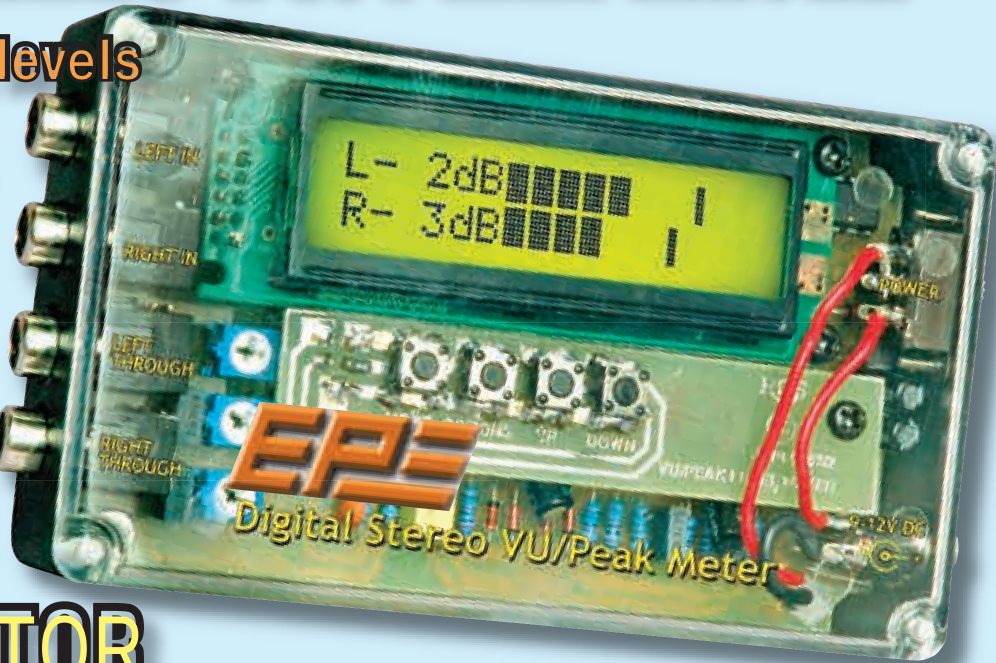
THE No 1 UK MAGAZINE FOR ELECTRONICS TECHNOLOGY & COMPUTER PROJECTS

EPE EVERYDAY PRACTICAL ELECTRONICS

www.epemag.co.uk www.epemag.com

DIGITAL STEREO VU/PEAK METER

- ★ Average and peak levels
- ★ Resolution of 1dB
- ★ LCD Bargraphs



TANK WATER LEVEL INDICATOR

An instant check on rainwater tank level

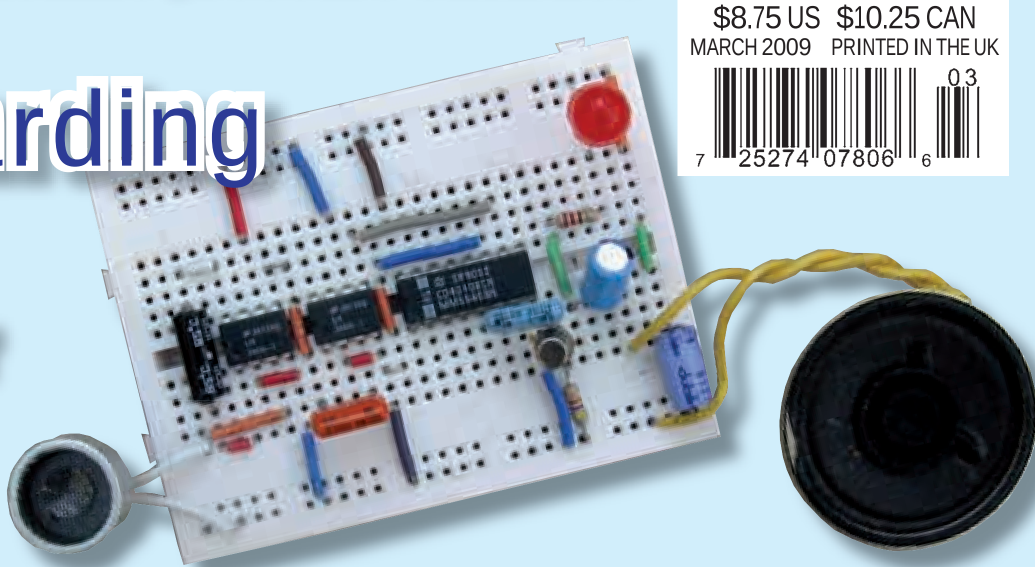
RECYCLE IT

Using washing machine pressure switches

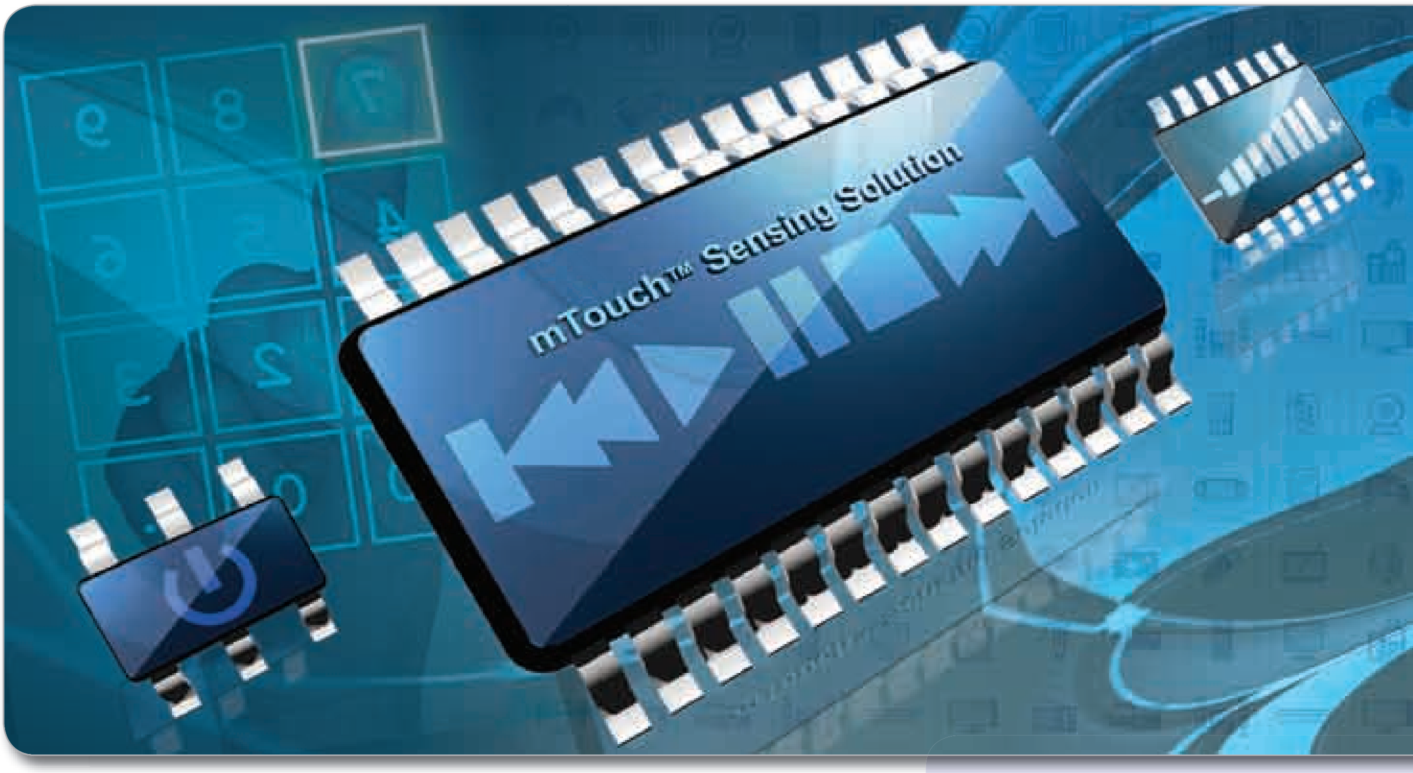
$8.75 US $10.25 CAN
MARCH 2009 PRINTED IN THE UK

Breadboarding Projects

Bat Detector



Capacitive Touch Sensing In a Flexible, Single-chip Solution



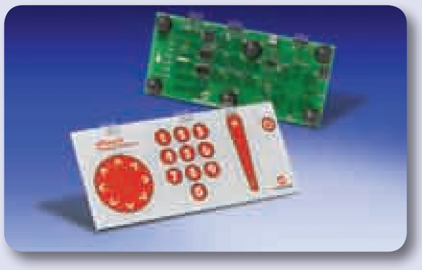
Capacitive touch interfaces provide an excellent way to add low-cost, reliable and stylish buttons into your design. Microchip Technology's mTouch™ Sensing Solution includes comprehensive development kits and a free diagnostic tool to make implementation easy and fast. Our free source code can be seamlessly integrated with your existing firmware on a single PIC® microcontroller – eliminating the need for additional controllers.

The mTouch Sensing Solution features:

- FREE license libraries and source code
- A FREE diagnostic tool
- Integration with 8- and 16-bit PIC microcontrollers
- Easy expansion, with support from 6 to 100 pins
- Low-power operation

GET STARTED IN 3 EASY STEPS

1. Visit the mTouch Sensing Solutions design center at www.microchip.com/mTouch
2. Download free libraries and source code
3. For a limited time, save 20% off a variety of touch sensing development tools when you purchase from www.microchipDIRECT.com and use voucher code **EUMTOUCH**.



Intelligent Electronics start with Microchip

microchip DIRECT www.microchipdirect.com

www.microchip.com/mtouch

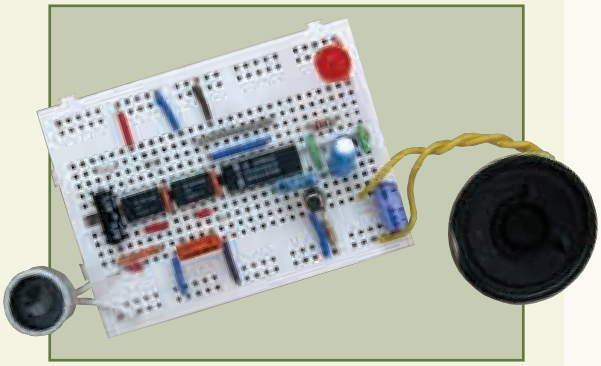
MICROCHIP

ISSN 0262 3617
• PROJECTS • THEORY •
• NEWS • COMMENT •
• POPULAR FEATURES •
VOL. 38. No 3 March 2009

EVERYDAY PRACTICAL ELECTRONICS

INCORPORATING ELECTRONICS TODAY INTERNATIONAL

www.epemag.com



Projects and Circuits

DIGITAL STEREO VU/PEAK METER by John Clarke — 10
LCD bargraph display of audio levels

TANK WATER LEVEL INDICATOR by Allan March — 24
Keep a check on rainwater tank level

LED TACHOMETER – PART 2 by John Clarke — 32
Final construction details plus testing and set-up

INGENUITY UNLIMITED Sharing your ideas with others — 46
Bass Guitar Headphone Amplifier

BREADBOARDING PROJECTS by Dr Malcolm Plant — 48
Part 6 – Bat Detector

Series and Features

TECHNO TALK by Mark Nelson — 22
2009 – The year of Femtomania?

RECYCLE IT by Julian Edgar — 40
Using salvaged washing machine pressure switches

PRACTICALLY SPEAKING by Robert Penfold — 44
Semiconductor marking and ordering

CIRCUIT SURGERY by Ian Bell — 54
Interconnecting audio equipment

PIC N' MIX by Mike Hibbett — 58
Interfacing PICs to the Internet via Ethernet – Part 6

NET WORK by Alan Winstanley — 66
On the WiFi radar; Time 2 Txt U

Regulars and Services

EDITORIAL — 7

NEWS – Barry Fox highlights technology's leading edge — 8
Plus everyday news from the world of electronics

SUBSCRIBE TO *EPE* and save money — 31

BACK ISSUES Did you miss these? — 42

ELECTRONICS MANUALS — 51
The Modern Electronics Manual and Electronic Service Manual on CD-ROM

PIC PROJECTS CD-ROM — 52
A plethora of handPICed projects

PIC RESOURCES CD-ROM — 53
EPE PIC Tutorial V2, plus PIC Toolkit Mk3 and a selection of PIC-related articles

CD-ROMS FOR ELECTRONICS — 61
A wide range of CD-ROMs for hobbyists, students and engineers

READOUT Matt Pulzer addresses general points arising — 64

DIRECT BOOK SERVICE — 67
A wide range of technical books available by mail order, plus more CD-ROMs

***EPE* PCB SERVICE** — 70

ADVERTISERS INDEX — 72

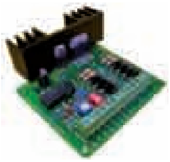
Our April 2009 issue will be published on Thursday 12 March 2009, see page 72 for details.

Readers' Services • Editorial and Advertisement Departments — 7

Hot New Products!

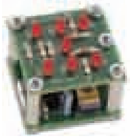
Here are a few of the most recent products added to our range. See website or join our email Newsletter for all the latest news.

Bipolar Stepper Motor Chopper Driver



New bipolar chopper driver gives better performance from your stepper motors. It uses a dual full bridge motor driver based on SGS Thompson chips L297 & L298. Motor current for each phase is set using an on-board potentiometer. Can handle motor winding currents of up to 2 Amps per phase. Operates from a DC supply voltage of 9-36V. All basic motor controls provided including full or half stepping of bipolar steppers and direction control. Synchroniseable when using multiple drivers. Perfect for desktop CNC applications.
Kit Order Code: 3187KT - **£29.95**
Assembled Order Code: AS3187 - **£39.95**

Shaking Dice

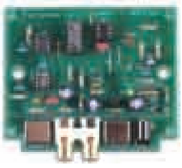


This electronic construction kit is great fun to build and play with. Simply shake and watch it slowly roll to stop on a random number.
Kit Order Code: VMK150KT - **£9.95**

Running MicroBug

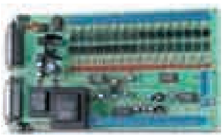
This electronic construction kit is an attractive bright coloured bug-shaped miniature robot. The microbug is always hungry for light and travels toward it!
Kit Order Code: VMK127KT - **£9.95**

Video Signal Cleaner



Digitally cleans the video signal and removes unwanted distortion in video signal. In addition it stabilises picture quality and luminance fluctuations. You will also benefit from improved picture quality on LCD monitors or projectors.
Kit Order Code: VK8036KT - **£19.95**
Assembled Order Code: VVM106 - **£26.95**

PC Interface Board



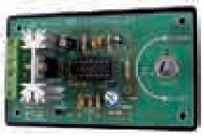
This interface card excels in its simplicity of use and installation. The card is connected in a very simple way to the printer port (there is no need to open up the computer). Likewise there is no need to install an extra printer port, even if a printer is to be used. This can be connected to the card in the usual manner. Connection to the computer is optically isolated, so that damage to the computer from the card is not possible.
Kit Order Code: VK8000KT - **£59.95**

Most items are available in kit form (KT suffix) or assembled and ready for use (AS prefix).

Motor Speed Controllers

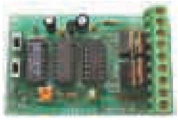
Here are just a few of our controller and driver modules for AC, DC, Unipolar/Bipolar stepper motors and servo motors. See website for full details.

DC Motor Speed Controller (100V/7.5A)



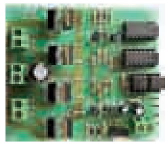
Control the speed of almost any common DC motor rated up to 100V/7.5A. Pulse width modulation output for maximum motor torque at all speeds. Supply: 5-15Vdc. Box supplied. Dimensions (mm): 60Wx100Lx60H.
Kit Order Code: 3067KT - **£13.95**
Assembled Order Code: AS3067 - **£21.95**

PC / Standalone Unipolar Stepper Motor Driver



Drives any 5, 6 or 8-lead unipolar stepper motor rated up to 6 Amps max. Provides speed and direction control. Operates in stand-alone or PC-controlled mode. Up to six 3179 driver boards can be connected to a single parallel port. Supply: 9Vdc. PCB: 80x50mm.
Kit Order Code: 3179KT - **£12.95**
Assembled Order Code: AS3179 - **£19.95**

Bi-Polar Stepper Motor Driver



Drive any bi-polar stepper motor using externally supplied 5V levels for stepping and direction control. These usually come from software running on a computer. Supply: 8-30Vdc. PCB: 75x85mm.
Kit Order Code: 3158KT - **£17.95**
Assembled Order Code: AS3158 - **£27.95**

Bidirectional DC Motor Controller

Controls the speed of most common DC motors (rated up to 32Vdc/10A) in both the forward and reverse direction. The range of control is from fully OFF to fully ON in both directions. The direction and speed are controlled using a single potentiometer. Screw terminal block for connections.
Kit Order Code: 3166v2KT - **£17.95**
Assembled Order Code: AS3166v2 - **£27.95**

AC Motor Speed Controller (700W)

Reliable and simple to install project that allows you to adjust the speed of an electric drill or single phase 230V AC motor rated up to 700 Watts. Simply turn the potentiometer to adjust the motors RPM. PCB: 48x65mm. Not suitable for use with brushless AC motors.
Kit Order Code: 1074KT - £12.95
Assembled Order Code: AS1074—£18.95
Box Order Code 2074BX - £5.95

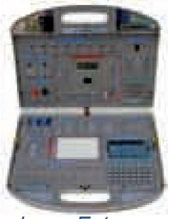
QUASAR electronics
Get Plugged In!

Credit Card Sales 0871 717 7168

Electronic Project Labs

Great introduction to the world of electronics. Ideal gift for budding electronics expert!

500-in-1 Electronic Project Lab



Top of the range. Complete self-contained electronics course. Takes you from beginner to 'A' Level standard and beyond! Contains all the hardware and manuals to assemble 500 projects. You get 3 comprehensive course books (total 368 pages) - *Hardware Entry Course*, *Hardware Advanced Course* and a microprocessor based *Software Programming Course*. Each book has individual circuit explanations, schematic and connection diagrams. Suitable for age 12+.
Order Code EPL500 - **£149.95**
Also available - 30-in-1 **£16.95**, 50-in-1 **£21.95**, 75-in-1 **£32.95** £130-in-1 **£39.95** & 300-in-1 **£59.95** (details on website)

Tools & Test Equipment

We stock an extensive range of soldering tools, test equipment, power supplies, inverters & much more - please visit website to see our full range of products.

Two-Channel USB Pc Oscilloscope

This digital storage oscilloscope uses the power of your PC to visualize electrical signals. Its high sensitive display resolution, down to 0.15mV, combined with a high bandwidth and a sampling frequency of up to 1GHz are giving this unit all the power you need.
Order Code: VPCSU1000 - **£289.95**

Personal Scope 10MS/s

The Personal Scope is not a graphical multimeter but a complete portable oscilloscope at the size and the cost of a good multimeter. Its high sensitivity - down to 0.1mV/div - and extended scope functions make this unit ideal for hobby, service, automotive and development purposes. Because of its exceptional value for money, the Personal-Scope is well suited for educational use.
Order Code: VHPS10 - ~~£129.95~~ £119.95

See website for more super deals!

