **Basics** – Voltage, current and resistance; Capacitance, inductance and impedance; Diodes and transistors; Op-amps and negative feedback; **Fault finding** – Analogue fault finding, Digital fault finding; Memory; Binary and hexadecimal; Addressing; Discrete logic; Microprocessor action; I/O control; CRT control; Dynamic RAM; Fault finding digital systems; Dual trace oscilloscope; IC replacement.

274 pages **Order code NE22** **£18.99**

## AN INTRODUCTION TO LIGHT IN ELECTRONICS

F. A. Wilson

This book is not for the expert but neither is it for the completely uninitiated. It is assumed the reader has

some basic knowledge of electronics. After dealing with subjects like Fundamentals, Waves and Particles and The Nature of Light such things as Emitters, Detectors and Displays are discussed. Chapter 7 details four different types of Lasers before concluding with a chapter on Fibre Optics.

161 pages **Order code BP359** **£4.95**

## UNDERSTANDING DIGITAL TECHNOLOGY

F. A. Wilson C.G.I.A., C.Eng., F.I.E.E., F.I. Mgt.

This book examines what digital technology has to offer and then considers its arithmetic and how it can be arranged for making decisions in so many processes. It then looks at the part digital has to play in the ever expanding information technology, especially in modern transmission systems and television. It avoids getting deeply involved in mathematics.

Various chapters cover: Digital Arithmetic, Electronic Logic, Conversions between Analogue and Digital Structures, Transmission Systems. Several Appendices explain some of the concepts more fully and a glossary of terms is included.

183 pages **Order code BP376** **£4.95**

# 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:

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** **£4.95**

## 45 SIMPLE ELECTRONIC TERMINAL BLOCK PROJECTS

R. Bebbington

Contains 45 easy-to-build electronic projects that can be constructed, by an absolute beginner, on terminal blocks using only a screwdriver and other simple hand tools. No soldering is needed.

Most of the projects can be simply screwed together, by following the layout diagrams, in a matter of minutes and readily unscrewed if desired to make new circuits. A theoretical circuit diagram is also included with each project to help broaden the constructor's knowledge.

The projects included in this book cover a wide range of interests under the chapter headings: Connections and Components, Sound and Music, Entertainment, Security Devices, Communication, Test and Measuring.

163 pages **Order code BP378** **£4.95**

## 30 SIMPLE IC TERMINAL BLOCK PROJECTS

R. Bebbington

Follow on from BP378 using ICs.

117 pages **Order code BP379** **£4.99**

## HOW TO DESIGN AND MAKE YOUR OWN P.C.B.S

R. A. Penfold

Deals with the simple methods of copying printed circuit board designs from magazines and books and covers all aspects of simple p.c.b. construction including photographic methods and designing your own p.c.b.s.

80 pages **Order code BP121** **£3.99**

## IC555 PROJECTS

E. A. Parr

Every so often a device appears that is so useful that one wonders how life went on before without it. The 555 timer is such a device. It was first manufactured by Signetics, but is now manufactured by almost every semiconductor manufacturer in the world and is inexpensive and very easily obtainable.

Included in this book are over 70 circuit diagrams and descriptions covering basic and general circuits, motor car and model railway circuits, alarms and noise makers as well as a section on 556, 558 and 559 timers. (Note. No construction details are given.)

A reference book of invaluable use to all those who have any interest in electronics, be they professional engineers or designers, students of hobbyists.

167 pages **Order code BP44** **£3.99**

# BOOK ORDERING DETAILS

**Our postage price is the same no matter how many books you order, just add £2.00 to your total order for postage and packing (overseas readers add £4 for countries in the EEC, or add £7 for all countries outside the EEC, surface mail postage) and send a PO, cheque, international money order (£ sterling only) made payable to **Direct Book Service** or credit card details, Visa or Mastercard – minimum credit card order is £5 – to: **DIRECT BOOK SERVICE, ALLEN HOUSE, EAST BOROUGH, WIMBORNE, DORSET BH21 1PF.****

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.**  
**DIRECT BOOK SERVICE IS A DIVISION OF WIMBORNE PUBLISHING LTD.**

Tel 01202 881749 Fax 01202 841692.

E-mail: [dbbs@epemag.wimborne.co.uk](mailto:dbbs@epemag.wimborne.co.uk)

# BOOK ORDER FORM

Full name: .....

Address: .....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

Please continue on separate sheet of paper if necessary



Pages	Issue	Pages	Issue
1-80	January	481-560	July
81-152	February	561-640	August
153-232	March	641-712	September
233-320	April	713-792	October
3211-400	May	793-8722	November
401-480	June	873-952	December