No.1 FOR KITS

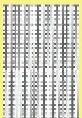
www.QuasarElectronics.com

Secure Online Ordering Facilities • Full Product Listing, Descriptions & Photos • Kit Documentation & Software Downloads

PCB Production - Development

0.1" Copper Stripboard

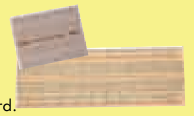
Size	Tracks/Holes	
25 x 64mm	9T / 25H	£0.24
64 x 95mm	24T / 37H	£0.87
95 × 127mm	36T / 50H	£1.41
95 × 432mm	36T / 170H	£4.39
100 × 100mm	39T / 38H	£1.40
100 × 500mm	39T / 199H	£7.50
119 × 455mm	46T / 179H	£5.40
Stripboard track cutter		£1.99



Solderless Breadboard

Tie Points	& Size	Power Rails	
390	81 x 60mm	2	£2.75
840	175 x 67mm	2	£4.86
740	175 x 55mm	1	£3.32
640	175 x 42mm	0	£3.08

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



PCB Production - Drafting Materials

A4 Artwork Film (per 10 sheets)

Clear Manual Film £1.20
Clear Laser Film £1.75
White HQ Laser Film £4.62

Etch Resist Pens

"Dalo" Pen £3.36
"Staedtler" Fine Pen £1.20

Etch Resist Transfers

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

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

Soldering Irons

We carry in stock a wide range of soldering iron and soldering accessories. Irons from 12 to 100 Watts.

25W 240V Ceramic £6.00
30W 240V Basic £4.68

Desolder Pumps

Basic 165 x 18mmØ £2.85
Antistatic 195mm £4.12
Antex Mini 198mm £6.52
Antex Pro 210mm £11.11

Soldering Station

A 48W adjustable temperature soldering station with a rotary dial, LED Temperature metering, on-off switch, iron holder and tip cleaning sponge. This station features accurate heat sensing for instant compensation & stable temperatures. Adjustable temperature range of 150 - 420°C, Low voltage iron with Silicone cable. Supply: 240V, Iron: 24V 48W

Model 167-540 £49.00

Soldering Station

A 48W adjustable temperature soldering station with a rotary dial, Digital Temperature Indication, on-off switch, iron holder and tip cleaning sponge. This station features accurate heat sensing for instant compensation & stable temperatures. Adjustable temperature range of 150 - 480°C, Low voltage iron with Silicone cable.
Supply: 240V, Iron: 24V 48W

Model 167-570 £52.23

Digital Multimeter

Model: 121-120
Price: £11.47

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

Technical Specifications

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

Now available online
Our large range of Tools by

DRAPER
JOKARI

PCB Production - Processing Equipment

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

UV Exposure units

2 x 8W Tubes, 6 min timer
229 x 159mm working area
Model 332-002 £95.00
4 x 15W Tubes, 7½ min timer
330 x 260mm working area
Model 332-004 £207.99

Chemical Processing

Low cost plastic tray £2.90
Process tanks feature electrically operated pumps and/or heaters with thermostat control, suitable.
ET20 Low cost Etching Tank with heater &pump. £42.84
Universal Tank with heater
Model 333-007 £160.00
Bubble etch Tank with heater & bubble pump.
Model 333-004 £196.00
Any of these items, carriage £5.50

PCB Production - Tools

Drill Bits

HSS parallel shank bits available in sizes from 0.3mm to 2.0mm

0.3-0.95mm in 0.05mm steps £0.60ea £4.00/10
1.0-2.0mm in 0.1mm steps £0.40ea £3.60/10

HSS Reduced shank (2.35mm) bit available in sizes from 0.6mm to 1.7mm in 0.1mm steps £0.84ea £7.60/10

Reground Tungsten carbide reduced shank available in sizes from 0.6 to 1.6mm in 0.1mm steps £1.90

Drilling Machines

Expo Zircon 12V drill, 3.8mm capacity, 11900rpm £14.20

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

SPECIAL PRICE £31.02

Servisol Products

Aerosols

200ml	Switch Cleaner	£2.61
200ml	Freezer	£4.75
400ml	Foam Cleanser	£2.60
400ml	Cleaner / lubricant	£2.99
75ml	Vide Head Cleaner	£1.94
200ml	Aero Klene	£3.90
200ml	Aero Duster	£5.89
400ml	Isopropyl alcohol	£3.58

Tubes

10g	Heatsink Compound	£1.66
25g	Heatsink Compound	£2.60
50g	Silicone grease	£3.16

Bench Power Supplies

A range of single output regulated bench power supplies with variable voltage & current limiting. Features: Short circuit and "Foldback" overload protection, Metal case with on/off switch, outputs via Red, Black & Green (Earth) 4mm shrouded sockets.

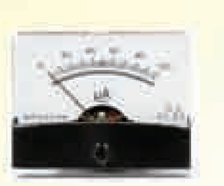
Model: 461-540	**0-20V 2A**	**£19.95**
Model: 461-550	**0-30V0-3A**	**£67.95**
Model: 461-552	**0-50V 0-3A**	**£69.50**
Model: 461-554	**0-30V 0-10A**	**£145.00**

Panel Meters

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

All meters £5.89 each

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



Magnifying Desk Lamp

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

Model: 028-205 £28.80

TheElectronicsShop.co.uk
Sound & Lighting
equipment for the Entertainment Industry

PCB Production - Laminates

Copper clad - paper

Single sided low cost paper composite board

100 × 160mm Board £0.58
100 × 220mm Board £0.62
160 x 233mm Board £1.34
220 x 233mm Board £1.86
8" x 12" Board £2.22

Copper clad - glass fibre

Single & Double 1.6mm 305g/m²

100 × 160mm Single £1.06
100 × 220mm Single £1.49
160 x 233mm Single £2.29
220 x 233mm Single £3.50
8" x 12" Single £3.98
100 × 160mm Double £1.09
100 × 220mm Double £1.23
160 x 233mm Double £2.30
220 x 233mm Double £2.90
8" x 12" Double £4.05

Photoresist Coated

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

	Paper		Glass Fibre	
Size	Single	Double	Single	Double
4 × 6"	£1.47	£1.82	£1.89	£2.17
6 x 12"	£4.20	£5.04	£5.60	£6.23
9 x 12"	£6.30	£7.70	£8.40	£9.38
10 x 12"	£8.19	£10.01	£10.78	£11.83
12 x 12"	£8.26	£10.08	£10.99	£12.25
100 x 160mm			£2.38	£2.66
203 x 114mm			£3.01	£3.43
220 x 100mm			£3.08	£3.71
233 x 160mm			£4.83	£5.32
233 x 220mm			£6.86	£7.70

PCB Production - Chemicals

100ml	Aerosol Photoresist spray, covers 2m²	£5.12
50g	Powder developer, makes 1lt	£1.09
500g	Powder developer, makes 10lt	£7.08
250g	Ferric Chloride Pellets, makes 500ml	£1.68
500g	Ferric Chloride Pellets, makes 1lt	£3.04
2.5kg	Ferric Chloride Pellets, makes 5lt	£9.84
1.1kg	Clear Fine etch crystals, makes 5lt	£17.58
90g	Tin Plating Powder, makes 1lt	£11.58
200ml	Aerosol Flux spray	£3.41
110ml	Aerosol PCB Laquer spray	£3.54

Tools - Cutters & Strippers

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

Side Cutters

130mm Low cost £1.99
115mm Draper £2.38

Wire Strippers

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

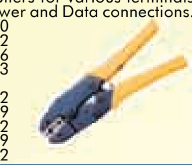
Tools - Ratchet Crimping Pliers

High quality ratchet crimping pliers for various terminals including Automotive, Data, Power and Data connections.

Red / Blue / Yellow £15.80
BNC /TNC RF series £15.62
RJ11/12 & 45 Series £11.76
Non insulated crimps £23.53

CK® Tools Crimp Pliers

Green/Red/Blue £30.62
Red/Blue/Yellow £24.49
0.24-2.5mm² crimps £30.62
0.5-6.0mm² crimps £28.29
Non insulated crimps £28.22



Cable - Ribbon

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

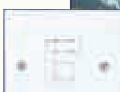
Size	per 305mm	per Reel
10 Way	£0.10	£5.80
14 Way	£0.14	£7.50
16 Way	£0.16	£8.58
20 Way	£0.27	£14.34
26 Way	£0.26	£13.94
34 Way	£0.34	£18.22
40 Way	£0.40	£21.44
50 Way	£0.50	£26.80
60 Way	£0.64	£33.92
IDC Crimp tool		£10.60

CAT5e Networking

UTP Cable
Conforms to CAT5E
100MHz standard,
ETA verified TIA/EIA 568-B.2

305m Box £63.56
100m Reel £24.30
exc carriage.

RJ45 Outlet Kit
Backing Box
2 Gang Plate
RJ45 Module
Blank Module
Coloured id inserts.
£2.86ea £2.29 (10+)



Tools
Plastic punch down tool & cable stripper £1.24
Professional punch down IDC & trim tool £4.94

Outlets
CAT5e Outlet Module £1.70
1Gang Plate (2 Mods) £0.50
2 Gang Plate (4 Mods) £0.88
½ Module Blank £0.25
1 Module Blank £0.35
2 Module Blank £0.45
Other keystone outlets, switches & accessories available. Patch & Cross-over leads from £0.50

ESR ELECTRONIC COMPONENTS
www.esr.co.uk
Tel: 0191 2514363
Fax: 0191 2522296
sales@esr.co.uk
Station Road
Cullercoats
Tyne & Wear
NE30 4PQ

Prices Exclude Vat @15%.
UK Carriage £2.50 (less than 1kg)
£5.50 greater than 1kg or >£30
Cheques / Postal orders payable to ESR Electronic Components Ltd.
PLEASE ADD CARRIAGE & VAT TO ALL ORDERS

0109

EVERYDAY PRACTICAL ELECTRONICS

THE UK'S NO.1 MAGAZINE FOR ELECTRONICS TECHNOLOGY & COMPUTER PROJECTS

Editorial Offices:
EVERYDAY PRACTICAL ELECTRONICS EDITORIAL
Wimborne Publishing Ltd., Sequoia House, 398a Ringwood Road, Ferndown, Dorset BH22 9AU
Phone: (01202) 873872. Fax: (01202) 874562.
Email: enquiries@epemag.wimborne.co.uk
Web Site: www.epemag.com
See notes on **Readers' Technical Enquiries** below – we regret technical enquiries cannot be answered over the telephone.
Advertisement Offices:
Everyday Practical Electronics Advertisements
Sequoia House, 398a Ringwood Road, Ferndown, Dorset BH22 9AU
Phone: 01202 873872 Fax: 01202 874562
Email: stewart.kearn@wimborne.co.uk

VOL. 38 No. 3 MARCH 2009

Looking back and forwards

At the time of writing, the first month of 2009 is nearly over and a couple of headline anniversaries have caught my eye. It's thirty years since Microsoft – then a very small company – moved to Washington state. From there, it soon started work on its famous disk operating system – DOS – the great great grand-daddy of most current computer's operating systems. Likewise, it's twenty-five years since Apple launched its 'Macintosh' computer, the first personal computer that really took advantage of (Xerox's) ideas about a visual interface for computer users. It is fascinating to see how these two companies, in very different ways, have grown, while most of their serious competitors have either fallen by the wayside or descended into relative obscurity. Of course, by today's standards early Apple and MS-DOS computers were slow, inflexible and expensive, but really, that makes these pioneering achievements all the more impressive given the tools they had to do the job.

It is also interesting to see what aspects of computers have changed and what have remained constant. One component that seems surprisingly stubborn is the electric motor. The very early PCs did not even have a hard disk – everything was stored, including much of the operating system, on floppy disks. 5¼- or 3½-inch floppies ruled the storage world, and without the motors to spin them nothing would happen.

Next came 10, 20 or 30Mb hard drives, which transformed storage options and speed of access; but again, no motors, no data. Then we had Zip drives, CD drives and DVD drives and even now, you'd be hard pressed to buy a computer that didn't come with, or need access to, a motor-driven storage device. Next, we'll be using Blu-ray drives, and the hard drive companies' products are still the only serious option if you want to store the terabytes of data that our digital cameras, video recorders and music centres produce. It is true that we are beginning to see all solid-state drives in computers, and storage to the internet is becoming more and more popular. However, for some time to come, the humble electric motor will still be the device that keeps the data moving – literally.

Matt

Editor: MATT PULZER
Consulting Editors: DAVID BARRINGTON
JOHN BECKER
Subscriptions: MARILYN GOLDBERG
General Manager: FAY KEARN
Editorial/Admin: (01202) 873872
Advertising and Business Manager:
STEWART KEARN (01202) 873872
On-line Editor: ALAN WINSTANLEY
EPE Online (Internet version) Editors:
CLIVE (Max) MAXFIELD and ALVIN BROWN
Publisher: MIKE KENWARD

AVAILABILITY

Copies of *EPE* are available on subscription anywhere in the world (see opposite) and from all UK newsagents (distributed by SEYMOUR). *EPE* can also be purchased from retail magazine outlets around the world. An Internet online version can be purchased and downloaded for just $18.99US (approx £13) per year, available from **www.epemag.com**

SUBSCRIPTIONS

Subscriptions for delivery direct to any address in the UK: 6 months £19.95, 12 months £37.90, two years £70.50; Overseas: 6 months £23.00 standard air service or £32.00 express airmail, 12 months £44.00 standard air service or £62.00 express airmail, 24 months £83.00 standard air service or £119.00 express airmail.

Online subscriptions, for downloading the magazine via the Internet, $18.99US (approx £13) for one year available from **www.epemag.com**.

Cheques or bank drafts (in £ sterling only) payable to *Everyday Practical Electronics* and sent to *EPE* Subs. Dept., Wimborne Publishing Ltd. Sequoia House, 398a Ringwood Road, Ferndown, Dorset BH22 9AU. Tel: 01202 873872. Fax: 01202 874562. **Email:** subs@epemag.wimborne.co.uk. Also via the Web at: **www.epemag.com**. Subscriptions start with the next available issue. We accept MasterCard, Maestro or Visa. (For past issues see the Back Issues page.)

BINDERS

Binders to hold one volume (12 issues) are available from the above address. These are finished in blue PVC, printed with the magazine logo in gold on the spine. Price £7.95 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, Maestro and MasterCard accepted. Send, fax or phone your card number, card expiry date, valid from date and card security code (the last 3 digits on or just under the signature strip), with your name, address etc. Or order on our secure server via our UK website. **Overseas customers** – your credit card will be charged by the card provider in your local currency at the existing exchange rate.

READERS' TECHNICAL ENQUIRIES

Email: 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. We are not able to answer technical queries on the phone.

PROJECTS AND CIRCUITS

All reasonable precautions are taken to ensure that the advice and data given to readers is reliable. We cannot, however, guarantee it and we cannot accept legal responsibility for it.
A number of projects and circuits published in *EPE* employ voltages that can be lethal. You should not build, test, modify or renovate any item of mains-powered equipment unless you fully understand the safety aspects involved and you use an RCD adaptor.

COMPONENT SUPPLIES

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

ADVERTISEMENTS

Although the proprietors and staff of *EVERYDAY PRACTICAL ELECTRONICS* take reasonable precautions to protect the interests of readers by ensuring as far as practicable that advertisements are bona fide, the magazine and its publishers cannot give any undertakings in respect of statements or claims made by advertisers, whether these advertisements are printed as part of the magazine, or in inserts.
The Publishers regret that under no circumstances will the magazine accept liability for non-receipt of goods ordered, or for late delivery, or for faults in manufacture.

TRANSMITTERS/BUGS/TELEPHONE EQUIPMENT

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

NEWS

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

Greener throwaway batteries

Energizer's new Zinc Air Prismatic batteries offer 'greater run times' from 'smaller devices'. Barry Fox reports.

USING throwaway batteries is expensive and wasteful; rechargeables can usually be relied on to let you down when most needed. Energizer is promising new and greener throwaways, which 'raise the bar for smaller, lighter and thinner devices'. The Energizer Zinc Air Prismatic battery will offer 'greater run times' from 'smaller devices'.

So far, the company has given away no technical details, but claims 'the highest energy density of any consumer portable power solution (either disposable or rechargeable) with up to three times more runtime compared to similarly sized alkaline or lithium ion batteries.'

Spilling the beans

As so often happens, patents spill some beans. There are relevant patent filings under Energizer's name, but also several from sister company Eveready. For instance, US application 20080096074 from James X Wu tells how to improve the efficiency of zinc air batteries by enhancing the air flow to the air electrode.

Air cells have a negative electrode (anode) made of zinc and shaped like a cup, which sits inside a similarly shaped positive air electrode (cathode), trapping alkaline electrolyte such as potassium hydroxide. Air oxidizes the zinc in an electrochemical reaction that generates electrical power. The better the air flow, the higher the power delivered.

Eveready builds the cell from materials with deliberately roughened surfaces. This creates a network of tiny channels which let air and oxygen travel freely to boost power output.

Zinc air cells are not rechargeable – unless the spent electrolyte can be replaced – but they are cheap to make from easily available and safe materials. An added bonus is that spent batteries can be recycled to recover zinc from the electrolyte.

Next generation

Meanwhile, US company Boston-Power is promising next-generation Lithium-ion (Li-ion) battery cells, dubbed Sonata, available first to HP laptop owners in early 2009. B-P claims like-new performance for three years, even under 'abusive environmental, mechanical and electrical conditions'. This lets HP offer a three-year warranty with its Enviro Series notebook batteries. So, fewer batteries need be junked over the lifetime of a notebook computer.

B-P also claims the new cells need only 30 minutes to recharge to 80% capacity, so are ideal for travellers. "Consumers depend on their notebook computers as much as they do because they enable mobility – whether being used for leisure or work activities," says Boston-Power Founder and CEO Dr Christina Lampe-Önnerud. "We're thrilled to be teaming with HP to bring Sonata to market."

Boston-Power was founded in 2005 by Christina Lampe-Önnerud and husband and CTO Per Önnerud. Ms Lampe-Önnerud is known in the electronics industry for warning – before the widely publicised spate of laptop battery fires and product recalls – that Li-Ion computer batteries contain roughly the same energy as a hand grenade.

Both inventors have filed patents for Boston-Power, and previously for the Kureha Chemical Industry Company of Tokyo. Most of their patents cover the highly complex chemistry of the active cathode, and reveal the hidden risk of making batteries too big and powerful – the battery is made by ganging together many smaller cells and these can start life with minor differences and then age differently to create an unbalanced system.

The weakest cells degrade quickest, to increase the imbalance. This can cause overheating, increased gas pressure and the risk of explosion. To control this, smart circuitry measures the voltage level on individual cells and triggers selective discharges to re-balance the systems. If gas pressure still rises to risky levels, parts of the metal casing separate to open the output circuit and stop the current flowing.

US patent 20080048614, filed in 2007 by Phillip Partin and Christina Lampe-Önnerud, reveals the trick for safe fast charging. Mechanical buttons on the battery or virtual buttons on the laptop screen offer a choice of slow or fast charging.

Standard charging, which takes around two hours, fully charges the battery; rapid charging with higher current takes only half an hour, but cuts off before the battery is fully charged. The rapid charge does not push the battery into a risky condition, and an 80% charge will give enough working time between re-charge opportunities.

SchmartBoard Starter Kit

SchmartBoard has announced the new 'Solder By Numbers (SBN) Starter Kit' for people who are new to electronics. The kit includes: An Elenco 40W electronic soldering station; assorted size of tips for the soldering iron; water-soluble solder flux in pen form; safety goggles; illuminated magnifying glass; two screwdrivers; wire cutters; wire strippers; needle nosed pliers; SchmartSolder; a Solder By Numbers Project with SchmartBoard and Components (LED Paperweight). The Starter Kit costs $99.00 (£68 approx.) and its release coincides with the launch of ***www.solderbynumbers.com****.*

"It takes two things to build an electronic circuit – the ability to solder the components and the ability to take an electronic schematic and transfer the schematic to a real circuit board," said Neal Greenberg, SchmartBoard VP of Marketing. "SchmartBoard has made these issues easy, which opens up electronics to a wider audience than previously possible."