### CONSTRUCTIONAL PROJECTS

ACTIVE FERRITE LOOP AERIAL <i>by Raymond Haigh</i>	672	METER, g-	504
AERIAL, ACTIVE FERRITE LOOP	672	METER, LOW-COST CAPACITANCE	344
ALARM, FRIDGE/FREEZER	764	MIC/AUDIO PREAMPLIFIER, VERSATILE	332
ALARM, OPTO-, SYSTEM	820	MICRO-PICSCOPE <i>by John Becker</i>	274
AMP, HANDY	572	MONITOR, VOLTAGE	102
ATMOSPHERIC ELECTRICITY DETECTOR <i>by Keith Garwell</i>	412, 546	MOODLOOP FIELD STRENGTH INDICATOR, EPE	781
AUDIO PREAMPLIFIER, VERSATILE MIC/	332	MOODLOOP POWER SUPPLY, EPE	682
AUTOMATIC NIGHTLIGHT <i>by Robert Penfold</i>	430	MOODLOOP, EPE	602
AUTOMATIC TRAIN SIGNAL <i>by Robert Penfold</i>	188	MOTORISTS' BUZZ-BOX <i>by Terry de Vaux-Balbirnie</i>	930
		MULTI-CHANNEL TRANSMISSION SYSTEM <i>by Andy Flind</i>	360, 464
BLANKER, SCRATCH	38	NIGHTLIGHT, AUTOMATIC	430
BURGLAR ALARM, VERSATILE	22	OPTO-ALARM SYSTEM <i>by Stephen Spencer</i>	820
BUZZ-BOX, MOTORISTS'	930		
CAMERA SHUTTER TIMER <i>by Robert Penfold</i>	492	PARKING WARNING SYSTEM <i>by Tom Webb</i>	164
CANUTE TIDE PREDICTOR <i>by John Becker</i>	440	PERFORMANCE REGENERATIVE RECEIVER, HIGH	174, 300
CAPACITANCE METER, LOW-COST	344	PIC DUAL-CHAN VIRTUAL SCOPE <i>by John Becker</i>	752
CHECKER, PIR LIGHT	374	PIC-GEN FREQUENCY GENERATOR/COUNTER <i>by John Becker</i>	515
CHRISTMAS BUBBLE <i>by Owen Bishop</i>	(Dec '00 Supp. 5)	PIC-MONITORED DUAL PSU Part 1 <i>by John Becker</i>	884
CHRISTMAS TREE LIGHTS FADER	(Dec '00 Supp. 7)	PIC PULSOMETER <i>by Richard Hinckley</i>	828
CLEANER, PIC VIDEO	114	PICSCOPE, MICRO-	274
CONTROL, IR DECODER, REMOTE	698	PICTOGRAM <i>by Andy Flind</i>	(Dec '00 Supp. 13)
CONTROLLER, EASY-TYPIST TAPE	92	PIC TOOLKIT MK2 UPDATE V2.4 <i>by John Becker</i>	838
COUNTER, PIC-GEN FREQUENCY GENERATOR/	515	PIC VIDEO CLEANER <i>by Mike Delaney</i>	114
		PIR LIGHT CHECKER <i>by Terry de Vaux-Balbirnie</i>	374
DECODER, REMOTE CONTROL IR	698	POWER SUPPLY, EPE MOODLOOP	682
DETECTOR, ATMOSPHERIC ELECTRICITY	412, 546	POWER SUPPLY UNIT, PIC-MONITORED DUAL	884
DETECTOR, STATIC FIELD	894	PREAMPLIFIER, VERSATILE MIC/ AUDIO	332
DON'T LOSE IT!, FIND IT	140	PREDICTOR, CANUTE TIDE	440
DOOR PROTECTOR <i>by Owen Bishop</i>	624	PROTECTOR, DOOR	624
DUAL-CHAN VIRTUAL SCOPE, PIC	752	PULSOMETER, PIC	828
		QUIZ GAME INDICATOR <i>by Max Horsey and Tom Webb</i>	598
EASY-TYPIST TAPE CONTROLLER <i>by Andy Flind</i>	92		
ELECTRICITY DETECTOR, ATMOSPHERIC	412, 546	RECEIVER, HIGH PERFORMANCE REGENERATIVE	174, 300
EPE ICEBREAKER <i>by Mark Stuart</i>	193	REGENERATIVE RECEIVER, HIGH PERFORMANCE	174, 300
EPE MOODLOOP <i>by Andy Flind</i>	602	REMOTE CONTROL IR DECODER <i>by Roger Thomas</i>	698
EPE MOODLOOP FIELD STRENGTH INDICATOR <i>by Andy Flind</i>	781		
EPE MOODLOOP POWER SUPPLY <i>by Andy Flind</i>	682	SAMPLE-AND-HOLD <i>by Owen Bishop</i>	804
		SCOPE, PIC DUAL-CHAN VIRTUAL	752
FERRITE LOOP AERIAL, ACTIVE	672	SCRATCH BLANKER <i>by Robert Penfold</i>	38
FESTIVE FADER <i>by Steve Dellow</i>	(Dec '00 Supp. 7)	SHUTTER TIMER, CAMERA	492
FIELD DETECTOR, STATIC	894	SIGNAL, AUTOMATIC TRAIN	188
FIELD STRENGTH INDICATOR, EPE MOODLOOP	781	SLAVE, FLASH	246
FIND IT - DON'T LOSE IT! <i>by Terry de Vaux-Balbirnie</i>	140	SNOWMAN, FLASHING	12
FLASH SLAVE <i>by Robert Penfold</i>	246	STAR, TWINKLING	(Dec '00 Supp. 1)
FLASHING SNOWMAN <i>by Robert Penfold</i>	12	STATIC FIELD DETECTOR <i>by Robert Penfold</i>	894
FREQUENCY GENERATOR/COUNTER, PIC-GEN	515	STEEPLECHASE GAME <i>by Owen Bishop</i>	652
FRIDGE/FREEZER ALARM <i>by Owen Bishop</i>	764	SWITCH, HANDCLAP	864
FROST BOX, VEHICLE	66	SYSTEM, MULTI-CHANNEL TRANSMISSION	360, 464
		SYSTEM, PARKING WARNING	164
g-METER <i>by Bill Mooney</i>	504		
GAME INDICATOR, QUIZ	598	TAPE CONTROLLER, EASY-TYPIST	92
GAME, STEEPLECHASE	652	TIDE PREDICTOR, CANUTE	440
GARAGE LINK <i>by Terry de Vaux-Balbirnie</i>	255	TIMER, CAMERA SHUTTER	492
GENERATOR/COUNTER, PIC-GEN FREQUENCY	515	TOOLKIT MK2 UPDATE V2.4, PIC	838
		TORCH, WIND-UP	724
HANDCLAP SWITCH <i>by Tom Webb</i>	864	TRAIN SIGNAL, AUTOMATIC	188
HANDY-AMP <i>by Terry de Vaux-Balbirnie</i>	572	TRANSMISSION SYSTEM, MULTI-CHANNEL	360, 464
HIGH PERFORMANCE REGENERATIVE RECEIVER		TWINKLING STAR <i>by Bart Trepak</i>	(Dec '00 Supp. 1)
<i>by Raymond Haigh</i>	174, 300		
ICEBREAKER, EPE	193	VEHICLE FROST BOX <i>by Steve Dellow</i>	66
INDICATOR, EPE MOODLOOP FIELD STRENGTH	781	VERSATILE BURGLAR ALARM <i>by Ian March</i>	22
INDICATOR, QUIZ GAME	598	VERSATILE MIC/AUDIO PREAMPLIFIER <i>by Raymond Haigh</i>	332
IR DECODER, REMOTE CONTROL	698	VIDEO CLEANER, PIC	114
		VIRTUAL SCOPE, PIC DUAL-CHAN	752
L.E.D. FLASHER, PICTOGRAM	(Dec '00 Supp. 13)	VOLTAGE MONITOR <i>by Robert Penfold</i>	102
LIGHT CHECKER, PIR	374		
LIGHT, AUTOMATIC NIGHT	430	WARNING SYSTEM, PARKING	164
LINK, GARAGE	255	WIND-UP TORCH <i>by Thomas Scarborough</i>	724
LOOP AERIAL, ACTIVE FERRITE	672		
LOSE IT!, FIND IT - DON'T	140		
LOW-COST CAPACITANCE METER <i>by Robert Penfold</i>	344		