With SchmartBoard prototyping technology, anyone can solder any type of SMT electronic component. SchmartSolder also makes it possible for anyone to hand solder through-hole components. Solder By Numbers tells you where to solder components onto the SchmartBoards to create your circuits. "Solder By Numbers is to circuit building what Paint By Numbers is to art", said Greenberg. "We plan to have hundreds of SBN circuits on the SolderByNumbers website available soon."

Details are available at: ***www.schmartboard.com/index.asp?page=sarter_kit.***

NEW FROM NURVE NETWORKS

Nurve Networks has introduced new development kits for PICs and AVRs, working directly with Microchip and Atmel to try and create really competitive and fun kits.

The XGS PIC 16-Bit kit, based on Microchip's new 16-bit PIC24 processor, is a highly integrated development kit for exploring Microchip's 16-Bit microcontrollers in a fun and engaging way. On the other hand, the XGS PIC 16-Bit is designed to be a serious PIC24 development kit for schools, students, engineers and anyone interested in learning PIC programming.

The system has the following features:

*PIC24 16-bit processor with 256K FLASH/16K SRAM running at over 40 MIPS

*3.3V/5V dual supplies

*VGA

*NTSC/PAL with colour generation helper hardware

*Micro SD card interface

*Serial port

*ISP and JTAG programming ports

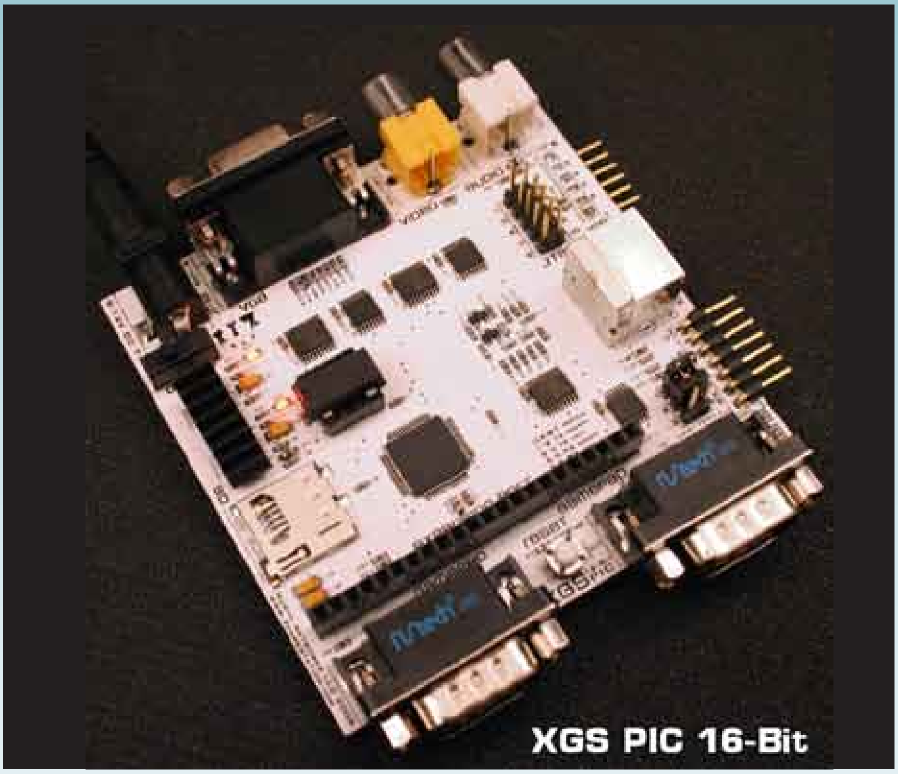
*PS/2 keyboard/mouse port

*Expansion port header exporting numerous I/O, power and signal lines for experimentation

*3.3V/5V internally regulated supplies

*Two game controller ports (Nintendo compatible)

The kit is said to give users a fun way to learn PIC programming in the context of graphics, audio and simple game development. So, instead of blinking LEDs and displaying digits on a 7-segment display, users can develop graphics applications that control the VGA and NTSC screen to learn PIC C and ASM. The kit comes with the following items in the bundle:



*350+ page printed manual covering hardware, software and numerous programming tutorials

*PICkit2 programmer and USB cable

*9V power supply

*A/V cable

*Game controller

*DB9 PC serial port to XGS header converter

*DVD-ROM with numerous examples and complete driver library, including graphics, sound, keyboard, SD card, serial comms, mechatronics and lots more

*Bonus materials on DVD-ROM include electronic copies of numerous game development and electronics gaming hardware books

The XGS PIC 16-Bit development kit is priced at $159.99 (£110 approx.). For more information on this kit and a similar one for AVRs, visit **www.xgamestation.com**.

Pico Adds Digital Persistance Display

All PC Oscilloscopes currently available from Pico Technology now have an advanced persistence display mode. Persistence mode is an oscilloscope feature that lets you view the history of your signal at the same time as the live waveform. This means that intermittent glitches, jitter and noise remain on the display for longer, giving you a chance to catch and analyse them.

You can use persistence mode to search for a problem without knowing exactly what sort of error you are looking for. Once you see an out-of-specification waveform on the screen, you can then switch to a standard display mode and set up the scope's advanced triggers to capture the problem in more detail.

Pico's persistence mode shows you multiple waveforms on every screen update, making the display more responsive. There is a digital colour mode that shows stable data in 'hot' colours and intermittent data in 'cool' colours. With a stable trigger signal, this mode can even display eye patterns for analysing serial data waveforms.

Digital colour mode is complemented by an analogue persistence mode, which emulates an analogue oscilloscope by drawing new data at full intensity, while allowing old data to fade away. This mode uses a single colour per channel.

To use the new feature, you just click the Persistence Mode button and let the PicoScope do the rest. The program lets you customise the display colours and persistence parameters if you need to.

Alan Tong, Managing Director of Pico Technology, commented: "The new persistence mode is ideal for research and development, field servicing and troubleshooting. Like all our software updates, it's free of charge to all our customers."

PicoScope 6.1 can be downloaded from the Pico Technology website at www.picotech.com. Free technical support and updates are available to all Pico customers.

MPLAB ICD 3 High-speed In-circuit Debugger

Microchip has unveiled a high-speed in-circuit debugger for 8-, 16- and 32-bit PICs and 16-bit dsPIC DSCs. The MPLAB ICD 3 is a cost-effective, high-speed development tool that supports in-circuit programming and debugging of Microchip's Flash-based 8-bit PICs, and its entire line of 16- and 32-bit MCUs and 16-bit dsPIC digital signal controllers (DSCs). With robust system capabilities and high-speed circuitry, flash MCU programming times are 15× or faster than the current generation, plus the MPLAB ICD 3 offers full compatibility with the MPLAB IDE, exceptional programming speed and reliability.

Key features include up to 1,000 software breakpoints, 2V to 5.5V operation, a ruggedised target interface for increased protection from over-voltage and over-current, internal memory for program storage, and 100mA of target current support. Future Microchip device firmware support is easily added through updated versions of the MPLAB IDE.

Maintaining backward compatibility with Microchip's RJ-11 interface, the MPLAB ICD 3 can easily connect to target boards for quick device programming. Further, by integrating this new tool with the free and feature-rich MPLAB IDE, Microchip provides design engineers with a familiar development environment. This integration also serves to shorten the learning curve for customers on the 500-strong PIC MCU and dsPIC DSC portfolios.

The MPLAB ICD 3 includes a diagnostic test interface module to assist users with system troubleshooting and failure isolation, RJ-11 and USB 2.0 cables, a CD containing the MPLAB IDE with full documentation and a reference poster. The MPLAB ICD 3 (part # DV164035) is available at **www.microchipDIRECT.com** for only $219.99 (£150 approx.). For further information, contact any Microchip sales representative or authorized distributor, or visit Microchip's website at **www.microchip.com/icd3**.

VU/Peak Meter with LCD bargraphs

Use it as a recording level indicator or simply as a signal level display

This easy-to-build bargraph VU meter makes it easy to record audio signals at the correct level. It shows both the average signal and peak levels in stereo on an LCD, and you can adjust both the display range and number of steps. A digital display option is also available.

By JOHN CLARKE

IF YOU ARE SERIOUS about making quality recordings, then you need to accurately monitor the audio signal level being fed into the recording device. This is to ensure that the signal level is within a range that the recorder can accept.

In particular, correct audio signal levels are quite important for modern digital recorders. These do not tolerate any amount of excess signal level and will severely distort such signals.

Dynamic range

Any audio signal, be it speech or music, varies constantly in level, and the difference between the highest and lowest levels is called the 'dynamic range'.

When recording, it's important that the lowest signal levels must be sufficiently above the 'noise floor' of the recording equipment, to prevent them from being buried in noise. On the other hand, the highest signal levels must be kept low enough to prevent signal overload and the inevitable distortion that accompanies this.

Ensuring that an audio signal stays within these bounds can be quite difficult unless its level is accurately monitored using a meter. This meter must respond not only to the average signal level, but also to peak levels as well.

Fig.1 illustrates why it is so important to get the signal levels correct. Note that each waveform shown is not the audio signal itself, but the instantaneous signal level plotted against time. These signal level variations occur constantly in music and speech. In music, for example, the

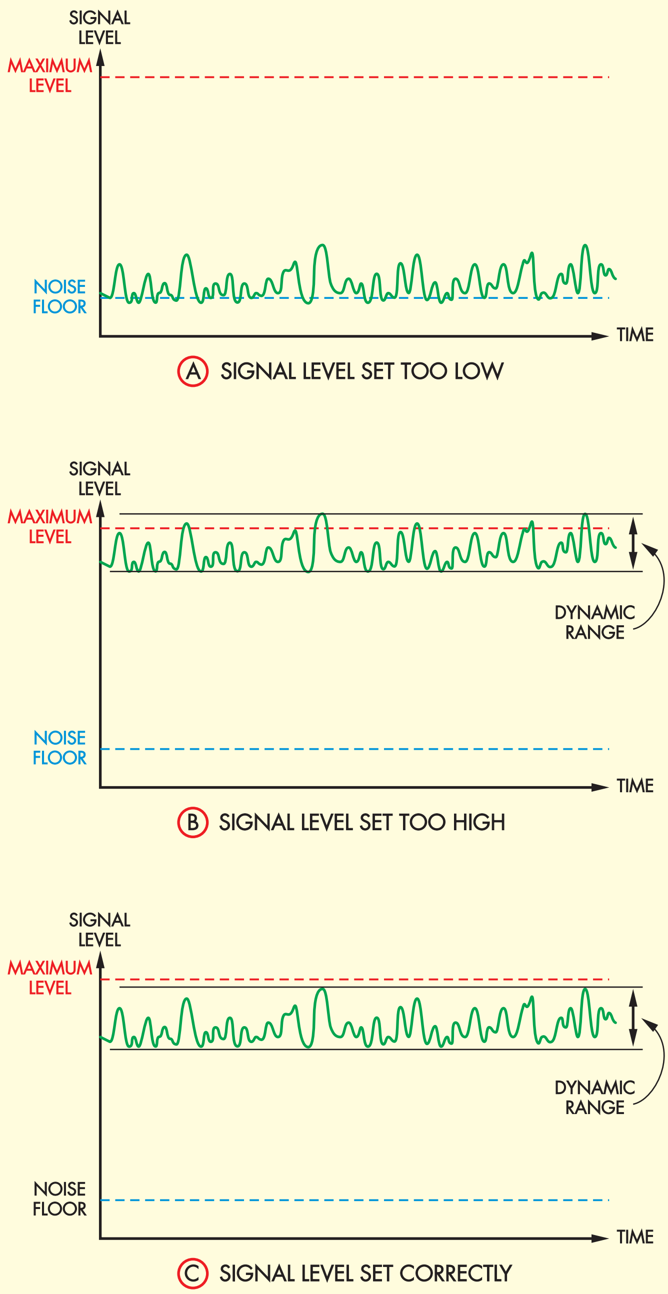


Fig.1: this diagram shows why it is important to set the correct signal level for recording. In A, the average signal level has been set too low, resulting in lots of background noise. In B, the level is too high and the recording system will overload and distort. Diagram C shows the correct level – ie, well above the noise floor but with the peaks below the maximum recording level.

level may range from soft passages to quite loud passages.

Fig.1(a) shows an example of a recording that's been made with the signal level set too low. What happens here is that lowest signal levels are lost within the noise and so only noise signals will be heard at these levels. The higher signal levels are above the noise floor, but the overall sound quality will be rather poor, with lots of background noise.

Conversely, Fig.1(b) shows what happens if the average signal level is too high. Here, the upper levels go above the maximum level that the recording device can handle without distortion.

For magnetic tape recording, some degree of signal peaking above the maximum level can be tolerated. That's because magnetic tape compresses the signal rather than severely clipping it. However, as previously indicated, this is not true for digital recordings, where any signal that goes above the maximum is simply clipped.

The ideal recording level is shown in Fig.1(c). This is where the signal levels are well above the noise floor but do not exceed the maximum level. By doing this, we ensure both low distortion and the best possible signal-to-noise ratio.

VU meter

In the past, audio signal levels were commonly measured using a 'Volume Unit' or VU meter. In fact, these have been used since broadcasting began, and are still widely used by the recording industry.

In practice, a VU meter displays the average signal level and is calibrated to show the true RMS value for a sine-wave signal. The true RMS value is simply the DC equivalent value of the AC waveform.

One drawback of conventional VU meters is that they are rather slow to react to signal variations. Typically, they take some 300ms to respond fully to a signal, and this means that they are unable to respond to the fast transients that often occur in speech and music.

As a result, many modern VU meters also include 'peak displays' that show the levels of any sudden transients. However, they only show transients that are sustained for a defined time and this assumes that any short duration transients that are clipped are inaudible.

VU/Peak meter

The unit described here falls into the latter category. It includes stereo (left and right channel) VU and peak level displays and employs an LCD readout (rather than a conventional meter) for a fast response.

As shown in the photos, the meter is housed in a small plastic utility case with a clear lid. It includes four RCA phono sockets (two input and two output) so that you can connect the unit in-line between the signal source and the recorder.

Both the Stereo VU/Peak Meter and the recorder must be set up so that the meter indicates the correct levels for recording. In practice, this means that the level control on the recorder is fixed in position. Any

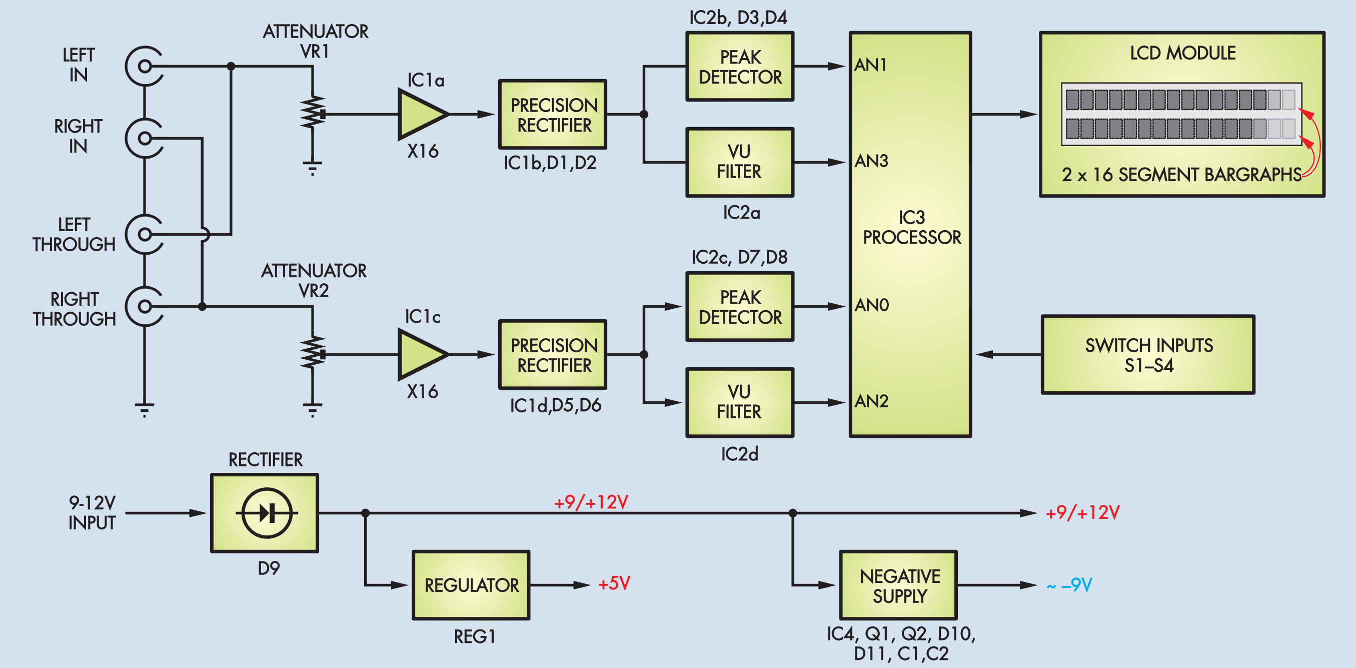


Fig.2: the block diagram of the digital Stereo VU/Peak Meter. The incoming signals are first amplified by IC1a and IC1c and then fed to precision rectifier stages. From there, they go to the peak detector and VU filter (averaging) stages before being fed to microcontroller IC3. IC3 converts the analogue peak and VU signal levels to digital values and drives the LCD module.

level changes are then made at the signal source – ie, prior to the VU meter – so that both the VU meter and recorder receive the same signal level.

Alternatively, the VU/Peak Meter could be installed within the recorder itself and the signal for it derived after the recorder's level control.

The LCD readout used consists of two 16-block bargraphs (one for each channel). These bargraphs are used here for VU indication and increase in length to the right with increasing signal level.

Main Features

- Stereo bargraph with VU and peak displays
- 15-segment bargraph for each channel
- Adjustable thresholds for each segment
- Signal level adjustment for calibration
- Digital display option
- Programmable VU and peak display options
- 9V to 12V DC power supply

A vertical thin line that travels ahead of each VU bargraph indicates the peak level for that channel.

Display options

As well as the bargraphs, there are several display options to choose from (ain't microcontrollers grand!).

These display options include choosing between either full 15-block bargraphs or 10-block bargraphs with digital readouts in the first six block positions. In each case, the display indicates the channel, with the top bargraph having an 'L' (left) and the lower bargraph an 'R' (right).

The initial pre-programmed settings are for a traditional VU meter covering the range from –28dB to +3dB as follows: –28dB, –25dB, –22dB, –19dB, –16dB, –13dB, –10dB, –7dB, –5dB, –3dB, –2dB, –1dB, 0dB, +1dB, +2dB and +3dB. These settings are the same for both channels. Note, however, that the –28dB block is not indicated because the 'L' and 'R' channel designations are shown here instead.

In addition, this programmed location is used when the digital format display option is selected.

The use of a microcontroller also makes it possible to change the bargraph settings to cover a wider or narrower range. In practice, each block position can be set from between –48dB through to a maximum of +16dB.

Note, however, that the overall range should be 48dB. This means that if the uppermost block in the bar is set at +16dB, the lowermost block should be set to a minimum of –32dB.

When used with a digital recorder, the uppermost bar should be set at 0dB. This would be the absolute maximum level that the digital recorder can handle before clipping.

Mode switch

Pressing the Mode switch for the first time changes the display to show the far lefthand block on the top line and the 'SET VALUE' (eg, –28dB) on the second line. Basically, the block on the top line shows the bargraph position that has the indicated set value.

Pressing the Mode switch again causes the display to show the next block in the bargraph and its value. This step can then be repeated, with each subsequent pressing of the Mode switch showing the next block in the bargraph (and its value).