### GENERAL FEATURES

CAVE ELECTRONICS <i>by Mike Bedford</i>	610	QUASAR KITS REVIEW <i>by Robert Penfold</i>	938
PEAK ATLAS COMPONENT ANALYSER REVIEW <i>by Andy Flind</i>	770	TELCAN HOME VIDEO <i>by Barrie Blake-Coleman</i>	314
PIC LOGICATOR REVIEW <i>by Robert Penfold</i>	858	TINA PRO REVIEW <i>by Mike Tooley BA</i>	54
PICO DrDAQ REVIEWED <i>by Robert Penfold</i>	526		



## SPECIAL SERIES

<b>CIRCUIT SURGERY</b> by Alan Winstanley and Ian Bell	75, 122, 219, 306, 380, 470, 502, 617, 686, 747, 814, 908	Low Cost AA to PP3 Converter	61
Assault and Ni-Cad Battery	687	Macrovision Blanker	811
Battery Flattery	382	Mini Disc Optical Interface	143
Beginner's Questions	686	Mini Photo Slave Flash	768
Biased Approach	306	Missed Call Indicator	903
Bistable Switches	122	Multi-Purpose A.C. Detector/Switch	523
Checking the Chips	502	Musical Chip Amplifier	524
Circuit Breakers	814	Narrow SCSI Active Terminator	525
Common Ground	686	Omnidirectional Pendulum	281
Conventional Current Flow	221	Paper, Stone, Scissors Game	903
Down with Heavy Metal	687	PC Controlled D.C. Motor	280
Earthy Feelings	748	PIC Adaptor Socket	201
Fault Finding	470	PIC UPS	678
Ferric Disposal	687	PICO Prize Winners	423
Gas Gauge Chips	687	Radio Sleep Timer	679
Get Wise about Piecewise and Lambda	617	Scissors, Paper, Stone Game	903
Hot Regulator	220	'Scope Synchroniser	679
Keep Soldering On	747	Sensitive Hall Effect Switch	342
Low Voltage Detector	503	Shaky Dice	202
More on Op.amps – Electrical Ratings	76	Single-Phase Power Regulator	810
Noise Source	123	Square Wave Circuit	583
Op.amp Differentials	219	Stone, Paper, Scissors Game	903
Op.amps – Getting Loaded	306	VCO Generator	143
Op.amps – Outputs and short-circuit protection	380	Versatile Car Interior Light Delay	524
Op.amps – Signal Handling	123	Voltage Booster	422
P.C.B. track widths	815	VOM Continuity Buzzer	583
RAM your Batteries	687	555 Power Supply	201
Royer Converter	908		
Shocking Stuff	686	<b>PRACTICALLY SPEAKING</b> by Robert Penfold	58, 227, 390, 510, 694
Socket to Me	307	Front panel labels for projects	510
Surface-Mount Selection	308	Mains power projects	58
Switched Mode Supplies	908	Project building	694
Teach-In Amplifiers	75	Resistors and potentiometers	227
Testing transistors the quick and easy way	747	Using stripboard	390
		<b>SCHMITT TRIGGERS</b> by Anthony H. Smith	842, 913
<b>INTERFACE</b> by Robert Penfold	120, 272, 424, 630, 734, 926	1. Bipolar Transistor triggers	842
Bidirectional Printer Ports	272	2. Op.Amp and Comparator triggers	913
Digital and Analogue Temperature PC Interface	734		
Extended Temperature PC Interface Software	926	<b>TEACH-IN 2000</b> by John Becker	30, 128, 206, 290, 384, 465, 534, 584, 662, 736
Four-Range Resistance Meter PC Interface	630	3 – Potentiometers, Sensor Resistors, Ohm's Law	30
Obtaining power from a PC's serial and parallel ports	424	4 – Diodes and L.E.D.s	128
12-Bit serial ADC using the AD7896	120	5 – Waveforms, Frequency and Time	206
		6 – Logic Gates, Binary and Hex Logic	290
<b>INGENUITY UNLIMITED</b> hosted by Alan Winstanley	61, 143, 201, 280, 342, 422, 523, 582, 678, 766, 810, 902	7 – Op.amps	384
Air-Flow Detector	423	8 – Comparators, Mixers, Audio and Sensor Amplifier	465
Anti-Tamper Loop Alarm	766	9 – Transistors	534
Auditory Illusion	343	10 – Transformers and Rectifiers	584
Bidirectional Printer Port	202	11 – Voltage Regulation, Integration, Differentiation	662
Brushless Fan Speed Control	283	12 – 7-Segment Displays, L.C.D.s, Digital-to-Analogue, Miscellany	736
Car Wash-Wipe Latch	902		
Clock Detector	423	<b>TECHNOLOGY TIMELINES</b> by Clive "Max" Maxfield and Alvin Brown	106, 182, 266, 350, 434
Colour TV Tester Add-On	768	1 – Days of Yore	106
Cool Controller	582	2 – Days of Later Yore, plus Fundamental 20th Century Electronics	182
Delay-On Timer	201	3 – Communications and Related Technologies 1900 – 1999	266
Doorbell Extension and Entry/Exit Indicator	767	4 – Computing – 1900 to 2000	350
Electric Garage Door Status Indicator	62	5 – Crystal Balls!	434
Experimenter's Power Supply	343		
Infra-red Remote Tester	342		
Loudener	678		

## REGULAR FEATURES

<b>EDITORIAL</b>	11, 91, 163, 245, 331, 411, 491, 571, 661, 723, 803, 883	<b>NEWS – plus reports by Barry Fox</b>	19, 99, 171, 249, 339, 419, 499, 578, 655, 730, 807, 892
<b>NET WORK – THE INTERNET PAGE</b> surf'd by Alan Winstanley	28, 148, 214, 264, 348, 428, 512, 592, 702, 774, 841, 929	<b>READOUT</b> addressed by John Becker	49, 105, 179, 285, 369, 449, 549, 622, 658, 761, 817, 905
<b>NEW TECHNOLOGY UPDATE</b> by Ian Poole	16, 96, 168, 252, 358, 426, 530, 580, 660, 744, 812, 924	<b>SHOPTALK</b> with David Barrington	15, 136, 202, 283, 382, 468, 521, 627, 688, 728, 854

## SPECIAL OFFERS AND SERVICES

<b>ADVERTISERS INDEX</b>	80,192, 232, 320, 480, 400, 560, 640, 712, 792, 872, 952	<b>ELECTRONICS MANUALS</b>	64, 138, 216, 304, 392, 472, 554, 628, 670, 778, 850, 922
<b>BACK ISSUES</b> Some now on CD-ROM	26, 146, 222, 262, 366, 462, 544, 595, 696, 776, 856, 899	<b>ELECTRONICS VIDEOS</b>	70, 147, 226, 313, 368, 469, 556, 594, 690, 746, 806, 949
<b>CD-ROMS FOR ELECTRONICS</b>	52, 126, 254, 288, 372, 452, 532, 620, 692, 772, 852, 940	<b>PRINTED CIRCUIT BOARD AND SOFTWARE SERVICE</b>	77, 149, 229, 308, 397, 477, 557, 637, 709, 788, 868, 946
<b>CHRISTMAS PROJECTS SUPPLEMENT</b> (Dec '00)	between pages 912/913	<b>GIANT TECHNOLOGY TIMELINES CHART</b>	between pages 360/361
<b>DIRECT BOOK SERVICE</b>	72, 144, 223, 310, 394, 474, 551, 634, 704, 785, 861, 943	<b>GIANT TRANSISTOR DATA CHART</b>	between pages 832/833

# VIDEOS ON ELECTRONICS

A range of videos selected by *EPE* and designed to provide instruction on electronics theory. Each video gives a sound introduction and grounding in a specialised area of the subject. The tapes make learning both easier and more enjoyable than pure textbook or magazine study. They have proved particularly useful in schools, colleges, training departments and electronics clubs as well as to general hobbyists and those following distance learning courses etc



## BASICS

**VT201 to VT206 is a basic electronics course and is designed to be used as a complete series, if required.**

**VT201** 54 minutes. Part One; **D.C. Circuits.** This video is an absolute must for the beginner. Series circuits, parallel circuits, Ohms law, how to use the digital multimeter and much more.

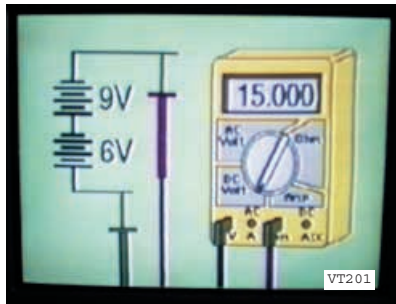
**Order Code VT201**

**VT202** 62 minutes. Part Two; **A.C. Circuits.** This is your next step in understanding the basics of electronics. You will learn about how coils, transformers, capacitors, etc are used in common circuits.

**Order Code VT202**

**VT203** 57 minutes. Part Three; **Semiconductors.** Gives you an exciting look into the world of semiconductors. With basic semiconductor theory. Plus 15 different semiconductor devices explained.

**Order Code VT203**



**VT204** 56 minutes. Part Four; **Power Supplies.** Guides you step-by-step through different sections of a power supply.

**Order Code VT204**

**VT205** 57 minutes. Part Five; **Amplifiers.** Shows you how amplifiers work as you have never seen them before. Class A, class B, class C, op.amps. etc.

**Order Code VT205**

**VT206** 54 minutes. Part Six; **Oscillators.** Oscillators are found in both linear and digital circuits. Gives a good basic background in oscillator circuits.

**Order Code VT206**

**£34.95** each  
inc. VAT & postage

Order 8 or more get one extra FREE  
Order 16 get two extra FREE

## VCR MAINTENANCE

**VT102** 84 minutes: Introduction to VCR Repair. Warning, not for the beginner. Through the use of block diagrams this video will take you through the various circuits found in the NTSC VHS system. You will follow the signal from the input to the audio/video heads then from the heads back to the output.

**Order Code VT102**

**VT103** 35 minutes: A step-by-step easy to follow procedure for professionally cleaning the tape path and replacing many of the belts in most VHS VCR's. The viewer will also become familiar with the various parts found in the tape path.

**Order Code VT103**

## DIGITAL

Now for the digital series of six videos. This series is designed to provide a good grounding in digital and computer technology.

**VT301** 54 minutes. Digital One; **Gates** begins with the basics as you learn about seven of the most common gates which are used in almost every digital circuit, plus Binary notation.

**Order Code VT301**

**VT302** 55 minutes. Digital Two; **Flip Flops** will further enhance your knowledge of digital basics. You will learn about Octal and Hexadecimal notation groups, flip-flops, counters, etc.

**Order Code VT302**

**VT303** 54 minutes. Digital Three; **Registers and Displays** is your next step in obtaining a solid understanding of the basic circuits found in today's digital designs. Gets into multiplexers, registers, display devices, etc.

**Order Code VT303**

**VT304** 59 minutes. Digital Four; **DAC and ADC** shows you how the computer is able to communicate with the real world. You will learn about digital-to-analogue and analogue-to-digital converter circuits.

**Order Code VT304**

**VT305** 56 minutes. Digital Five; **Memory Devices** introduces you to the technology used in many of today's memory devices. You will learn all about ROM devices and then proceed into PROM, EPROM, EEPROM, SRAM, DRAM, and MBM devices.

**Order Code VT305**

**VT306** 56 minutes. Digital Six; **The CPU** gives you a thorough understanding in the basics of the central processing unit and the input/output circuits used to make the system work.

**Order Code VT306**

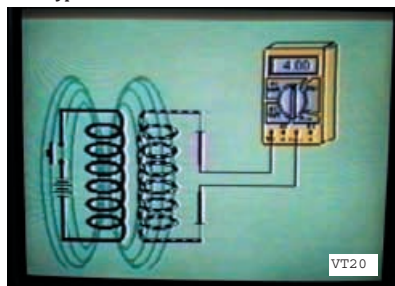
## RADIO

**VT401** 61 minutes. **A.M. Radio Theory.** The most complete video ever produced on a.m. radio. Begins with the basics of a.m. transmission and proceeds to the five major stages of a.m. reception. Learn how the signal is detected, converted and reproduced. Also covers the Motorola C-QUAM a.m. stereo system.

**Order Code VT401**

**VT402** 58 minutes. **F.M. Radio Part 1.** F.M. basics including the functional blocks of a receiver. Plus r.f. amplifier, mixer oscillator, i.f. amplifier, limiter and f.m. decoder stages of a typical f.m. receiver.

**Order Code VT402**



**VT403** 58 minutes. **F.M. Radio Part 2.** A continuation of f.m. technology from Part 1. Begins with the detector stage output, proceeds to the 19kHz amplifier, frequency doubler, stereo demultiplexer and audio amplifier stages. Also covers RDS digital data encoding and decoding.