The displayed values can be changed using the Up and Down switches, which are located behind the front panel. Note that it is important that these values are set to increase in value from left to right. So a sequence of –22, –19, –16, etc is correct but –22, –23, –24 is incorrect.

Options switch

The Options switch invokes the various display selections. These can be toggled using the Up and Down switches to select one of the following display options:
(1) Bar, VU On, Peak On
(2) Bar, VU Off, Peak On
(3) Bar, VU On, Peak Off
(4) Digital and Bar, VU On, Peak On
(5) Digital and Bar, VU Off, Peak On
(6) Digital and Bar, VU On, Peak Off

This means that you can select the full 15-block bargraph with both the peak and VU displays shown, or you can have either peak or VU only shown. Similarly, you could choose the digital display for the first six blocks (DIGITAL selection) and then choose to show either the VU or peak readings, or both.

Note that when the DIGITAL selection is made, the digital reading will show the VU value unless the Peak display only is selected. If Peak only is selected, then the Digital display shows the peak readings.

As indicated above, the DIGITAL display uses 'L' and 'R' designations to indicate the left and right channel bargraphs. The digital values that are displayed will only be in steps of the actual programmed values for each block in the bargraph.

The digital display indicates these values (and the 'L' and 'R' designations) within the first six blocks of the displays (ie, the bargraphs no longer occupy these first six blocks). However, if the signal goes below the minimum block setting, then the digital display will show blanks instead of the numbers.

Once the display mode and other settings have been entered, the setup is saved simply by switching the power off and on again.

Block diagram

Refer now to Fig.2 for a block diagram of the Stereo VU/Peak Meter.

As shown, both the Left In and Left Through sockets are paralleled, as are the Right In and Right Through sockets. This allows the audio source signals to be fed into the VU meter and also fed straight back out to the recording device.

Specifications

Display graph: 15-block bargraph or 10-block bargraph with digital display

Display range: 48dB (0 to –48dB) or value variations from +16dB maximum to –32dB

Signal levels: requires 440mV RMS to over-range on VU scale

Accuracy: within 1dB for signals above –40dB

Display resolution selectable to a minimum of 1dB

Input impedance: 100kΩ

Supply voltage: 9V to 15V DC maximum.

Supply current: 108mA with backlit display; 68mA with non-backlit display

Following the L and R input sockets, the audio signal is fed to trimpots VR1 and VR2, which act as level attenuators. The left and right channel signals are then amplified by op amps IC1a and IC1c, which operate with gains of 16. From there, the signals are then precision rectified and fed to the peak detector and VU filter stages.

The outputs from these stages are fed to the AN0 to AN3 inputs of microcontroller IC3. This processes the input signal levels and drives the LCD module according to the settings and values entered using switches S1 to S4.

In operation, IC3 converts the analogue voltages from the peak detector and VU stages to digital values ranging from 1 to 1024. A value of 1024 represents the maximum analogue signal level, which is 5V.

Normally, the unit is set up so that the far righthand block of the bargraph turns on when signal value goes above 1024. This is set to occur when the righthand block is set at 0dB or higher. However, if the far righthand block is set at a minus dB value, then the signal value is reduced to coincide with that dB setting.

The remaining blocks in the bargraph are then calculated to show the lower signal levels. For example, a signal that is at –6dB (or half the 0dB signal level) will have a digital value of 1024/2 or 512 when converted by IC3. Similarly, a –12dB signal will have a digital value of 256. And a signal that is 48dB below the 1024 maximum level will have a digital value of 4 (ie, 251 times less).

These values are all calculated using the following equation:

Attenuation (dB) = 20log(the signal ratio)

For example, if the signal level is half the maximum, then the log of this is –0.3 and 20 times this is –6dB.

Note that IC3 only indirectly uses this equation because it uses a look-up table that already has the values programmed into it.

Power source

Power for the meter comes from an external 9V to 12V DC supply and this is fed in via reverse polarity protection diode D9. The resulting 9V to 12V rail, together with a –9V rail generated by the 'negative supply' block, is used to power the op amps that form the input amplifiers, precision rectifiers, peak detectors and VU filters.

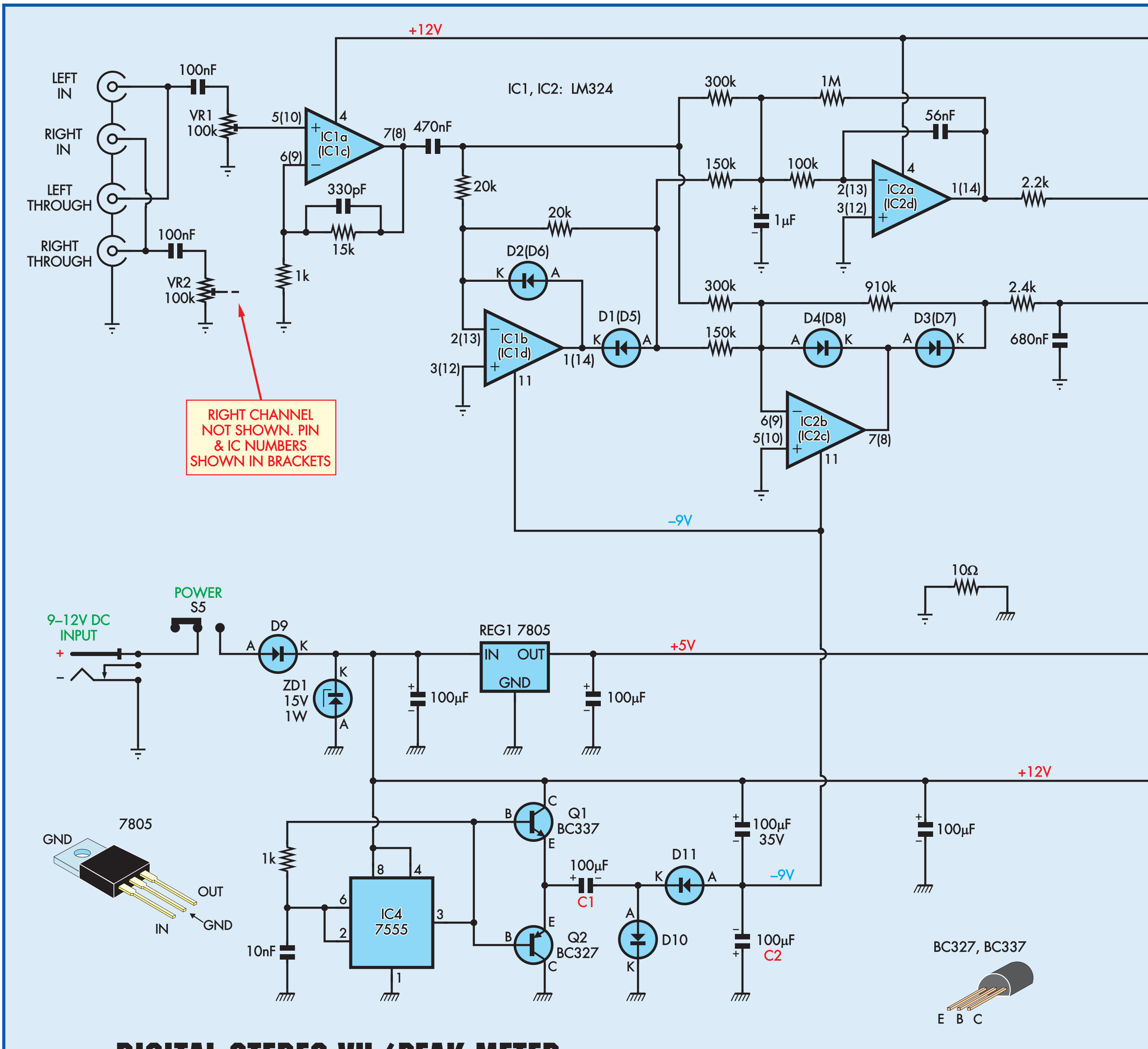
Finally, regulator REG1 produces a +5V rail, which is used to power microcontroller IC3 and the LCD.

Circuit details

Fig.3 shows the Digital Stereo VU/Peak Meter circuit details, but note that only the lefthand channel circuitry before IC3 has been depicted for the sake of clarity. The righthand channel is identical, so we'll describe lefthand channel operation only.

As before, the incoming left-channel audio signal is attenuated via trimpot VR1, which sets the display sensitivity. The signal at the wiper (moving contact) is then applied to op amp IC1a, which operates with a gain of 16 (ie, it amplifies the signal by a factor of 16). This is done to boost the signal level to at least 5V peak-to-peak, so that it is suitable for the following level display circuitry.

IC1a's output is fed via a 470nF capacitor to the full-wave precision rectifier. For the VU signal path, this stage is based on op amp IC1b, diodes D1 and D2 and op amp IC2a. Similarly, for the peak detector, the precision rectifier uses IC1b, D1 and D2 and op amp IC2b. It operates as follows.



DIGITAL STEREO VU/PEAK METER

When the input signal goes positive, pin 1 of IC1b goes low and forward biases diode D1. The resulting gain of the signal appearing at the anode of D1 is –1, as set by the 20kΩ input resistor and 20kΩ feedback resistor.

This inverted signal at D1's anode is applied to the inverting input (pin 2) of IC2a via 150kΩ and 100kΩ resistors. IC2a operates with a gain of –6.66 on this signal, as set by the ratio of the 1MΩ feedback resistor and the 150kΩ input resistor (the 100kΩ resistor in series with the input is inside the feedback loop).

As a result, the overall gain for the signal path between pin 2 of IC1b and pin 1 of IC2a is –1 x –6.66, or +6.66 (ie, IC1b's gain x IC2a's gain).

At the same time, the positive-going signal from IC1a is applied via a second path to IC2a via a 300kΩ resistor. In this case, IC2a operates with a gain of –3.33 due to the ratio of the 1MΩ feedback resistor and the 300kΩ input resistor. Thus, the overall signal gain at the output of IC2a is 6.66 – 3.33 = 3.33.

Now let's consider what happens when IC1a's output swings negative. When this occurs, diode D2 is forward biased and so IC1b's output is clamped at 0.6V above the pin 2 input signal and no signal flows through D1. IC1b is therefore effectively taken out of circuit and IC2a now simply amplifies the signal from IC1a (applied via the 300kΩ resistor) on its own.

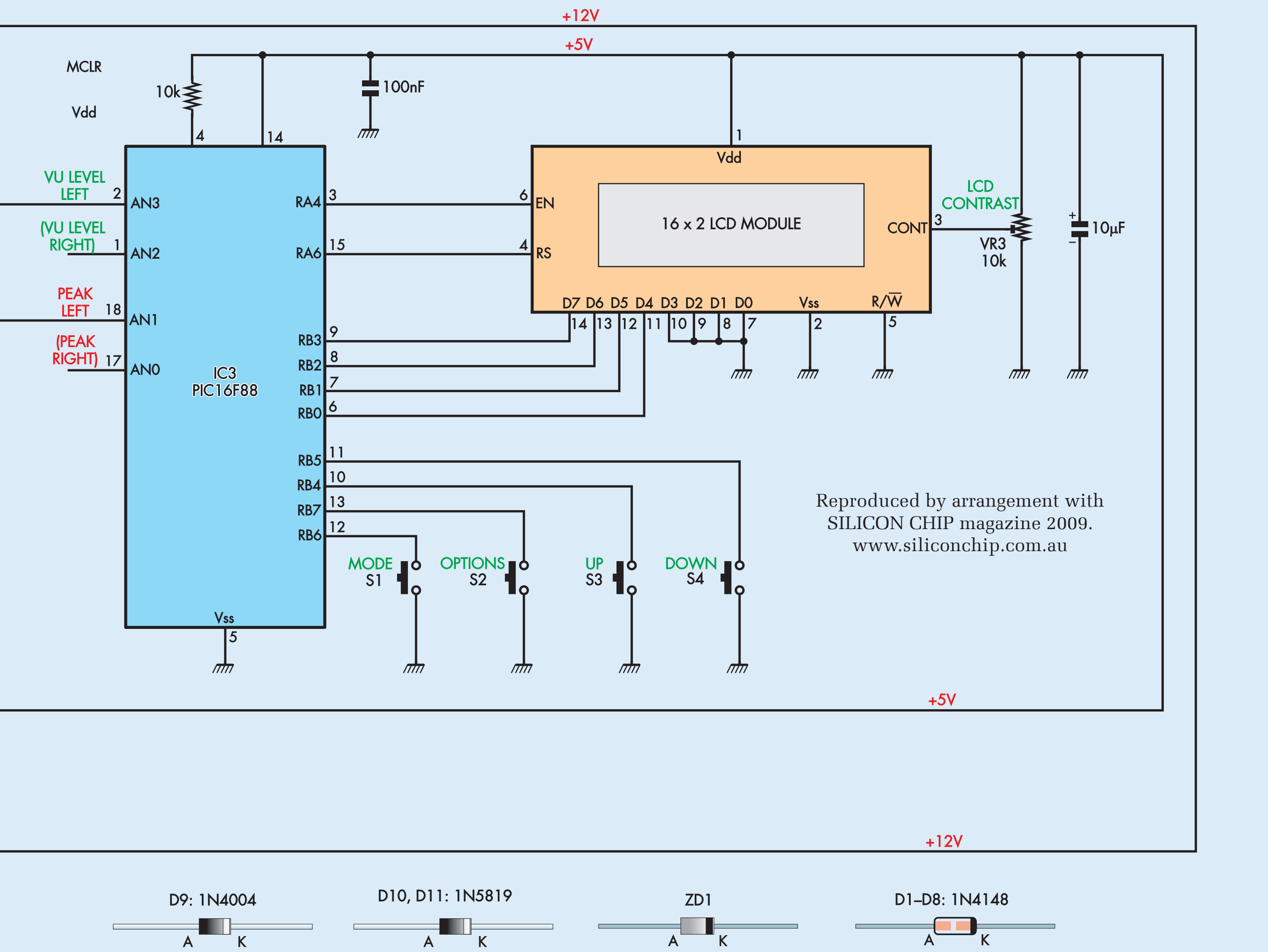


Fig.3: the parts shown in this circuit diagram can be directly related to the block diagram shown in Fig.1. Note that only the lefthand channel circuitry before IC3 has been shown for the sake of clarity – the righthand channel is identical. IC1a is the input amplifier, IC1b, D1, D2 and IC2a form the precision rectifier and VU filter stages; and IC2b, D3 and D4 function as the peak detector. IC4, transistors Q1 and Q2, diodes D10 and D11 and capacitors C1 and C2 make up a diode charge pump, which provides the required –9V rail.

As before, it operates with a gain of –3.33 for this signal path. Since the input signal is negative, the output at pin 1 is positive – ie, it inverts and amplifies the negative input signal.

The precision rectifier therefore provides a positive output with gain of 3.33 for both positive and negative going inputs.

VU response

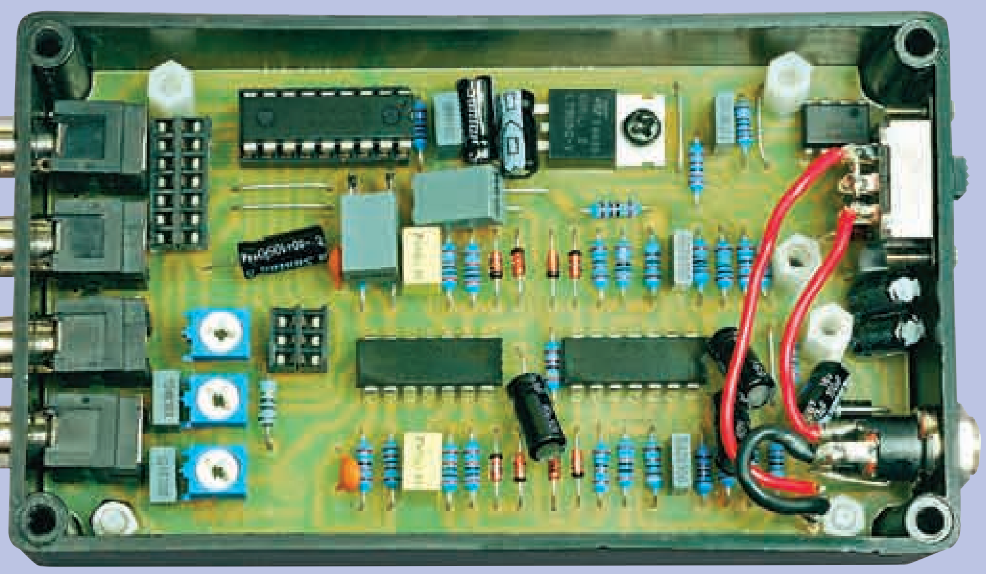
IC2a also provides low-pass filtering of the rectified signal so that its response is relatively slow. This filtering conforms to VU (volume unit) standards, so that the output reaches the input level after 300ms and overshoots by about 1.5%.

The filtering is carried out using the 100kΩ and 1MΩ resistors, the 56nF and 1μF capacitors and the parallel combination of the 300kΩ and 150kΩ input resistors. Together, these provide the 2.1Hz roll-off frequency and a Q (quality factor) of 0.62.

Peak level detector

IC2b and its associated components comprise the peak level detector. This stage is also fed via two signal paths: (1) directly from the output of IC1a via the 470nF capacitor and a 300kΩ resistor; and (2) from diode D1 in the precision rectifier circuitry (and a series 150kΩ resistor).

How this works is again best explained in two steps – ie, when the signal from IC1a swings positive and when the signal swings negative.



The main PC board is secured inside the case using four M3 nylon screws, two tapped nylon spacers and two nylon nuts. Two additional tapped nylon spacers are also fitted to the PC board (centre, right) to support the bottom righthand corner of the LCD module and the righthand end of the switch PC board. Note that the capacitors that go under the LCD module and switch board must be mounted horizontally, to provide the necessary clearance.

As we know from the precision rectifier explanation, when the input signal goes positive, pin 1 of IC1b swings low and forward biases D1. The resulting gain of the signal at the anode of D1 is –1, as set by IC1b's 20kΩ input and 20kΩ feedback resistors.

This amplified signal is applied to pin 6 of IC2b via the 150kΩ resistor. As a result, IC2b's output swings high and forward biases D3. This diode is in series with a 910kΩ resistor in the feedback loop.

The signal at D3's cathode is thus amplified by –910kΩ/150kΩ or –6.066, which means that the output signal is positive and the overall gain from the output of IC1a for this signal path is +6.066 (ie, –1 × –6.066).

For the second signal path (ie, via the 300kΩ resistor), IC2b operates with a gain of –910kΩ/300kΩ or –3.033. This means that the overall gain of the signal from IC1a is 6.066 – 3.033, or +3.033.

When the signal goes negative, D2 is forward biased and IC1b's output is clamped as before. IC2b now operates on its own and amplifies the signal applied to it via the 300kΩ resistor with a gain of –3.033 (ie, –910kΩ/300kΩ).

As a result, IC2b delivers a positive output signal on both positive and negative output signal swings from IC1a. And in both cases, the absolute signal gain is the same at 3.033.

Note that a 910kΩ feedback resistor is used for IC2b instead of a 1MΩ resistor (as used for IC2a in the VU filter). That's because the peak value must be 3dB higher than the VU value.

This 3dB figure comes about because the peak of a sinewave is 1.414 times the RMS value (ie, 3dB greater). Another way of saying this is that the RMS value of a sinewave is 0.7071 of the peak value.

In our case, the VU signal is the average level of the full-wave rectified signal, and this is only 0.637 of the input signal's peak level. The 910kΩ resistor is therefore used to provide a peak output that is 0.91 (approximately 0.637/0.7071) of the peak signal, or about 3dB higher than the VU signal.