**Order Code VT403**

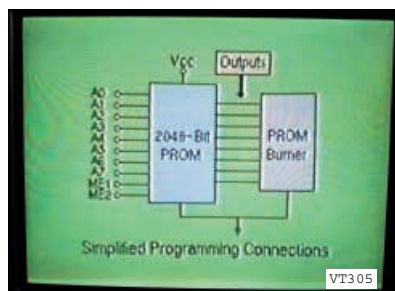
## MISCELLANEOUS

**VT501** 58 minutes. **Fibre Optics.** From the fundamentals of fibre optic technology through cable manufacture to connectors, transmitters and receivers.

**Order Code VT501**

**VT502** 57 minutes. **Laser Technology** A basic introduction covering some of the common uses of laser devices, plus the operation of the Ruby Rod laser, HeNe laser, CO<sub>2</sub> gas laser and semiconductor laser devices. Also covers the basics of CD and bar code scanning.

**Order Code VT502**



Each video uses a mixture of animated current flow in circuits plus text, plus cartoon instruction etc., and a very full commentary to get the points across. The tapes are imported by us and originate from VCR Educational Products Co, an American supplier. We are the worldwide distributors of the PAL and SECAM versions of these tapes. (All videos are to the UK PAL standard on VHS tapes unless you specifically request SECAM versions.)

**ORDERING: Price includes postage to anywhere in the world.**

**OVERSEAS ORDERS:** We use the VAT portion of the price to pay for airmail postage and packing, wherever you live in the world. Just send £34.95 per tape. All payments in £ sterling only (send cheque or money order drawn on a UK bank). Make cheques payable to Direct Book Service.

**Visa and Mastercard** orders accepted – please give card number, card expiry date and cardholder's address if different from the delivery address.

Orders are normally sent within seven days but please allow a maximum of 28 days, longer for overseas orders.

**Send your order to: Direct Book Service, Allen House, East Borough, Wimborne, Dorset BH21 1PF**

Direct Book Service is a division of Wimborne Publishing Ltd., Publishers of *EPE*

**Tel: 01202 881749. Fax: 01202 841692**

Due to the cost we cannot reply to overseas orders or queries by Fax.

**E-mail: dbs@epemag.wimborne.co.uk**

Everyday Practical Electronics reaches twice as many UK readers as any other UK monthly hobby electronics magazine, our audited sales figures prove it. We have been the leading independent monthly magazine in this market for the last fifteen 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 £8 (+VAT) per single column centimetre (minimum 2.5cm). The prepaid rate for classified adverts is 30p (+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.

Valve Output Transformers: Single ended 50mA, £4.50; push/pull 15W, £27; 30W, £32; 50W, £38; 100W, £53. Mains Transformers: Sec 220V 30mA 6V 1A, £3; 250V 60mA 6V 2A, £5; 250V 80mA 6V 2A, £6. High Voltage Caps: 50µF 350V, 68µF 500V, 150µF 385V, 330µF 400V, 470µF 385V, all £3 ea., 32+32µF 450V £5. Postage extra.  
Record Decks and Spares: BSR, Garrard, Goldring, motors, arms, wheels, headshells, spindles, etc. Send or phone your want list for quote.

**RADIO COMPONENT SPECIALISTS**

**337 WHITEHORSE ROAD, CROYDON SURREY, CR0 2HS. Tel: (020) 8684 1665**  
Lots of transformers, high volt caps, valves, output transformers, speakers, in stock. Phone or send your wants list for quote.

**Z88** NOW AVAILABLE WITH 128K AND 512K - OZ4

**ALSO SPECTRUM AND QL PARTS**  
**W. N. RICHARDSON & CO.**

PHONE/FAX 01494 8713196  
RAVENSMED, CHALFONT ST PETER, BUCKS, SL9 0NB

**TIS - Midlinbank Farm Ryeland, Strathaven ML10 6RD**  
*Manuals on anything electronic*

Circuits - VCR £8, CTV £6  
Service Manuals from £10  
Repair Manuals from £5  
P&P any order £2.50

Write, or ring 01357 440280 for full details of our lending service and FREE quote for any data

**BTEC ELECTRONICS TECHNICIAN TRAINING**

GNVQ ADVANCED ENGINEERING (ELECTRONIC) - PART-TIME  
HND ELECTRONICS - FULL-TIME  
B.Eng FOUNDATION - FULL-TIME  
Next course commences  
**Monday 29th January 2001**  
FULL PROSPECTUS FROM

**LONDON ELECTRONICS COLLEGE (Dept EPE) 20 PENYERN ROAD EARLS COURT, LONDON SW5 9SU**  
TEL: (020) 7373 8721

**THE BRITISH AMATEUR ELECTRONICS CLUB**

exists to help electronics enthusiasts by personal contact and through a quarterly Newsletter.

For membership details, write to the Secretary:

Mr. M. P. Moses,  
5 Park View, Cwmaman,  
Aberdare CF44 6PP

Space donated by  
Everyday Practical Electronics

**Miscellaneous**

**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, E-mail agar@argonet.co.uk.

**PROTOTYPE PRINTED CIRCUIT BOARDS** one offs and quantities, for details send s.a.e. to B. M. Ansbro, 38 Poynings Drive, Hove, Sussex BN3 8GR, or phone/fax Brighton 883871, Mobile 07949 598309. E-mail b.m.a@cwctv.net.

**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.

Philips Pronto Intelligent Remote now available!

**Laser Business Systems Ltd.**



E-Mail: info@laser.com  
http://www.laser.com  
Tel: (020) 8441 9788  
Fax: (020) 8449 0430



**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.

**G.C.S.E. ELECTRONIC KITS**, at pocket money prices. S.A.E. for FREE catalogue. SIR-KIT Electronics, 52 Severn Road, Clacton, CO15 3RB.

**VALVE ENTHUSIASTS:** Capacitors and other parts in stock. For free advice/lists please ring, Geoff Davies (Radio), Tel. 01788 574774.

**DETECT ATMOSPHERIC ACTIVITY.** Unique Designs. Self-addressed envelope: PO Box 694, Saint Helier, JE4 9PZ, Jersey, CI.

**FOR SALE: E-PROMS**, 27128A-2, 27256-2, 2764, 27C011, 27C256-15, 27C512, a total of 247 devices; also Dataman Designs Softy 3 programmer emulator, Gang of Eight copier, UV eraser. Prefer to sell as one lot, £600. E-mail MCW@cwcom.net or tel: 01234 781300.

**K.I.A. CATALOGUE**, s.a.e. Projects, offers plus bargains and component samples . . . lots from Santa! K.I.A., 1 Regent Road, Ilkley LS29.

**FLUKE SCOPEMETER**, Model 92, combines the functions of a rugged dual-channel oscilloscope with multimeter functions. Boxed, as new, cost £1,250, nearest cash offer to £350 secures. For further details tel: 01884 258272 (Devon).