Diode D4 ensures that IC2b's output does not swing negative by more than about 0.7V, so that its response to signals is not compromised. In normal operation, diode D3 is forward biased and D4 does not conduct. However, when the signal is at 0V, IC2b's output tends to switch positive and negative to maintain control. That is when D4 comes into operation.

The peak signal level at D3's cathode is filtered using a 2.4kΩ resistor and a 680nF capacitor. This filtering slows the peak signal level response so that it is not instantaneous but instead conforms to an audio standard. This ensures that only peaks that are wide enough to be audible are displayed.

The standard we picked is IEC60268-10, which has a 1.7ms response time to peak signals. This means that the measured signal level will be 1dB lower than it otherwise would be for a 10ms signal burst and 4dB lower for a 3ms burst (compared to an instantaneous measurement).

How The Diode Charge Pump Works

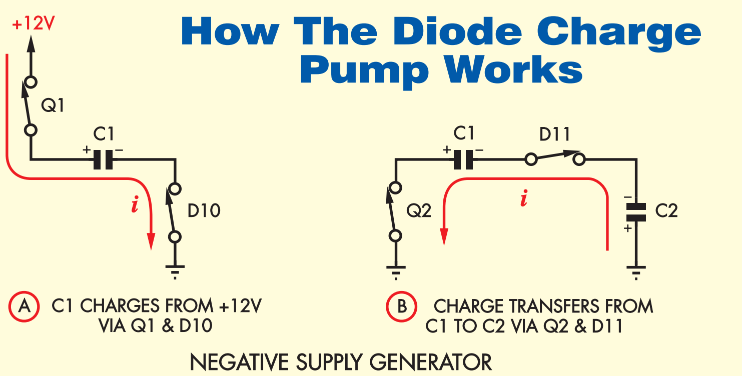


Fig.4: how the diode charge pump works. Capacitor C1 charges towards the +12V rail when transistor Q1 turns on and then transfers its charge to C2 when Q1 switches off and Q2 turns on.

In practice, the 2.4kΩ resistor and the 680nF capacitor in the filter circuit set the time constant at 1.63ms.

The decay time constant specified in the IEC standard is –20dB in 1.5s (equivalent to a 650ms decay time constant). In this circuit, the 910kΩ resistor and the 680nF capacitor set the decay rate at 619ms which is near enough.

Microcontroller

The left-channel VU and peak level signals are respectively applied to analogue inputs AN3 and AN1 of microcontroller IC3. Similarly, the right-channel signals are applied to inputs AN2 and AN0.

Note that the VU input signal is fed via a 2.2kΩ resistor to limit the current flow when IC2a's output goes above 5V. The 2.4kΩ resistor in the output filter circuit for IC2b does the same job.

IC3 is a PIC16F88 microcontroller. It measures the incoming VU and peak signal levels for the left and right channels and drives the 2-line 16-segment LCD module accordingly.

In operation, the signal levels at the AN inputs of the microcontroller are converted to 10-bit digital values using an internal A/D (analogue-to-digital) converter. Outputs RB0 to RB3 then drive the LCD's D4 to D7 data lines, while outputs RA4 and RA6 drive the enable (EN) and register select (RS) lines on the LCD.

Switches S1 to S4 are used to enter data into the microcontroller. Normally, inputs RB4 to RB7 are held high via internal pull-up resistors. Closing a switch pulls the associated input to ground and this is detected and processed by the microcontroller.

IC3 operates at a frequency of 8MHz, as set by an internal oscillator. It is powered from a regulated +5V supply rail, with the reset input at pin 4 tied high via a 10kΩ resistor. The 100nF capacitor and a 100µF filter capacitor provide supply rail decoupling.

The LCD module also runs from the +5V supply rail and a 10µF capacitor decouples its supply. The lower four data lines (D0 to D3) are tied to ground and the LCD module is driven using the upper four bits (D4 to D7). Preset VR3 provides display contrast adjustment.

Software

The software files are available for download via the *EPE* Library site, access via **www.epemag.com**. Pre-programmed PICs are available from Magenta Electronics – see their advert in this issue for contact details.

Power supply

The +5V supply rail for the circuit is derived from a 9V to 12V DC plugpack via diode D9 (which provides reverse polarity protection) and 3-terminal regulator REG1. This regulator has its input and output terminals bypassed using 100µF electrolytic capacitors. Zener diode ZD1 clamps any transients from the plugpack that go above 15V.

The positive supply rail for op amps IC1 and IC2 is derived immediately following D9 (ie, before REG1). This rail is typically 9V to 12V. By contrast, the negative supply rail for these op amps is generated using a diode charge pump. This comprises a 7555 oscillator (IC4), transistors Q1 and Q2 and diodes D10 and D11.

In operation, IC4 oscillates at about 75kHz, with the 10nF capacitor on pin 6 charged and discharged via a 1kΩ resistor connected to the pin 3 output. Pins 2 and 6 are the lower and upper threshold inputs and these monitor the capacitor voltage.

The pin 3 output drives the bases of transistors Q1 and Q2. When pin 3 is high, transistor Q1 switches on

Parts List – Digital Stereo VU/Peak Meter

1 PC board, code 702 (Main), size 116 × 65mm
1 PC board, code 703 (Switch), size 81 × 19mm
(Both boards are available as a set from the *EPE PCB Service*)
1 LCD module with back lighting (Jaycar QP-5516 or equivalent)
1 120 × 70 × 30mm box with clear lid (Jaycar HB-6082 or equivalent)
4 SPST micro tactile switches (S1-S4)
1 DPDT slider switch (S5)
1 8-pin IC socket cut to 2 × 3-way strips
1 14–pin IC socket cut to 2 × 7-way strips
2 14-pin IC sockets for IC1 and IC2 (optional)
1 18-pin IC socket for IC3
4 PC mount right-angle RCA phono sockets
1 20-way DIL header strip
1 2.5mm DC bulkhead socket
4 M3 × 10mm nylon screws
2 M3 × 6mm nylon screws
4 M3 × 6mm screws
1 M3 × 10mm metal screw
4 M3 tapped × 15mm nylon stand-offs (cut to 11mm)
2 M3 nylon nuts
1 M3 metal nut
2 M2 × 8mm screws for S5
2 PC stakes
1 100mm length of red hookup wire
1 50mm length of black hookup wire
1 200mm length of 0.7mm tinned copper wire

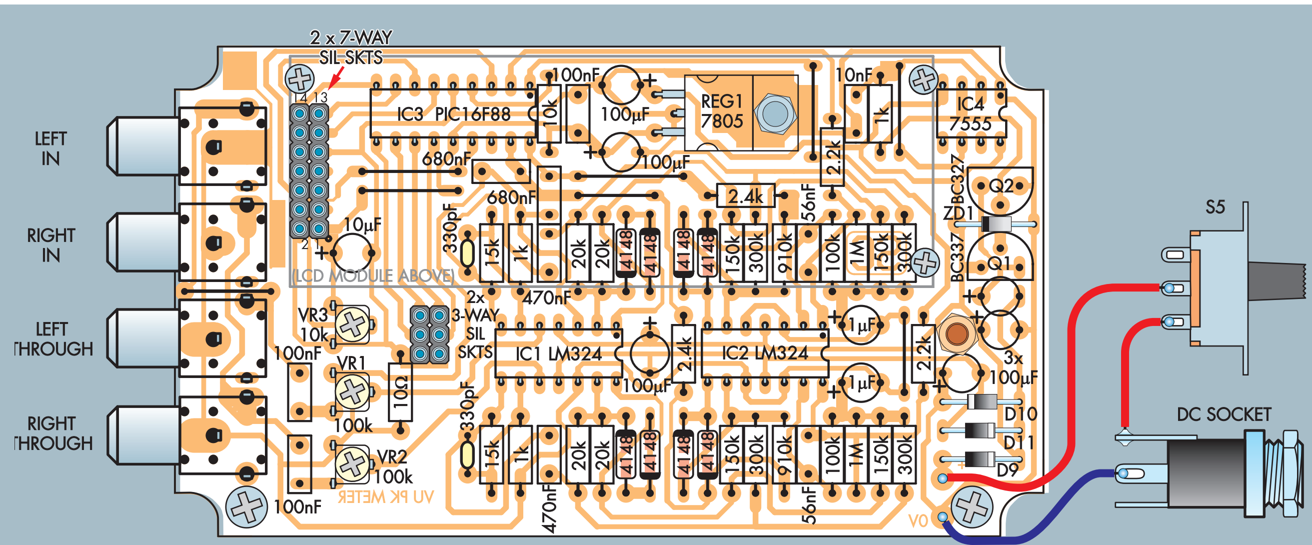
Semiconductors
2 LM324 quad op amps (IC1,IC2)
1 PIC16F88-I/P microcontroller (IC3) programmed with VUPEAK.hex
1 7555 CMOS timer (IC4)
1 LM340T5, 7805 5V regulator (REG1)
1 BC337 *NPN* transistor (Q1)
1 BC327 *PNP* transistor (Q2)
8 1N4148 diodes (D1-D8)
1 IN4004 diode (D9)
2 1N5819 Schottky diodes (D10,D11)
1 15V, 1W Zener diode (ZD1)

Capacitors
1 100mF 35V PC electrolytic
5 100mF 16V PC electrolytic
1 10mF 16V PC electrolytic
2 1mF 16V PC electrolytic
2 680nF MKT polyester
2 470n MKT polyester
3 100n MKT polyester
2 56nF MKT polyester
1 10nF MKT polyester
2 330pF ceramic

Potentiometers
2 100kΩ horizontal trimpots with 2.5mm pin spacing (VR1, VR2) (Code 104)
1 10kΩ horizontal trimpot with 2.5mm pin spacing (VR3) (Code 103)

Resistors (0.25W 1% carbon film)

2 1MΩ	2 15kΩ
2 910kΩ	1 10k
4 300kΩ	2 2.4kΩ
4 150kΩ	2 2.2kΩ
2 100kΩ	3 1kΩ
4 20kΩ	1 10Ω



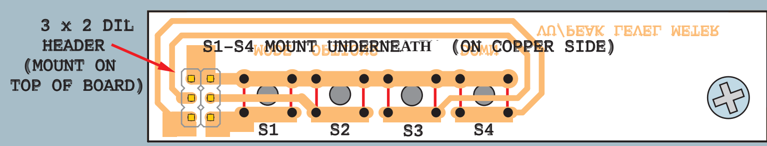


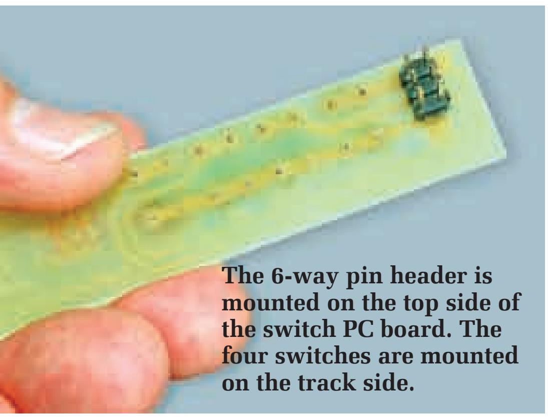
Fig.5: assemble the two PC boards as shown here. Note that most of the capacitors on the main board must be mounted horizontally, so that they don't foul the LCD module and switch PC board when these are installed (see photos).

and Q2 is off. Conversely, when pin 3 is low, transistor Q2 switches on and Q1 turns off.

Basically, the transistors act as current buffers which drive the following voltage converter circuitry without loading IC4's output.

Diodes D10 and D11, along with capacitors C1 and C2 (both 100μF), act as a 'diode charge pump' converter to derive the negative (–9V) supply. Fig.4 shows a more simplified arrangement of how this works.

When transistor Q1 switches on, C1 charges towards the 12V supply rail via diode D10. Subsequently, when Q1 switches off and Q2 turns on, the positive terminal of C1 is connected to ground and the negative side of the capacitor is pulled below ground by an amount equal to the voltage across it.



The 6-way pin header is mounted on the top side of the switch PC board. The four switches are mounted on the track side.

Capacitor C2 now quickly charges towards this negative voltage via diode D11. As a result, it reaches a negative voltage that is close in value to the 12V supply, minus the voltage drops across the diodes and the saturation voltages of transistors Q1 and Q2.

In practice, this is about –9V and this rail is bypassed using another 100μF capacitor (to the positive rail) to minimise the supply impedance.

Note that the diodes used are Schottky types, which have a lower voltage drop than standard diodes. In addition, these diodes are better suited for high-frequency operation and produce less losses at 75kHz.

Construction

The Stereo VU/Peak Level Meter is built on two PC boards – see Fig.5. The main board is coded 702, and carries all the input metering circuitry, the microcontroller and the LCD module, which is connected via a pin header.

The second, smaller board is coded 703, and carries switches S1 to S4 to allow the display values and options to be changed from the pre-programmed settings. Both printed circuit boards are available as a set from the *EPE PCB Service.*

Begin construction by checking the PC board for any faults. These could include bridges between tracks, breaks in the copper and incorrect hole sizes. In addition, make sure that the various mounting holes are all the correct size, including those for the RCA phono sockets.

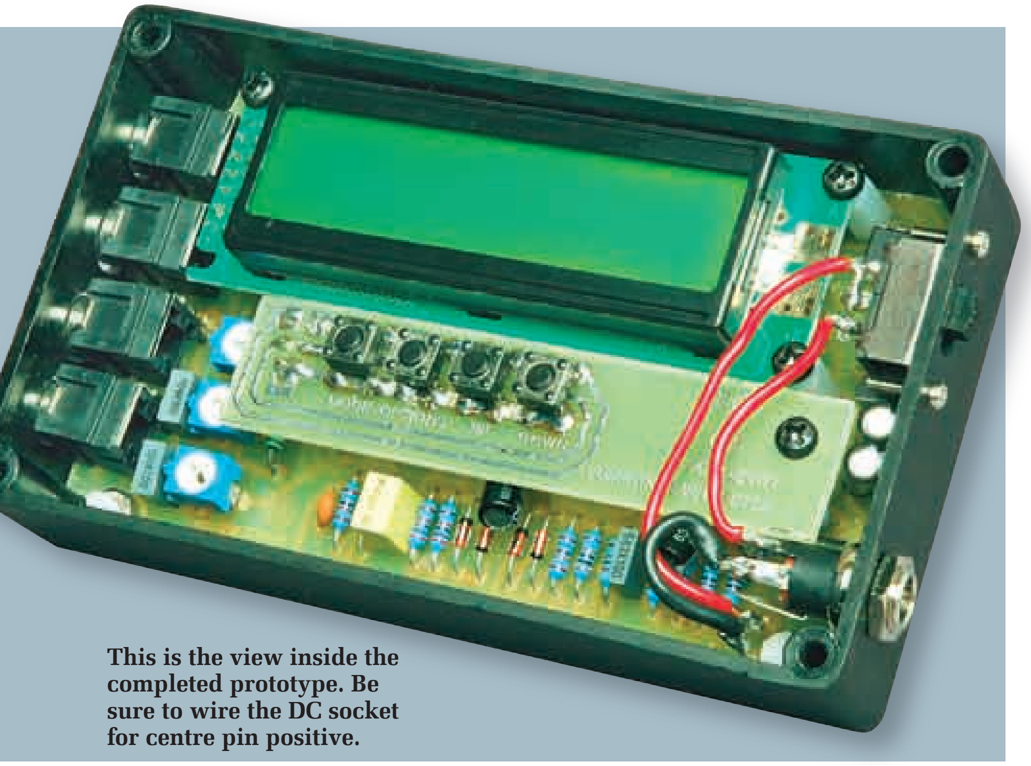
Start the assembly by installing PC stakes at the two supply terminals (ie, the bottom right connections to the DC socket and switch S5), then install the eight wire links. In particular, note the link situated between the two central phono sockets – don't leave it out.

The resistors can go in next. Table 1 shows the resistor colour codes, but you should also use a digital multimeter to confirm their values (some colours can be difficult to decipher).

Next on the list are the diodes. Several different types are used in this circuit, so be careful not to mix them up. Once they're in, transistors Q1 and Q2 can be installed. Note that Q1 is a BC337 (*NPN*), while Q2 is a BC327 (*PNP*) – be sure to install them in their correct locations.

Note also that the tops of the transistors must be no more than 9mm above the PC board, to allow clearance for switch S5 when the unit is mounted inside its case.

Now for regulator REG1. As shown, this is installed flat against the board (just bend its leads down at right angles) and secure its metal tab using an M3 × 10mm metal screw and nut. Be sure to tighten the nut before soldering REG1's leads. Doing this the other



This is the view inside the completed prototype. Be sure to wire the DC socket for centre pin positive.

way around could place undue stress on the soldered joints.

IC1, IC2 and IC4 can now be installed, taking care to ensure they are all correctly oriented (ie, pin 1 at top, right). Note that IC4 is a CMOS device, so observe the usual static precautions (ie, discharge yourself by touching an earthed metal object, avoid touching its pins and earth the barrel of your soldering iron using a clip lead).

An 18-pin socket is used for IC3. Don't plug IC3 in yet, though – that step comes later.

Trimpots VR1, VR2 and VR3 are next on the list. Note that VR3 is 10kΩ (code 103), while VR1 and VR2 are both 100kΩ (code 104). Once they're in, the four RCA phono sockets can be installed.

Installing the capacitors

Take a careful look at the photos before installing the capacitors. In particular, note that all the electrolytic types, except for the two 100µF units just below transistor Q2, must be installed horizontally (ie, laid over on their sides). This is necessary to allow clearance for the LCD module and the switch carrier PC board.

In practice, its just a matter of bending their leads down at right angles before installing them. Make sure they all go in with the correct polarity.

Depending on the brand, it may also be necessary to mount some of the polyester capacitors in this fashion.

Header sockets

The main board assembly can now be completed by installing two 7-way SIL (single-in-line) sockets (for the LCD header) and two 3-way SIL sockets (for the switch board header).

In both cases, these socket strips are made by cutting down IC sockets – ie, a 14-pin IC socket and an 8-pin IC socket, respectively. Use side cutters to split the sockets in half and a file to clean up the edges.

Once these are in, a matching 14-way pin header (which is cut from a 20-way header) can be soldered to the LCD module. Note that this header must be inserted from the underside of the module's PC board and its pins soldered on the top side.

Switch PC board

There's nothing complicated about the switch board, since it carries just switches S1 to S4 and a 6-way pin header. Note however, that the four switches are mounted on the copper side of the board – see photo.

The 6-way header is mounted in the usual manner (ie, it is installed on the non-copper topside of the board).

Testing

The unit is now ready for testing, before final assembly into its case. This should be done without microcontroller IC3 in place and with the LCD module unplugged.