**EPE NET ADDRESSES**

**EPE FTP site:** <ftp://ftp.epemag.wimborne.co.uk>

Access the FTP site by typing the above into your web browser, or by setting up an FTP session using appropriate FTP software, then go into quoted sub-directories:

PIC-project source code files: **/pub/PICS**

PIC projects each have their own folder; navigate to the correct folder and open it, then fetch all the files contained within. *Do not try to download the folder itself!*

EPE text files: **/pub/docs**

Basic Soldering Guide: **solder.txt**

EPE TENS Unit user advice: **tens.doc** and **tens.txt**

Ingenuity Unlimited submission guidance: **ing\_unl.txt**

New readers and subscribers info: **epe\_info.txt**

Newsletters or Usenet users advice: **usenet.txt**

Ni-Cad discussion: **nicadfaq.zip** and **nicad2.zip**

Writing for EPE advice: **write4us.txt**

**On-line readers! Try the EPE Chat Zone - a virtually real-time Internet "discussion board" in a simple to use web-based forum!**

<http://www.epemag.wimborne.co.uk/wwwboard>

Or buy EPE Online: [www.epemag.com](http://www.epemag.com)

Ensure you set your FTP software to ASCII transfer when fetching text files, or they may be unreadable.

Note that any file which ends in .zip needs unzipping before use. Unzip utilities can be downloaded from:

<http://www.winzip.com> or  
<http://www.pkware.com>



## TRAIN TODAY FOR A BETTER FUTURE

Now you can get the skills and qualifications you need for career success with an ICS Home Study Course. Learn in the comfort of your own home at the pace and times that suit you. ICS is the world's largest, most experienced home study school. Over the past 100 years ICS have helped nearly 10 million people to improve their job prospects. Find out how we can help YOU. Post or phone today for **FREE INFORMATION** on the course of your choice

Electrical Contracting & Installation  
Electrical Engineering  
C&G/ICS Basic Electronic Engineering  
C&G/ICS Basic Mechanical Engineering  
TV and Video Servicing  
Radio and Hi-Fi Servicing  
Refrigeration Heating & Air Conditioning  
Motorcycle Maintenance

**FREEPHONE 0500 581 557**

Or write to: International Correspondence Schools, FREEPOST 882, 8 Elliot Place, Clydeway Skypark, Glasgow, G3 8BR. Tel: 0500 581 557 or Tel/Fax: Dublin 285 2533.

Please send me my Free Information on your Electronics Courses.

Mr/Mrs/Ms/Miss  
(BLOCK CAPITALS PLEASE) Date of Birth / /

Address

Postcode

Occupation Tel. No.

From time to time, we permit other carefully screened organisations to write to you about products and services. If you would prefer not to hear from such organisations please tick box ☐ Dept. ZEEVC1K0

## Professional 88-108MHz FM Broadcasting Kits

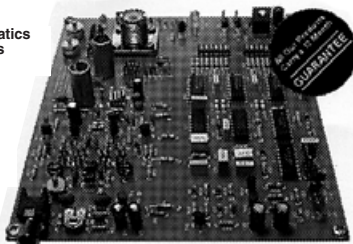
### All Our Kits Include

Detailed Instructions with Schematics  
High Quality Screen Printed PCBs  
High Quality Components

### Our Product Range Includes

Transmitters from 0.05W to 35W  
FM Stereo Coders  
Audio Compressor Limiters  
Antennas  
RF Power Amps

Our Kits Are Also Available  
Fully Assembled And Tested



1W Professional PLL FM Transmitter for Licensed Use in the UK

Visit our Website at <http://www.veronica.co.uk>

WE DELIVER WORLD-WIDE AND  
ACCEPT MAJOR CREDIT CARDS

Contact Us Now For A Free Brochure

Tel 01274 883434 Fax 01274 428665

email [info@veronica.co.uk](mailto:info@veronica.co.uk)

Unit 5/6 1A Sandbeds/Albert Rd Queensbury BRADFORD BD13 1AA



## ELECTRONICS SURPLUS CLEARANCE SALE

### SCOOP PURCHASE:

### FLUKE HAND HELD DIGITAL MULTIMETER, MODEL 8024B

Cancelled export order 750V AC/DC 2 amp AC/DC Resistance 20Megohm plus Siemens range. Also measures temperature -20°C to +1265°C. Temp. probe not included. Calibrated for K-type thermocouple. Peak hold facility. Supplied brand new and boxed but with original purchasing organisation's small identifying mark on case. Test leads and handbook included.

Offered at a fraction of original price: £47.50, p&p £6.50

**THE ELECTRONICS SURPLUS TRADER** - This is a listing of new first class components, books and electronic items at below trade prices. Includes manufacturers' surplus and overstocks. Also obsolete semiconductors, valves and high voltage caps and components. Send two first class stamps for large catalogue.

### (Dept E) CHEVET SUPPLIES LTD

157 Dickson Road, BLACKPOOL FY1 2EU

Tel: (01253) 751858. Fax: (01253) 302979

E-mail: [chevet@globalnet.co.uk](mailto:chevet@globalnet.co.uk) Telephone Orders Accepted

Callers welcome Tues, Thurs, Fri and Sat.



## COVERT VIDEO CAMERAS

Black and White Pin Hole Board Cameras with Audio. Cameras in P.I.R., Radios, Clocks, Briefcases etc. Transmitting Cameras with Receiver (Wireless). Cameras as above with colour. Audio Surveillance Kits and Ready Built Units, Bug Detector etc.

## A.L. ELECTRONICS

Please phone **0181 203 6008** for free catalogue.

Fax **0181 201 5359**

E-mail: [surveillance@btclick.com](mailto:surveillance@btclick.com) [www.uspy.com](http://www.uspy.com)

New DTI approved Video Transmitters and Receivers (Wireless)

Major credit cards now taken



MANUFACTURER OF HIFI AUDIO MODULES AND  
TOROIDAL TRANSFORMERS SINCE 1971

CONTACT US NOW FOR A FREE CATALOGUE

## ILP DIRECT LTD.

SPONG LANE, ELMSTED, ASHFORD, KENT TN25 5JU

TEL +44 1233 750481 FAX +44 1233 750578



## 2001 CATALOGUE

NOW AVAILABLE, FREE OF CHARGE, PLEASE SEND SAE.  
KITS AVAILABLE FOR MOST EPE PROJECTS. PLEASE SEND SAE  
FOR DETAILS OF ANY KIT THAT INTERESTS YOU.

SPECIAL £1 OFFER PACKS IN OUR 2001 CATALOGUE NOW INCLUDE:

2	BB104 VARICAP DIODE	7	2N2926 YELLOW TRANSISTOR
6	BC107 TRANSISTOR	10	2N3704 TRANSISTOR
6	BC108 TRANSISTOR	16	16-PIN DIL SOCKET
6	BC109 TRANSISTOR	8	18-PIN DIL SOCKET
2	BC117 TRANSISTOR	3	6 x AA BATTERY HOLDER 61 x 45 x 28mm
3	BC142 TRANSISTOR	5	STRIPBOARD 25 x 64MM (9T x 25H)
6	BC167 TRANSISTOR	10	13A 1in. MAINS PLUG TOP FUSES
6	BC168 TRANSISTOR	10	2-PIN DIN LOUDSPEAKER PLUG
6	BC213LB TRANSISTOR	10	2-PIN DIN LOUDSPEAKER CHASSIS SOCKET
3	BC303-5 TRANSISTOR	10	ASSORTED FUSES
4	BC413 TRANSISTOR	20M	ASSORTED WIRE PACK
2	TIC206D TRIAC 400V 4A		SEE LAST/NEXT MONTH'S EPE FOR MORE BARGAINS

PRICE INCLUDES VAT. CLAIM YOUR FREE GIFT WITH ALL ORDERS OVER £10 IN VALUE WITH THIS ADVERT.  
MAJOR CREDIT CARDS, CHEQUES AND PO'S ACCEPTED. MAIL ORDER ONLY.  
UK MAINLAND P&P ONLY £1 (EXPORT AT COST MIN. £2).

## FML ELECTRONICS

FREEPOST NEA 3627, BEDALE, NORTH YORKSHIRE DL8 2BR

TEL: 01677 425840

## N. R. BARDWELL LTD (EPE)

100	Signal Diodes 1N4148	£1.00	200	Asstd. disc ceramic capacitors	£1.00
75	Rectifier Diodes 1N4001	£1.00	50	Asstd. Skel Presets (sm, stand, cermet)	£1.00
50	Rectifier Diodes 1N4007	£1.00	50	Asstd. RF chokes (inductors)	£1.00
10	W01 Bridge Rectifiers	£1.00	50	Asstd. grommets	£1.00
10	555 Timer I.C.s	£1.00	80	Asstd. solder tags, p/conn's, terminals	£1.00
4	741 Op Amps	£1.00	10	Asstd. crystals - plug in	£1.00
50	Assorted Zener Diodes 400mW	£1.00	24	Asstd. coil formers	£1.00
12	Assorted 7-segment Displays	£1.00	8	Asstd. di switches	£1.00
25	5mm I.e.d.s, red, green or yellow	£1.00	20	Miniature slide switches sp/co	£1.00
25	3mm I.e.d.s, red, green or yellow	£1.00	10	Standard slide switches dp/dt	£1.00
50	Axial I.e.d.s, 2mcd red Diode Package	£1.00	100	Asstd. beads (ceramic, teflon, fish spine)	£1.00
25	Asstd. High Brightness I.e.d.s, var cols	£1.00	80	Asstd. small stand off's, ultrathroughs etc	£1.00
20	BC182L Transistors	£1.00	30	Asstd. di sockets up to 40 way	£1.00
20	BC212L Transistors	£1.00	10	TV coax plugs, plastic	£1.00
30	BC237 Transistors	£1.00	40	metres very thin connecting wire, red	£1.00
20	BC327 Transistors	£1.00	20	1in. glass reed switches	£1.00
30	BC328 Transistors	£1.00	20	Magnetic ear pips with lead and plug	£1.00
30	BC347 Transistors	£1.00	100	Any one value 1/4W 5% of resistors range	£1.00
30	BC548 Transistors	£1.00	1R to 10M		£0.45
30	BC549 Transistors	£1.00	7812 Voltage Regulators		£1.00
25	BC557 Transistors	£1.00			
30	BC558 Transistors	£1.00			
30	BC559 Transistors	£1.00			
20	2N3904 Transistors	£1.00			
100	1nf 50V wkg Axial Capacitors	£1.00			
100	4n7 50V wkg Axial Capacitors	£1.00			
12	1uf 250V encapsulated radial plastic				
	cased capacitors	£1.00			
80	Asstd capacitors electrolytic-				
80	Asstd. capacitors 1nF to 1µF	£1.00			

288 Abbeydale Road, Sheffield S7 1FL  
Phone: 0114 255 2886 ★ Fax: 0114 250 0689  
e-mail: [sales@bardwells.co.uk](mailto:sales@bardwells.co.uk) ★ Web: [www.bardwells.co.uk](http://www.bardwells.co.uk)  
Prices include VAT. Postage £1.65  
44p stamp for lists or disk



## DIGITAL TEST METER

Built-in transistor test socket and diode test position.  
DC volts 200mV to 1000V.  
AC volts 200V to 750V.  
DC current 200mA to 10A.  
Resistance 200 ohms to 2000K ohms.

**£6.99** incl. VAT

**FREE 240-page  
colour catalogue**

Great value for Speakers, Microphones, Aerials, Headphones, TV Amps, Transmitters, Leads, Plugs, Sockets, Leads, CD Storage Cases, CCTV, Security, Connectors, Adaptors, Switch Boxes, Gadgets, Disco Lighting & Effects, Mixers, Amplifiers, Turntables, Musicians' Leads, Car Audio, Test Equipment, Hobby Kits, Computer Leads & Accessories, Power Supplies, Inverters, Transformers, Battery Chargers, Tools, Soldering, Switches, Fuses, Indicators, Cable & Wire, Crossovers, Speaker Hardware, PA Amps, and a great deal more... all for the price of a stamp.

**SKY ELECTRONICS**  
Tel: 020 8450 0995  
Fax: 020 8208 1441

## Sky Electronics

**40-42 Cricklewood Broadway London NW2 3ET**  
Tel: 020 8450 0995 Fax: 020 8208 1441  
[www.skyelectronics.co.uk](http://www.skyelectronics.co.uk)

The Catalogue is FREE to callers or send stamps to the value of £1.85 to cover postage.

# ELECTRONICS 2001

## Millions of quality components at lowest ever prices!

Plus anything from bankruptcy – theft recovery  
– frustrated orders – over productions etc.  
Send 54p stamped self-addressed label or  
envelope for clearance lists.

**Brian J Reed**

**6 Queensmead Avenue, East Ewell,  
Epsom, Surrey KT17 3EQ**  
Tel: 07775 945386 or 0208 393 9055  
**Mail Order UK only.**

Lists are updated and only 40 are sent out every 2 weeks. This normally ensures that orders can be fulfilled where only a few thousands of an item is available. (Payment is returned if sold out. I do not deal in credit notes).