First, temporarily wire a DC socket to the +12V and 0V terminals on the main PC board (the +12V lead goes to the centre terminal of the socket). That done, connect a 9V to 12V DC power supply to the unit and switch on (**warning:** do not apply more than 15V to the unit, otherwise Zener diode

Table 1: Resistor Colour Codes

❏	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❏	2	1MΩ	brown black green brown	brown black black yellow brown
❏	2	910kΩ	white brown yellow brown	white brown black orange brown
❏	4	300kΩ	orange black yellow brown	orange black black orange brown
❏	4	150kΩ	brown green yellow brown	brown green black orange brown
❏	2	100kΩ	brown black yellow brown	brown black black orange brown
❏	4	20kΩ	red black orange brown	red black black red brown
❏	2	15kΩ	brown green orange brown	brown green black red brown
❏	2	2.4kΩ	red yellow red brown	red yellow black brown brown
❏	2	2.2kΩ	red red red brown	red red black brown brown
❏	3	1kΩ	brown black red brown	brown black black brown brown
❏	1	10Ω	brown black black brown	brown black black gold brown

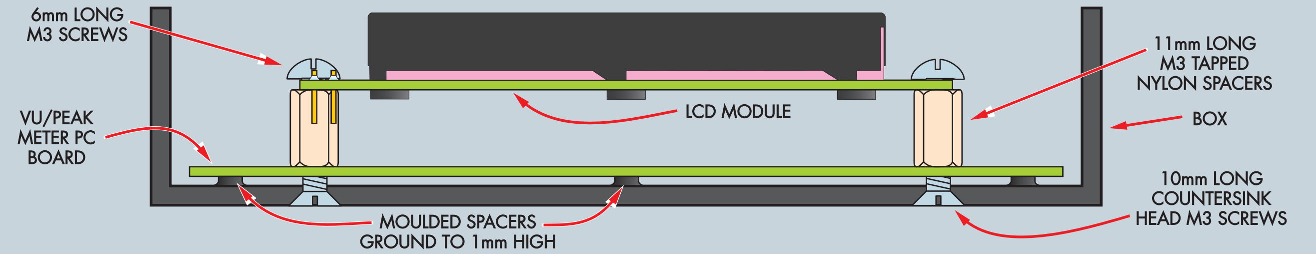


Fig.6: here's how the PC board assembly fits inside the case. Be sure to use tapped nylon spacers as specified (not metal), to prevent shorts to the PC tracks. The 10mm countersink M3 screws through the base of the case should also be nylon, again to prevent shorts on the PC board.

ZD1 will become hot and may be damaged by excess current).

Now measure the voltage between pins 5 and 14 of IC3's socket. This should be 5V (anywhere between 4.85V and 5.15V is OK). The voltage on pin 11 of both IC1 and IC2 should be anywhere from –7V to –10V, depending on the input voltage.

If you don't get the correct voltages, switch off immediately and check for wiring errors. If you don't get any voltage at all, check the supply polarity.

Assuming everything is OK, switch off and plug IC3 into its socket, making sure it is oriented correctly. That done, plug the LCD module into its header socket and temporarily support it at the other end on nylon stand-offs.

Now apply power again, and check that the display shows 'L' and 'R' to indicate the positions of the bargraphs. If there is no display or the contrast is poor, try adjusting the contrast trimpot (VR3). If there is still no display, check the connections to the module through the header and sockets.

Final assembly

Once the checkout is complete, the PC boards can be installed in a small plastic case measuring 120 × 70 × 30mm. The specified case comes with clear lid and is available from Jaycar (Cat.HB-6082).

Four countersunk holes will have to be drilled in the case base in line with the corner mounting holes of main the PC board. In addition, you will need to drill four holes at one end for the RCA phono sockets and a hole at the other end for the DC power socket – see photos. Be sure to position the latter hole so that the power socket clears the switch board.

Finally, you will need to drill two holes for switch S5 mounting screws and make a square cutout for the switch actuator. The square hole can be made by drilling a series of small holes around the inside perimeter and then knocking out the centre piece and cleaning up with a small file.

Fig.6 shows the final assembly details. First, the integral (moulded) spacers on the case base should be ground down to a height of 1mm. That done, secure an M3 × 11mm tapped nylon spacer (cut it down from a 15mm spacer) to the PC board immediately to the left of transistor Q1 (this spacer supports the lower righthand corner of the LCD module).

A second similar spacer is also fitted just below this (to the right of the 2.2kΩ resistor) to support the righthand end of the switch PC board.

The main board can now be installed in the case by sitting it on the 1mm moulded spacers. Secure it along the top edge using two M3 × 10mm countersink screws, which go into two more M3 × 11mm tapped nylon spacers. The bottom edge of the board is then secured using M3 × 10mm countersink Nylon screws and nuts.

Once the main board is secured, the LCD module can be installed by plugging it into its header socket and securing it to its three matching nylon spacers using M3 × 6mm screws.

Similarly, the switch PC board is plugged into its header socket and secured to its matching 11mm spacer at the other end.

Finally, fit the DC socket and power switch S5 and complete the wiring as shown in Fig.5. The switch is secured using the supplied M2 screws.

Calibration

Just how you calibrate the meter depends on the application. First, VR1 and VR2 are used to set the signal level sensitivity for the left and right channels respectively.

In practice, a true VU meter will show +0dBU when the applied signal is +4dBU. Now, 0dBU is 1mW into 600Ω. Thus, when 1mW is multiplied by 600Ω

DISPLAY MODES

Fig.7: just two of the optional display modes that can be selected: top – Digital and Bar, VU On, Peak On; bottom – Bar, VU On, Peak On

MODE SELECTION

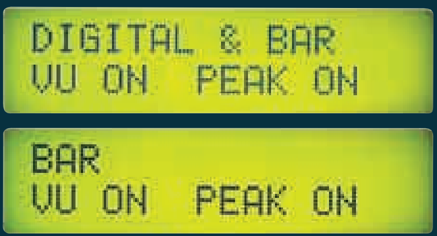
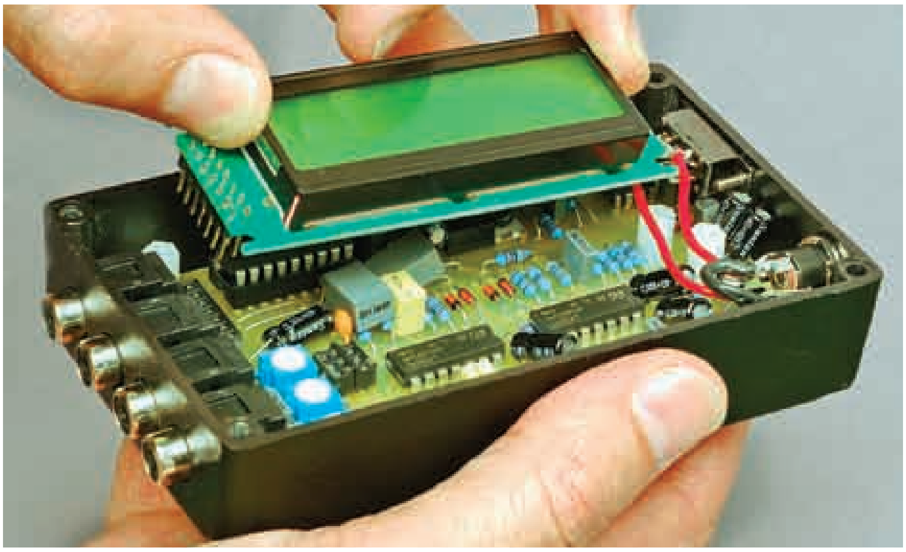


Fig.8: the display mode is selected by pressing the Options switch and then stepping through the selections using the Up and Down buttons. These two modes correspond to the displays shown in Fig.7.

SETTING THE BLOCK

Fig.9: the individual bargraph block values can be altered using the Mode switch and the Up and Down switches.



The LCD module plugs into the 2 × 7-way SIL sockets on the PC board and is secured to three of the nylon spacers. The switch PC board (not shown here) mounts in similar fashion and is secured to the fourth nylon spacer.

and the square root taken (V = square root of power × resistance), the voltage is 774mV. 4dBU is 1.584 times greater and so the 4dBU signal level is 1.23V.

The peak level will be some 3dB higher than this because the peak value of a sinewave is 1.414 times higher than its RMS value. So if you are replacing existing VU meters, the Stereo VU/Peak Meter should be calibrated to show 0VU with a 1.23V sinewave input.

For most other applications, the display readings are set according to the level that produces clipping. With digital recorders, these invariably include a clipping indication that shows whenever the signal goes above the maximum level for digital conversion.

This means that the meter should be calibrated so that the 0VU peak block is just displayed at this clipping level.

The display range may also be altered to suit your application. A digital recorder would normally use a meter display that shows 0VU at the far righthand block. The values below this can then be set according to preference.

For example, you could set each block to display in just 1dB steps, or you could use much larger steps or a combination of step sizes. Larger steps are more useful at lower signal levels, while 1dB steps are best as the signal level approaches the upper threshold. ***EPE***

2009 – The year of Femtomania?

TechnoTalk

Mark Nelson

Pico is no longer the extreme; femto is the new buzz word! Confused? You will be when you have read this report on the next big change in wireless technology from Mark Nelson.

You've decided to lay out good money on a mobile broadband package that offers you voice, data bandwidth and video streaming at home. You've been promised rock-solid signal strength so you assume the service provider must have installed an adequate base station in your close-by neighbourhood, right?

Mindset

Wrong, in fact, you have just betrayed your antique 'last century' mindset. It's simply not the way people do things in the 21st century. Or at least not if the people promoting femtocells have their way. Instead of swamping swathes of the population with high-power wireless service on the off-chance that subscribers will sign up, these guys want to offer each subscriber their own mini on-site base station that uses existing cable or phone line broadband as the backhaul route into the mobile network. And the name they have given to these personal base stations is *femtocells*.

Femto is an international unit prefix denoting a factor of 10^{-15} or 0.000 000 000 000 001. In the grand order of things it follows nano (10^{-9}) and pico (10^{-12}), named after the Danish word femten, meaning fifteen. But just as nano has generically come to mean technical things that are very small, femto now describes technical things that are even smaller than nano.

In this article, we'll be looking exclusively at femtocells and femtocell technology, leaving others to fathom out alternative aspects of the femto world.

Crazy or what?

Before we investigate the whys and the wherefores of femtocells, let me answer your first question. Who on earth needs or wants their own wireless base station at home – and why?

The answer lies in the statistics. Already 60 per cent or so of mobile usage takes place indoors, either in the home, out shopping or at work. Many people give out only their mobile number and you've probably noticed the growing number of people who don't even bother with a landline phone at home. Mobile broadband is taking off like mad and the proportion of users on 'all you can eat' packages is likely to reach 75 per cent by 2011.

For all that, mobile coverage is never as good indoors as outdoors, and even outside the number of dead spots in what people jokingly call 'urban canyons' is getting worse, not better. The gigahertz frequencies for new wireless systems make the risk of 'black holes' in in-building coverage even more inevitable, so it makes far better sense to provide indoor coverage from within, using femtocells. Of course, someone has to pay for all these femtocells and we'll come back to this later.

Femtocells defined

So what exactly is a femtocell? According to the Femto Forum, a not-for-profit organisation that promotes femtocell deployment worldwide, femtocells are low-power wireless access points. Using licensed radio spectrum, they connect standard mobile devices to a mobile operator's network using residential broadband connections (phone line or cable).

But why do we need another access device for the home? The forum says it's clear that more and more consumers want to use mobile phones in the home, even when there's a fixed line available. Friends and family usually call a mobile number first, and it's where messages and contact lists are stored.

But femtocells are not only for homes. They are equally viable in small offices and factories, also in homes that are used as offices as well. From a competitive perspective, femtocells are important because mobile operators need to seize residential minutes from fixed providers, also to respond to emerging VoIP and Wi-Fi offerings. Improving user experience in the home is also essential for reducing churn, also gaining market share and new revenues.

However, high deployment costs ensure that 3G networks rarely extend beyond the regulatory minimum. Using femtocells solves these problems with a device that employs power and backhaul from users' existing resources. It also provides capacity equivalent to a full 3G network sector at very low transmit powers, dramatically increasing battery life of existing phones, without needing to introduce wifi enabled handsets.

The future's bright

And Orange too. The company plans to launch a commercial femtocell service in France during 2009 for small-to-midsize enterprises and large corporate customers and also in the UK to fill indoor 3G coverage gaps. Last year 02 talked about the possibility of a commercial launch in the UK in early 2009 and Vodafone was carrying out trials in Spain. Analyst ABI Research forecasts that by 2011 there will be 102 million users of femtocell products on 32 million access points worldwide.

Somebody is going to have to pay for this step change in mobile technology and mobile operators realise they will have to subsidise or even fully underwrite the cost of femtocells if consumers are to take them up.

Femtocells are not yet a small object of desire, and as Joachim Hallwachs of DesignArt Networks explains, "High quality service delivery into residential homes is a subscriber expectation, not a consumer value proposition". For this reason the cost (and size!) of equipment must be kept low, along with any hike in service charges.

According to chip manufacturer Texas Instruments (TI), for the femtocell to become a successful mass-market consumer item, the packed-up factory gate price cannot exceed $100 in today's values. For this reason, in its own wireless base station designs, TI is using hardware accelerators such as digital signal processing devices to lower the cost and power consumption.

Several other chip firms are addressing this market, including Broadcomm, Intel, Qualcomm and UK-based picoChip. System on chip (SoC) platform architecture is also being used by some chip makers to help equipment makers to shatter the unit price barrier of femtocells below the important $100 barrier.

Containing costs

The price of the hardware is not the only cost challenge facing mobile operators looking to deploy femtocells. There is also an outlay on delivering, installing and maintaining them. Getting a large number of relatively complex devices up and running at once could be a logistical nightmare, which is why the operators are looking to self-installation by users.

This in turn calls for hardware manufacturers to design a highly intelligent, self-testing device that has as few user controls as possible.

The femtocell must be capable of reaching an operational state rapidly once it is connected to a fixed broadband connection in the home or office where it is to be used. That's quite a challenge, but if the electronics industry can design self-tuning televisions and self-commissioning Wi-Fi hubs, it should not be too problematic.

One concern, already resolved, is the potential for interference problems between femtocells and existing base stations (now dubbed macrocells). Techniques based on frequency diversity have been devised to mitigate the problem.

So when will it all happen for femtocells? In these straitened times it's anybody's guess, but in a survey of service provider professionals last year, a third of these said their commercial launches would take place in 2011 or later. Economic considerations may defer this activity to a year or two later, but the latent demand is not going to go away.

TANK WATER LE

Worldwide news reports are continually quoting 'scientists' warnings that 'global warming' will lead to increasing extremes of seasonal weather patterns in the future. Two of the most predicted events being, longer periods of drought and widespread flooding. With thousands of homes now installing outside water storage tanks every year, and water rates increasing year-on-year, we thought it about time to publish a simple tank water level indicator.

EVEL INDICATOR

From an original by Allan March

HOME WATER TANKS are undoubtedly a good idea. Why pay for water when you can catch it free? You can have the greenest garden in the street, along with the cleanest car, while you thumb your nose at summertime hosepipe bans.

But once installed, how can you determine how full (or how empty) your tank really is?

There are several traditional methods for finding the level of water, among them:

1) Tapping down the side of the tank until the sound suddenly changes
2) On a hot day, feeling down the tank for a change in temperature
3) Pouring boiling water down the side of the tank and looking for the line of condensation
4) Removing the tank cover, dipping in a measuring stick.

The first two methods are notoriously unreliable, while the last two also have their problems. Only the last is accurate. But who wants to clamber on top of a tank each time you want to find out how much water is inside it?

Raising the bar

That's where this simple circuit comes in. It uses a row of ten coloured LEDs arranged in a bargraph display to give a clear indication of how the water supply is holding up. The more LEDs that light, the higher the water in the tank.

The LEDs are arranged in the familiar 'traffic light' colours of green, yellow and red to instantly indicate relative levels at a glance (green is good, yellow not so good and red is a warning) as well as the specific levels represented by the individual LEDs.

A further red LED lights when the tank level drops below a critical threshold. This can simply be to warn you of impending localised drought (hey, your tank's empty!) – or it (or indeed any of the ten-LED 'string') could be used to trigger an audible alarm or turn on a pump, as we will discuss later.

There are no fancy microcontrollers or digital displays used in this project. Instead, it uses just a handful of common parts to keep the cost as low as possible.

It can be used in virtually any type of tank. As long as you can get access inside the tank from the top to the bottom, this circuit will work.

Circuit description

The circuit diagram for the Tank Water Level Indicator is shown in Fig.1. It is based on an LM3914 linear LED dot/bar display driver (IC1) which drives ten LEDs (LEDs 1 to 10).

Pin 9 of the LM3914 is tied high so that the display is in bargraph mode and the height of the LED column indicates the level of the water in the tank. However, this pin can be easily isolated, turning the display into a dot type, thus saving power. If you're running from a battery supply in your garden, then every milliamp is precious.

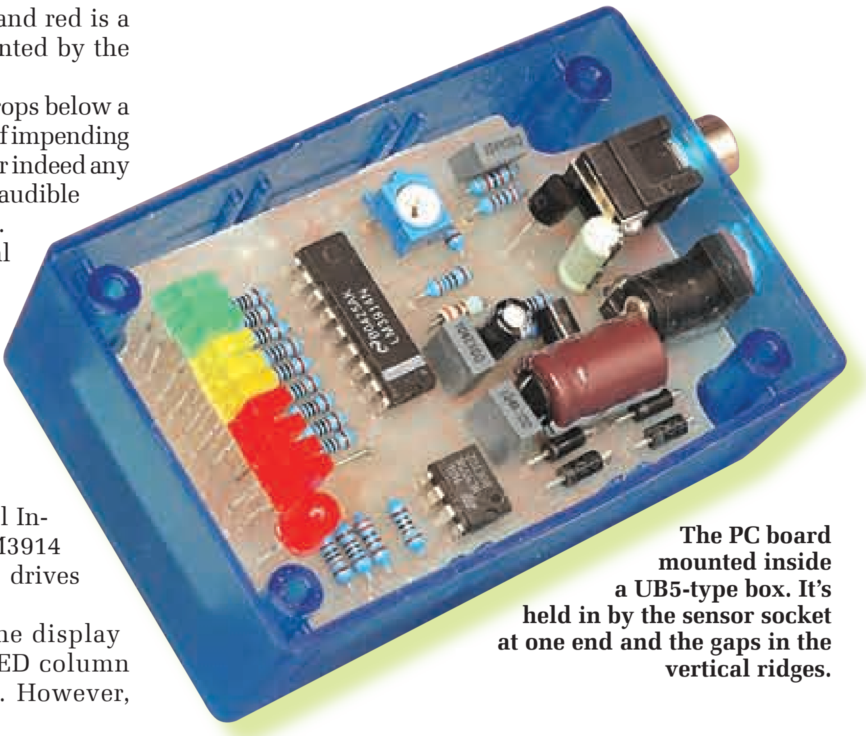
Indeed, the PC board pattern has been arranged so that a miniature switch could be included to swap between bar and dot modes.

The full-scale range of the bargraph depends on the voltage on pin 6. This voltage can be varied using preset VR1 from about 1.61V to 2.36V. After taking into account the voltage across the 390Ω resistor on pin 4, this gives a full-scale range that can be varied (using VR1) between about 1.1V (VR1 set to 0Ω) and 2V (VR1 set to 470Ω).

If you're wondering where all the above voltages came from, just remember that IC1 has an internal voltage reference that maintains 1.25V between pins 7 and 8. This lets us calculate the current through VR1 and its series 1kΩ resistor, and since this same current also flows through the series 1.5kΩ and 390Ω resistors, we can calculate the voltages on pins 6 and 4.

As well as setting the full-scale range of the bargraph, VR1 also adjusts the brightness of LEDs 1 to 10 over a small range. However, this is only a secondary effect – it's the full-scale range that's important here.

IC1's outputs directly drive LEDs 1 to 10 via 1kΩ current-limiting resistors. We have used the full 10 outputs of the chip to obtain a more accurate level indication.



The PC board mounted inside a UB5-type box. It's held in by the sensor socket at one end and the gaps in the vertical ridges.

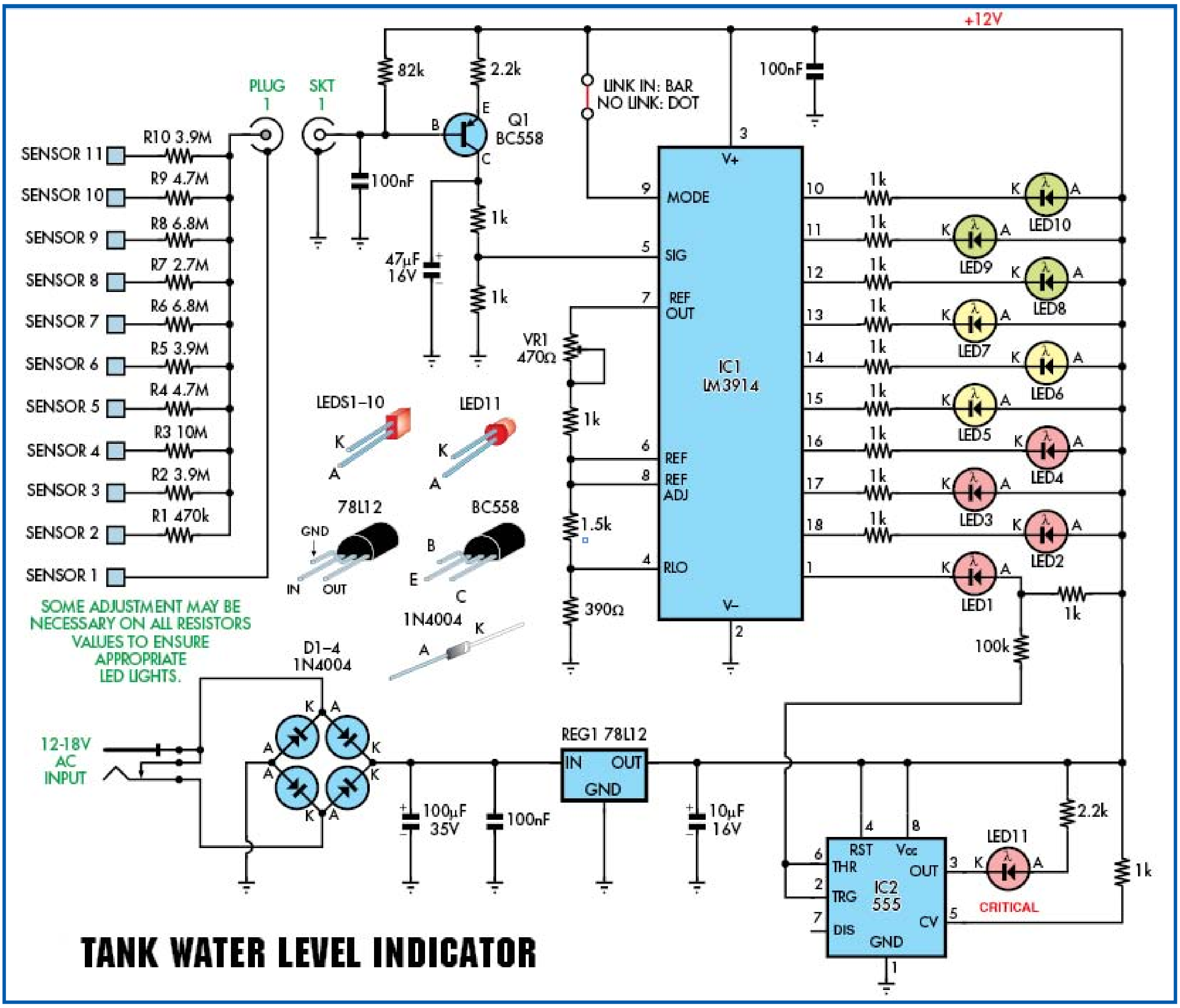


Fig.1: the circuit is essentially a bargraph display, calibrated so that appropriate LEDs light up as the sensors are covered by the rising tank water level. The 555 timer triggers another LED when the water level falls to critical.

If you only want five levels, you could omit LEDs 2, 4, 6, 8 and 10 and tie pin 11 to pin 10, 13 to 12, 15 to 14, 17 to 16 and 1 to 18. In this case we'd use two green, one yellow and two red LEDs in the bargraph.

Water level sensor

The input signal for IC1 is provided by an assembly consisting of 11 sensors located in the water tank and connected to the indicator unit via light-duty figure-8 cable. This sensor assembly relies on the fact that there is a fairly low (and constant) resistance between a pair of electrodes in a tank of water, regardless of the distance between them.

Every school child is taught that pure water is an insulator. This circuit demonstrates the fact that even rain water is not exactly pure.

As shown in Fig.1, sensor 1 is connected to ground (0V), while sensors 2 to 10 are connected in parallel to the base of *PNP* transistor Q1 via resistors R1 to R10. Transistor Q1 functions as an inverting buffer stage and its collector voltage varies according to how many sensor resistors are in-circuit (ie, how many sensors are covered by water).

When the water level is below sensor 2, resistors R1 to R10 are out of circuit and so Q1's base is pulled high by an 82kΩ resistor. As a result, Q1 is off and no signal is applied to IC1 (therefore, LEDs 1 to 10 are off).

However, if the water covers sensor 2, the sensor end of resistor R1 is essentially connected to ground. This resistor and the 82kΩ resistor now form a voltage divider and so about 9.6V is applied to Q1's base.

As a result, Q1's emitter is now at about 10.2V, which means that 0.8mA flows through the 2.2kΩ emitter resistor. Because this same current also flows through the two 1kΩ collector load resistors, we now get about 0.8V DC applied to pin 5 (SIG) of IC1. This causes pin 1 of IC1 to switch low and so the first red LED (LED1) in the bargraph lights.

When each successive sensor is covered by water, an additional resistor is switched in parallel with R1 and Q1's base is pulled lower and lower.

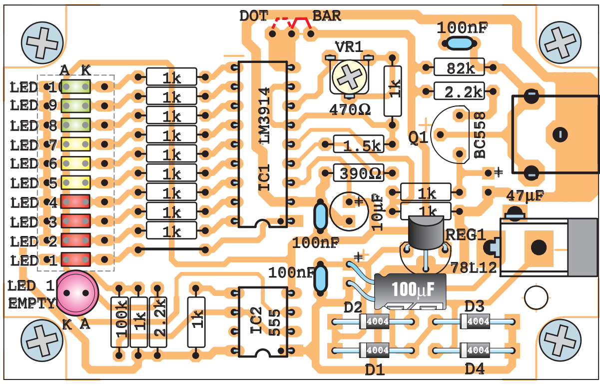
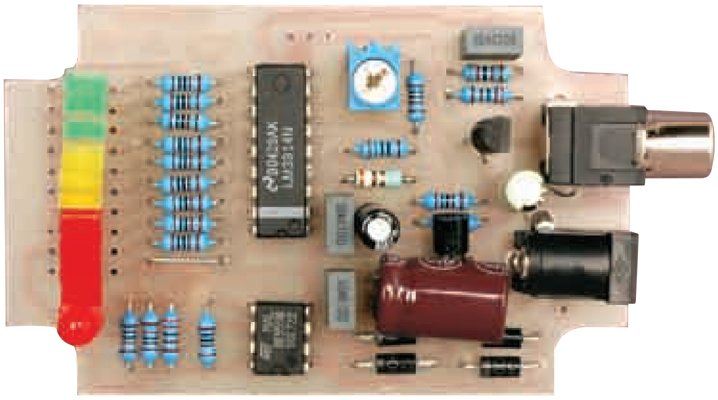


Fig.2: the PC board parts layout with matching photo alongside. Note the 'laid over' regulator and filter capacitor.



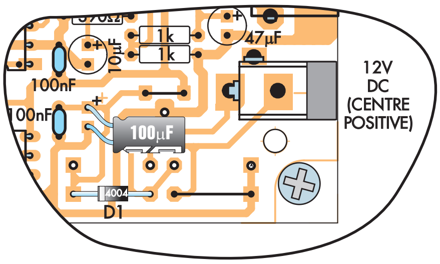


Fig.3, right, is the relevant section of the PC board revised for 12V DC operation.

As a result, Q1 turns on 'harder' with each step (ie, its collector current increases) and so the signal voltage on pin 5 of IC1 increases accordingly. IC1 thus progressively switches more outputs low to light additional LEDs.

Note that Q1 is necessary to provide a reasonably low-impedance drive into pin 5 (SIG) of IC1, while keeping the current through the water sensors below the level at which electrolysis becomes a problem.

Going critical

A 555 timer (IC2) drives LED11 (a 5mm round type to be obviously different) to provide a warning when the water level falls below the lowest sensing point; ie, when all the other LEDs have been extinguished.

However, in this role, IC2 isn't used as a timer. Instead, it's wired as a threshold detector and simply switches its output at pin 3 high or low in response to a signal on its threshold and trigger inputs (pins 6 and 2).

It works like this: normally, when there is water in the tank, LED1 is on and its cathode (K) is low. This pulls pins 6 and 2 of IC2 low via a 100kΩ resistor, so that these two pins sit below the lower threshold voltage. As a result, pin 3 output of IC2 is high and LED11 is off.

However, if the water level falls below sensor 2, LED1 turns off and its cathode 'jumps' to near +12V. This exceeds the upper threshold voltage of IC2 and so pin 3 switches low and LED11 turns on to give the critical low-level warning.

As the control pin (pin 5) of IC2 is tied to the positive supply rail via a 1kΩ resistor, it will switch at thresholds of $0.46V_{CC}$ (5.5V) and $0.92V_{CC}$ (11V) instead of the usual 555 thresholds of $1/3V_{CC}$ and $2/3V_{CC}$. This is necessary to ensure that IC2 switches correctly to control LED11.

Power sources

Power for the unit is normally derived from a 12V AC plugpack supply. This drives a bridge rectifier D1-D4, whose output (nominally about 17V) is then filtered using a 100µF 35V electrolytic capacitor. This is applied to a 12V 3-terminal voltage regulator (REG1). The 12V output from REG1 is then filtered using a 10µF electrolytic capacitor.

The inclusion of 100nF capacitors in parallel with the electrolytics is to prevent oscillation.

The reason a regulated supply rail is used is to ensure that the water level indication doesn't change due to supply variations.

Having said that, the circuit is just as happy being powered from 12V DC, for example in a mobile home or caravan, or even a solar-backed battery supply in the garden.

A 12V supply with centre positive can be plugged into the power socket. In this case, regulator REG1 and diodes D2, D3 and D4 can be omitted. Both D4 and REG1 are then replaced by wire links – ie, install a link instead of D4 and install a link between the IN and OUT terminals of REG1. These changes are shown in Fig.3.

Diode D1 should remain in circuit to protect against reverse battery connection. Or at the expense of another half-volt or so (which shouldn't cause any problems), D1-D4 can be left in situ and then it won't matter which polarity the power connector uses. Regulator REG1 is still omitted in this case.

Also, with a known 12V supply (ie, one which doesn't rise markedly above 12V), the 100µF capacitor can be changed to a cheaper (and smaller) 16V type.

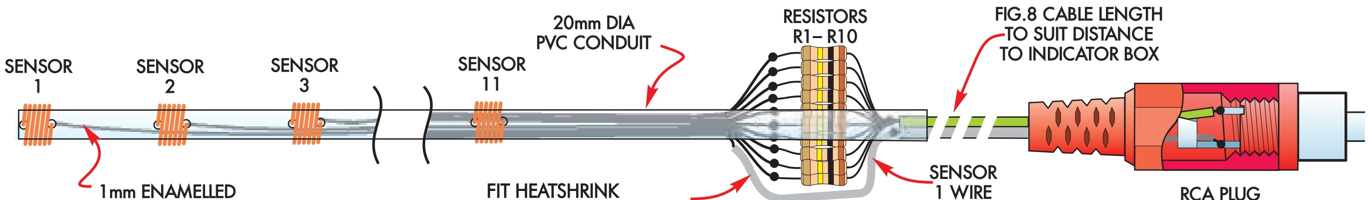


Fig.4: an 'x-ray' view of the sensor assembly, built into a 2.4m length of 20mm PVC electrical conduit.

Construction

Construction is fairly straightforward, with all the parts installed on a PC board, code 701, measuring 80 × 50mm. This board is available from the *EPE PCB Service*. The board is installed in a standard UB5-type (83 × 54 × 31mm) plastic case, with the LEDs all protruding through the lid. We happened to use one of the translucent blue types (because they look smart!) but they also come in black, grey and clear.

Before fitting any components to the PC board, you'll probably need to modify it by cutting the four inwards-rounded corners which accommodate the pillars in the case. The easiest way to do this is to drill out the four corner holes with a much larger drill (say 8mm) then cutting from each of the edges of the board to the hole edges.

We also found that our board was slightly oversize (by perhaps 2mm) to fit into the plastic case, but a couple of minutes with a file soon took care of that. Check to see that your board is a neat (friction) fit in the top of the case. Don't worry about the holes for the power and sensor plugs – we'll do those later.

Fig.2 shows the topside component layout on the PC board. The underside copper foil master pattern is shown (full-size) in Fig.5.

Begin construction by installing the resistors (and the single link at the bottom of the LED ballast resistors), diodes and capacitors (with the exception of the 100µF electrolytic), then install transistor Q1 and the ICs (but not the regulator). Make sure that the diodes and ICs are installed the right way around. The same applies to the electrolytic capacitors – be sure to install each one with its positive lead oriented as shown in Fig.2.

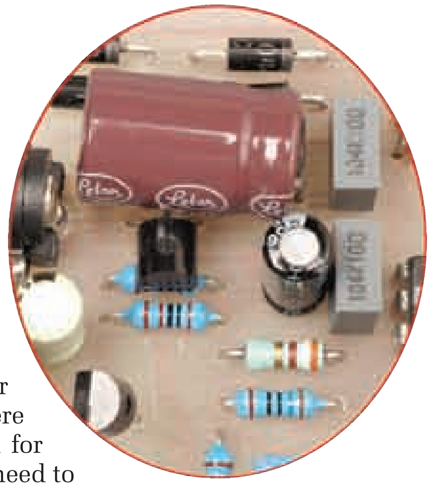
While the circuit calls for a 100µF 35V electrolytic as the main smoothing capacitor, these are now fairly hard to get and you may be forced to use a physically larger 100µF, 50V version instead.

The only way this is going to fit (and allow the LEDs to poke through the case lid) is to lay it on its side. This, in turn, means that the 3-terminal regulator (REG1) also needs to be installed almost flat with its legs under the capacitor (you can see what we mean from the photos).

Trimpot VR1 can now be installed, followed by the RCA phono socket and the 2.5mm power socket. The two sockets are both PC-mounting types and mount directly on the board.

The LEDs are fitted last and must be installed so that the top of each LED is 15mm above the PC board. This ensures that the LEDs all just protrude through the lid when the board is mounted in the case. Make sure that all LEDs are correctly oriented – the anode (A) lead is the longer of the two. Note that there are four holes provided for each of the LEDs – you need to use the innermost pairs of holes.

Here's the sensor assembly, built on a 2.4m length of 20mm PVC electrical conduit. Each 'sensor' (250mm of bared 1mm enamelled copper wire wound around the conduit) is spaced 200mm apart. A drop of glue on the end of each wire should hold the 'coil' tight but be careful not to cover too much bare wire with glue. The wires emerge at the top of the conduit to their respective resistors. The copper wire sensors should last a long time in the relatively pure tank water.



Close-up of the PC board area showing the 'bent-over' regulator and 100µF electrolytic capacitor.

It's not particularly easy to get ten LEDs all aligned and at the same height. We cheated a bit by sticky-taping the reds, greens and yellows together as sets, aligning those three sets and then soldering them in. The pads on the board are arguably a little close together to fit standard rectangular LEDs without splaying their legs a little, but they can be made to look good.

Dot operation

As mentioned earlier, you can easily convert the LM3914 (IC1) from bar to dot operation if that's what you prefer. All you have to do is cut the thinned section of copper track between two pads immediately above and to the left of the trimpot.

If you want to get really clever, a miniature single-pole, two-position switch can be installed in place of the cut link (ie, between the two pads) so you can switch between bar and dot modes at will. This can be arranged so that it emerges through the case lid.

Checking it out

If a visual check confirms that you have all components in the right way and there are no solder bridges or dry joints, set trimpot VR1 to mid-way and plug in the power lead. If all is OK, the 'tank empty' LED should light, but all the others should remain unlit.

If the reverse happens, adjust the pot so that the 'tank empty' LED lights and all others are off.

Now lick your finger and press hard on the two solder joints (ie under the PC board) of the sensor connector, CON1. You should be rewarded with one or more lit LEDs in the string (with the 'tank empty' LED going out). The harder you press, the more LEDs should come on. You are, of course, simulating the resistor sensor string with your wet finger. The harder you press, the lower the resistance – and the more LEDs will light.

Final assembly

The PC board is designed to snap into the purpose-designed locators in the vertical ridges on the side of the case. However, first you need to drill two holes in one end of the case, so that they line up with the RCA phono socket and the power socket when the board is installed (see Figs.6 and 7).

You should only introduce the PC board to these holes and the ridge gaps after the PC board is working properly and set up because once in, it's very difficult to get out again!

There is one 5mm hole to be drilled here (for the 'tank empty' LED), along with a 25 × 5mm slot for the ten bargraph LEDs. The front-panel artwork (Fig.6) can be photocopied and glued to the case lid.

Sensor assembly

The sensor assembly is made by threading 10 lengths of 1mm enamelled copper wire through 20mm OD PVC electrical conduit – see Fig.4. This conduit should be long enough to reach the bottom of the tank, with sufficient left over to fasten the top end securely. The reason for using 1mm wire is primarily to make it easy to thread it through the conduit. Unfortunately, a single 100g roll isn't quite enough for all ten sensors: you'll need part of a second roll.

The top sensor (S11) is placed about 100 to 150mm below the overflow outlet at the top of the tank, while the other sensors are spaced evenly down the tube.

The distance apart is entirely up to you – depending on how accurate you want the readout and also, of course, the height of your tank.

Begin by using a 1.5mm bit to drill holes through the tube wall at the appropriate points, including a hole for the bottom sensor (S1) to hold it in place securely. The holes should be angled up slightly to convince the 1mm wire that this is the direction to head during the next step.

That done, you can thread the wires through by pushing them through the drilled holes and then up the tube. The end of each wire should also be smoothed before pushing it into the tube, to avoid scratching the enamel of the wires already in the tube. Leave about 250mm of wire on the outside of the tube at each point.

It's a good idea to trim each successive wire so that it protrudes say 20mm further out of the top of the tube than its predecessor. This will allow you to later identify the individual wires when attaching the resistors.

When all 11 wires have been installed, the next step is to solder the wire for sensor S1 to the 'earthy' side of the figure-8 lead, cover it with insulating sleeving and pull the covered joint down about 50mm into the tube. This done, the resistors can be soldered to their appropriate wires.

Push about 15mm of 2.5mm sleeving over each wire before attaching its resistor. This sleeving should then be pulled up over the joint and the bottom end of each resistor after it is soldered. Once all the resistors have been soldered, the wires should be pulled down so that the joints are just inside the tube, as shown in Fig.4.

When this process is complete, there will be 10 resistors protruding from the top of the conduit. Their remaining leads are then twisted together, soldered to the other side of the figure-8 cable and covered with heatshrink tubing.

The other end of the figure-8 cable is fitted with an RCA phono plug, with the resistor lead going to the centre pin and the sensor 1 lead going to the earth side of the connector.