## ADVERTISERS INDEX

A.L. ELECTRONICS	951
ANTEX	928
N. R. BARDWELL	951
BELL COLLEGE OF TECHNOLOGY	878
B.K. ELECTRONICS	Cover (iii)/928
BRIAN J. REED	952
BRUNNING SOFTWARE	911
BULL ELECTRICAL	Cover (ii)
CHEVET SUPPLIES	951
CRICKLEWOOD ELECTRONICS	898
CROWNHILL ASSOCIATES	904
DISPLAY ELECTRONICS	874
ECONOMATICS (EDUCATION)	878
EPTSOFT	Cover (iv)
ESR ELECTRONIC COMPONENTS	882
FML ELECTRONICS	951
FOREST ELECTRONIC DEVELOPMENTS	891
GREENWELD	876
ICS	951
ILP DIRECT	951
J&N FACTORS	942
JPG ELECTRONICS	898
LABCENTER ELECTRONICS	897
MAGENTA ELECTRONICS	880/881/912
MAPLIN ELECTRONICS	901
MILFORD INSTRUMENTS	921
NATIONAL COLLEGE OF TECHNOLOGY	898
PEAK ELECTRONIC DESIGN	925
PICO TECHNOLOGY	877
QUASAR ELECTRONICS	937
SERVICE TRADING CO	898
SHERWOOD ELECTRONICS	952
SKY ELECTRONICS	952
SQUIRES	878
STEWART OF READING	912
SUMA DESIGNS	907
TELNET	879
VERONICA KITS	951

**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 883

## SHERWOOD ELECTRONICS

### FREE COMPONENTS

Buy 10 x £1 Special Packs and choose another one FREE

SP1	15 x 5mm Red LEDs	SP131	2 x TL071 Op.Amps
SP2	12 x 5mm Green LEDs	SP133	20 x 1N4004 diodes
SP3	12 x 5mm Yellow LEDs	SP134	15 x 1N4007 diodes
SP6	15 x 3mm Red LEDs	SP135	6 x Min. slide switches
SP7	12 x 3mm Green LEDs	SP136	3 x BFY50 transistors
SP10	100 x 1N4148 diodes	SP137	4 x W005 1-5A bridge rectifiers
SP11	30 x 1N4001 diodes	SP138	20 x 2-2/63V radial elect. caps.
SP12	30 x 1N4002 diodes	SP140	3 x W04 1-5A bridge rectifiers
SP18	20 x BC182 transistors	SP142	2 x CMOS 4017
SP20	20 x BC184 transistors	SP143	5 Pairs min. crocodile clips (Red & Black)
SP21	20 x BC212 transistors	SP145	6 x ZTX300 transistors
SP23	20 x BC549 transistors	SP146	10 x 2N3704 transistors
SP24	4 x CMOS 4001	SP147	5 x Stripboard 9 strips x 25 holes
SP25	4 x 555 timers	SP151	4 x 8mm Red LEDs
SP26	4 x 741 Op.Amps	SP152	4 x 8mm Green LEDs
SP28	4 x CMOS 4011	SP153	4 x 8mm Yellow LEDs
SP29	3 x CMOS 4013	SP154	15 x BC548 transistors
SP31	4 x CMOS 4071	SP156	3 x Stripboard, 14 strips x 27 holes
SP34	20 x 1N914 diodes	SP160	10 x 2N3904 transistors
SP36	25 x 10/25V radial elect. caps.	SP161	10 x 2N3906 transistors
SP37	15 x 100/35V radial elect. caps.	SP165	2 x LF351 Op.Amps
SP39	10 x 470/16V radial elect. caps.	SP167	6 x BC107 transistors
SP40	15 x BC237 transistors	SP168	6 x BC108 transistors
SP41	20 x Mixed transistors	SP175	20 x 1/63V radial elect. caps.
SP42	200 x Mixed 0-25W C.F. resistors	SP177	10 x 1A 20mm quick blow fuses
SP47	5 x Min. PB switches	SP182	20 x 4-7/63V radial elect. caps.
SP102	20 x 8-pin DIL sockets	SP183	20 x BC547 transistors
SP103	15 x 14-pin DIL sockets	SP187	15 x BC239 transistors
SP104	15 x 16-pin DIL sockets	SP191	3 x CMOS 4023
SP105	4 x 74LS00	SP192	3 x CMOS 4066
SP109	15 x BC557 transistors	SP193	20 x BC213 transistors
SP112	4 x CMOS 4093	SP194	8 x OA90 diodes
SP114	5 x ZTX500 transistors	SP195	3 x 10mm Yellow LEDs
SP115	3 x 10mm Red LEDs	SP197	6 x 20 pin DIL sockets
SP116	3 x 10mm Green LEDs	SP198	5 x 24 pin DIL sockets
SP118	2 x CMOS 4047		
SP120	3 x 74LS93		
SP124	20 x Assorted ceramic disc caps		
SP130	100 x Mixed 0-5W C.F. resistors		

**2000 Catalogue now available £1 inc. P&P or FREE with first order.**

**P&P £1.25 per order. NO VAT**

**Orders to:**

**Sherwood Electronics,  
7 Williamson St., Mansfield,  
Notts. NG19 6TD.**

<b>RESISTOR PACKS – C.Film</b>			
RP3	5 each value – total 365 0-25W	£2.85	
RP7	10 each value – total 730 0-25W	£4.10	
RP10	1000 popular values 0-25W	£5.85	
RP4	5 each value-total 365 0-5W	£3.80	
RP8	10 each value-total 730 0-5W	£6.45	
RP11	1000 popular values 0-5W	£8.15	

Published on approximately the second Thursday of each month by Wimborne Publishing Ltd., Allen House, East Borough, Wimborne, Dorset BH21 1PF. Printed in England by Apple Web Offset Ltd., Warrington, WA1 4RW. Distributed by COMAG Magazine Marketing, Tavistock Rd., West Drayton, UB7 7QE. **Subscriptions** INLAND: £14.50 (6 months); £27.50 (12 months); £50 (2 years). OVERSEAS: Standard air service, £17.50 (6 months); £33.50 (12 months); £62 (2 years). Express airmail, £27 (6 months); £51 (12 months); £97 (2 years). Payments payable to "Everyday Practical Electronics", Subs Dept, Allen House, East Borough, Wimborne, Dorset BH21 1PF. **E-mail:** [subs@epemag.wimborne.co.uk](mailto: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.