The next step is to scrape away the enamel from the 150mm wire lengths at each sensor point and wind them firmly around the outside of the tube. A 30mm length of

Parts List – Tank Water Level Indicator

1 PC board, code 701, available from the *EPE PCB Service*, size 80 × 50mm
1 UB5-type plastic case, size 83 × 54 × 31mm
1 PC-mount RCA phono socket
1 RCA phono plug
1 PC-mount 2.5mm power socket
1 12V AC 500mA plugpack
2 100g spools 1.0mm enamelled copper wire
1 length (to suit) 20mm-OD PVC electrical conduit

Semiconductors
1 LM3914 linear dot/bar driver (IC1)
1 NE555 timer (IC2)
1 BC558 *PNP* transistor (Q1)
1 78L12 12V regulator (REG1)
4 1N4004 diodes (D1-D4)
4 rectangular red LEDs (LEDs 1 to 4)
3 rectangular yellow LEDs (LEDs 5 to 7)
3 rectangular green LEDs (LEDs 8 to 10)
1 5mm red LED (LED11)

Capacitors
1 100µF 35V PC electrolytic
1 47µF 16V PC electrolytic
1 10µF 16V PC electrolytic
3 100nF MKT polyester

Resistors (0.25W, 1%)

1 10MΩ	2 6.8MΩ	2 4.7MΩ	3 3.9M
1 2.7MΩ	1 470kΩ	1 100kΩ	1 82kΩ
2 2.2kΩ	1 1.5kΩ	14 1kΩ	1 390Ω

1 470Ω trimpot, horizontal

Miscellaneous
Light-duty figure-8 cable, 2.5mm PVC sleeving, heatshrink tubing.

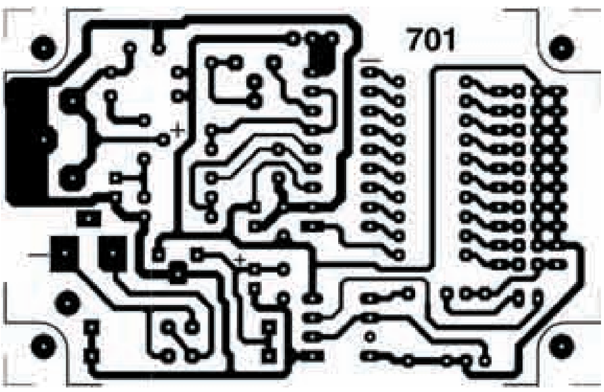


Fig.5: full-size copper foil PC board artwork.

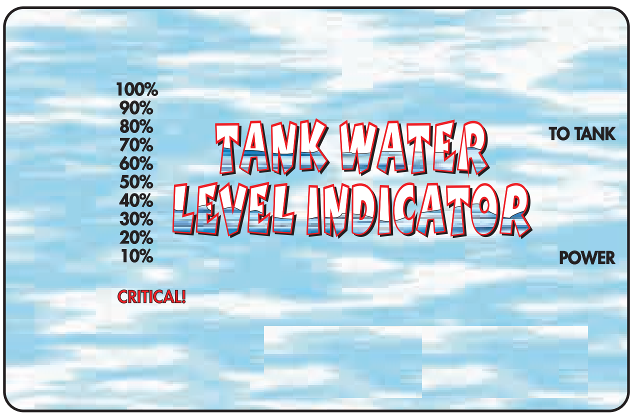
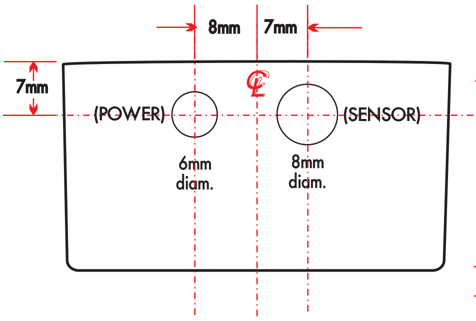


Fig.6: front panel artwork. A photocopy of this may be used as a drilling template for the front panel.



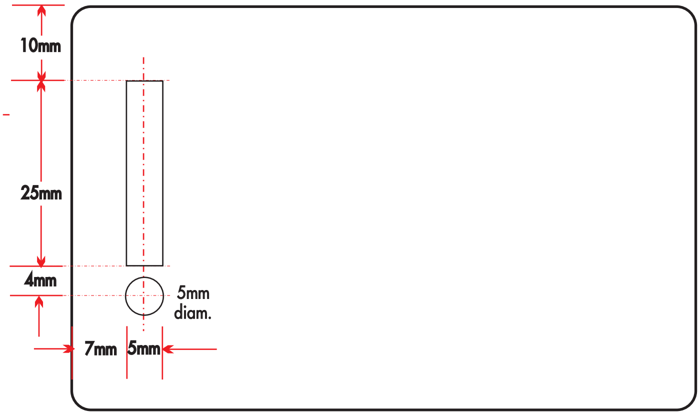


Fig.7: drilling detail for the box end (right) and box lid (far right). The slot can be made by drilling a row of 4.5mm holes down the centre line and enlarging with a small file.

20mm copper water pipe can be pushed over sensor 1 to add weight and increase the surface area if desired.

On no account should solder be used on the submerged part because corrosion will result from galvanic action.

Finally, the end of the plastic conduit and the holes can be sealed with neutral-cure silicone sealant. However, don't get any silicone sealant on the coiled sensor wires, as this will reduce the contact area (and perhaps render them ineffective).

Switching on

Now for the big test. Apply power to the unit and check that the red 'tank empty' LED comes on and that there is +12V on pin 3 of IC1. If all is well, the unit can now be tested by connecting the sensor assembly and progressively immersing it (starting with sensor 1) in a large container full of water (we used a swimming pool). When sensor 1 and sensor 2 are immersed, LED1 should extinguish and LED2 should come on.

Similarly, when sensors 1, 2 and 3 are immersed, LEDs 1 to 5 should be on and so on until all LEDs are lit.

Finally, trimpot VR1 must be set so that the appropriate LEDs light as the sensors are progressively immersed in water. In practice, you should find the two extremes of the pot range over which the circuit functions correctly, then set the pot midway between these two settings.

Using it on metal tanks

If the tank is of made of metal, you can dispense with Sensor 1 and connect the tank directly to the circuit ground. You *must* also ensure sensors 2 to 10 do ***not*** touch the walls of the tank. This can be done by slipping a length of 25mm-OD PVC conduit over the completed probe, securing it at the top so that the water inside can follow the level in the tank.

Controlling other devices

You could use this project to control something external – for example, a pump to refill the tank from a larger storage tank or reservoir, a siren or warning alarm, or perhaps to trigger a radio link to remotely warn, and so on. Provision has been made on the PC board for this: you will note that each of the LEDs, with the exception of the 'critical level' LED, has another pair of pads associated with it – these are intended to connect to external circuitry.

The reason the 'critical level' LED has no extra pads is not simply lack of space – we would imagine that any action you wanted to take would have happened long before the water level reached that critical point.

However, if you really wanted to, this level could also be used as outlined here for the rest of the LEDs – it's just that you'd have to arrange connections yourself.

As the LM3914 outputs go low to turn on their LEDs, these could also switch on a *PNP* transistor (with suitable current limiting resistors), leaving the LEDs in place. That transistor could be used to switch, say, a relay to control whatever you wished.

You could also switch an optocoupler, such as a 4N28, in parallel with the LEDs, itself perhaps switching a relay. With due care to power wiring, a triac optocoupler might be used instead.

Solidstate relays are also an option, providing you can get one which operates when its input is taken low. Of course, a transistor could invert the LM3914 output for you.

Regardless of what you are controlling, you MUST take into account the following:

- Get your project working as described (ie, stick to low voltages) before attempting to interface it to anything.
- Anything switching or controlling mains voltages **must be more-than-adequately insulated**, with cable clamps to prevent broken leads contacting anything else.
- Ensure that any relays you use are rated for both the voltage and the current of the device being controlled. Bear in mind that pump motors, for example, usually have a significantly higher starting current than running current.
- If in doubt, don't!

EPE

Reproduced by arrangement
with SILICON CHIP
magazine 2009.
www.siliconchip.com.au

EVERYDAY PRACTICAL ELECTRONICS

UK readers you can SAVE 79p on every issue of *EPE*

How would you like to pay £3.16 instead of £3.95 for your copy of *EPE*?

Well you can – just take out a one year subscription and save 79p an issue, or £9.50 over the year. You can even save over £1 an issue if you subscribe for two years – a total saving of £24.30.

Overseas rates also represent exceptional value.

You also:

- **Avoid any cover price increase for the duration of your subscription**
- **Get your magazine delivered to your door each month**
- **Ensure your copy, even if the newsagents sell out**

Order by phone or fax with a credit card or by post with a cheque or postal order, or buy online from www.epemag.com. You can also order a combined one year hard copy plus downloadable online issue from our website, priced at just £5 more than the one year hard copy subscription.

EVERYDAY PRACTICAL ELECTRONICS

SUBSCRIPTION PRICES

Subscriptions for delivery direct to any address in the UK: 6 months £19.95, 12 months £37.90, two years £70.50; Overseas: 6 months £23.00 standard air service or £32.00 express airmail, 12 months £44.00 standard air service or £62.00 express airmail, 24 months £83.00 standard air service or £119.00 express airmail.

Cheques or bank drafts (in **£ sterling only**) payable to *Everyday Practical Electronics* and sent to EPE Subs. Dept., Wimborne Publishing Ltd., Sequoia House, 398a Ringwood Road, Ferndown, Dorset BH22 9AU. tel: 01202 873872. Fax: 01202 874562. **Email:** subs@epemag.wimborne.co.uk. Also via the **Web** at **http://www.epemag.com**.

Subscriptions start with the next available issue. We accept MasterCard, Maestro or Visa. (For past issues see the Back Issues page.)

ONLINE SUBSCRIPTIONS

Online subscriptions, for downloading the magazine via the Internet, $18.99US (approx. £13.00) for one year available from **www.epemag.com**.

SUBSCRIPTION ORDER FORM

☐ **6 Months: UK £19.95, Overseas £23.00 (standard air service), £32.00 (express airmail)**
☐ **1 Year: UK £37.90, Overseas £44.00 (standard air service) £62.00 (express airmail)**
☐ **2 Years: UK £70.50, Overseas £83.00 (standard air service) £119.00 (express airmail)**

To: Everyday Practical Electronics, Wimborne Publishing Ltd., Sequoia House, 398a Ringwood Road, Ferndown, Dorset BH22 9AU
Tel: 01202 873872 Fax: 01202 874562
E-mail: subs@epemag.wimborne.co.uk

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

☐ Please charge my Visa/Mastercard/Maestro

My card number is: ....
Please print clearly, and check that you have the number correct

Signature ....

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

Card Ex. Date ....Maestro Issue No. ....

Name ....

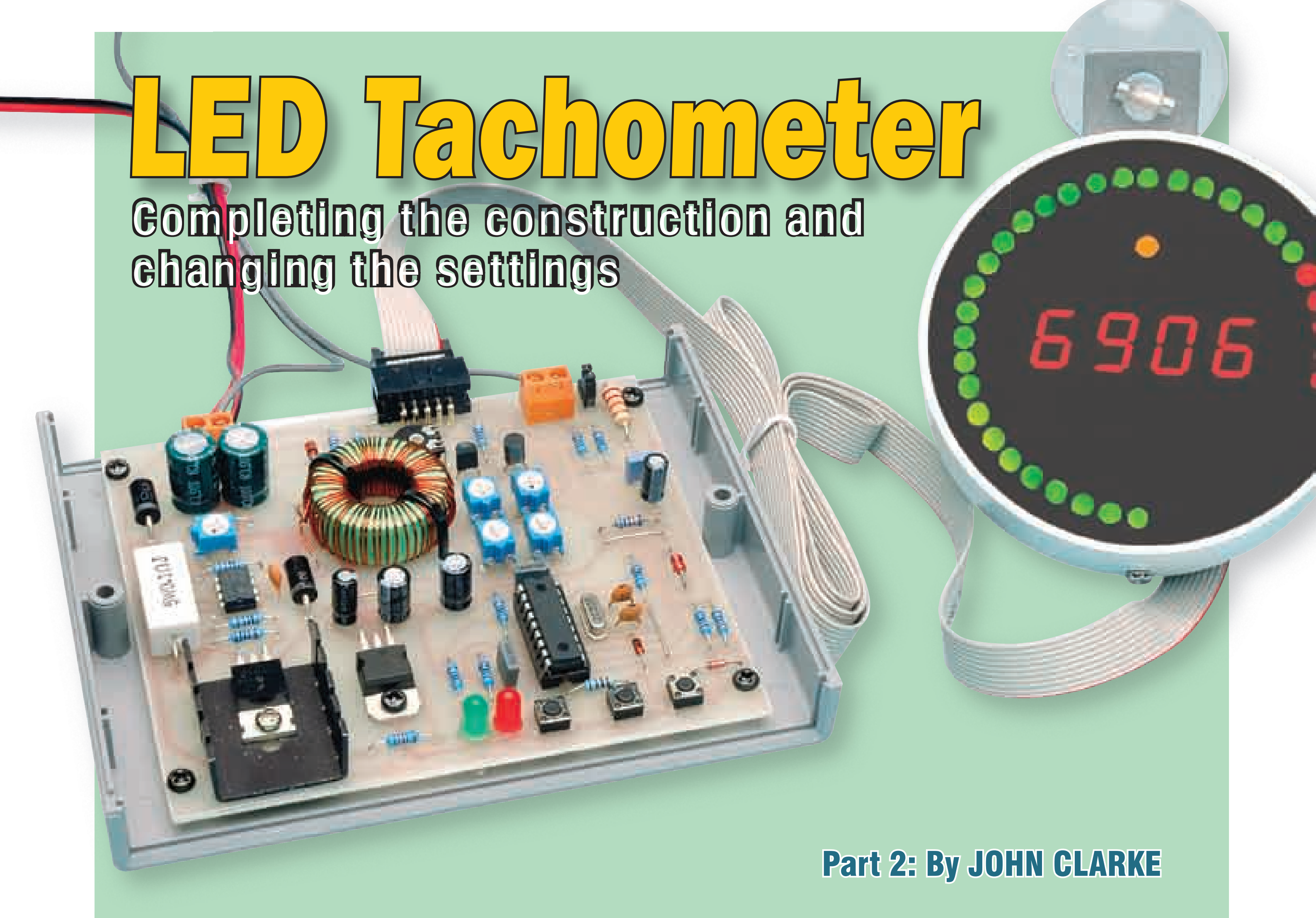
Address ....

Post code .... Tel. ....

Subscriptions can only start with the next available issue.

LED Tachometer

Completing the construction and changing the settings



Part 2: By JOHN CLARKE

Setting up the LED Tacho mainly involves stepping through and reprogramming the default software settings in the PIC to suit your vehicle. Here's how it's done.

HAVING COMPLETED the PC board assemblies and made up the connecting cable as described last month, it's now time to test the tachometer. However, before applying power, check that all parts are in their correct locations and are correctly oriented. Check also for any solder shorts between the board's copper tracks and IC pads.

Do not connect the display PC board to the main board yet – that step comes later, after the initial voltage checks. In addition, the PIC micro (IC3) should be left out of its socket.

Once you are satisfied that everything is correct, apply power (12V DC) to the main PC board and check that pins 4 and 14 on IC3's socket are at +5V. That done, monitor the voltage at TP1 (with respect to 0V) and check that this voltage can be varied from about 2V to 5V using trimpot VR1.

If this checks out, switch off the power and install IC3 in its socket – see Fig.5 last month. Make sure that this IC is oriented correctly; ie, with its notched end towards the adjacent 100nF capacitor.

Next, connect the display board to the main board using the IDC cable, then set VR1 fully anticlockwise and VR6 fully clockwise. Trimpots VR2, VR3, VR4 and VR5 should all be set to mid-position.

Apply power and you should be greeted by a single '0' on the digital display (ie, on the righthand digit). In addition, LED1 in the bargraph should light. If this does not happen, switch off immediately and check for assembly errors (ie, parts placement, faulty or missed solder joints, solder shorts between IC pads).

Testing the displays

Assuming everything is OK so far, you can now test the displays by switching off and then pressing the Up switch (S3) while you re-apply power. If you keep this switch pressed, the digital display should show all 'eights', with the two far-left decimal points also lighting. In other words, you should see 8.8.88 (do not

expect the two righthand decimal points to light).

At the same time, each LED on the circular bargraph should light in sequence, followed by the shift LED when the bargraph sequence is completed. The lighting sequence should then start again.

Now release the Up switch – the display should now show a '1' and the unit will be placed in the settings mode. To exit from this mode, simply switch off and re-apply power without pressing the Up switch.

If any of the LEDs fails to light, check its orientation and the soldering. Check also for broken tracks or shorts between pads and tracks. Alternatively, the LED itself may be faulty.

Dimming response

The next step is to adjust the dimming response, but first adjust VR1 so that the display is reasonably bright. You can do this using just the '0' display on the righthand digit to judge the brightness, or you can use the preceding display test mode to light all the display segments.

There are two sets of dimming controls and these allow you to balance the segment brightness on the 7-segment digital displays. This is necessary because the top and bottom segments of each display are driven by different driver ICs.

Begin by adjusting VR2 and VR3 so that the top segments have the same brightness as the bottom segments. In practice, you should not need to vary these much from the previously set half-way position. Do not turn these trimpots fully anticlockwise, otherwise the dimming effect will be lost.

Trimpot VR6 sets the dimming threshold – the ambient light level where dimming begins. You can simulate this by placing a finger over the LDR. It's just a matter of turning VR6 so that the displays begin to dim as the LDR is shadowed. Next, cover the LDR completely and adjust VR4 and VR5 to set the minimum display brightness.

Changing the settings

As mentioned, the various settings for the tachometer are changed using a special mode of operation (ie, the 'settings' mode). As described above, this mode is invoked by holding down the Up switch (S3) and simultaneously applying power to the unit (if this switch is not pressed, the tachometer operates in 'normal' mode).

Initially, the unit will go through the display test cycle just described and this is repeated for as long as the Up switch is pressed. Releasing the Up switch then causes the display to show a '1' and invokes the settings mode. The Green Mode LED (34) will also be lit and this indicates that the display is showing the current mode selection (the default is mode 1). You can now change the mode by using the Up or Down switches to select from mode 1 through to mode 13.

For each mode, you can force the display to show its current setting by pressing the Toggle switch (S1). During this time, the Red settings LED (35) will light and the Mode LED will be off. The settings are changed by using the Up and Down switches.

Basically, you have to step through and set each mode in turn. These modes and their options are as follows:

Mode 1 – Number of cylinders: enter the exact number of cylinders for a 4-stroke engine (1-12 cylinders). In operation, each cylinder in a 4-stroke engine fires once every two-engine revolutions. This means that a 4-cylinder 4-stroke engine delivers two pulses per revolution to the tachometer, while 6-cylinder and 8-cylinder engines respectively deliver three and four pulses per revolution.

A selection of '11' (or '7') should be made for a 2-cylinder asymmetrical 4-stroke motorcycle engine, where the firing spacings between each cylinder are uneven. This gives a steadier RPM reading than a 2-cylinder option. Similarly, use a '9' setting for an asymmetrically fired 3-cylinder 4-stroke engine.

Two stroke engines are also catered for. For these, simply use a cylinder number that's double the actual number of cylinders. For example, select '2' for a 1-cylinder 2-stroke, 4 for a 2-cylinder 2-stroke, and so on.

Mode 2 – Red LEDs: this setting refers to the number of red LEDs used for the 'red-line' (RPM warning zone). During construction, you may choose how many red LEDs to use and these are placed at the clockwise end of the bargraph display – see photograph. The number of LEDs is nominally set at five, however any number from 0 to 10 can be accommodated.

Mode 3 – Red-line: this mode is used to set the maximum (or red-line) RPM recommended for your engine. The default setting is 9000 RPM, but you can alter this in 100 RPM steps from 0 RPM to above 30,000 RPM.

Note that this display is shown in a x1000 RPM format. So 9000 RPM will be shown as 9.00 and 10,000 RPM will be displayed as 10.00. The

Operating The Tacho From 24V DC

Want to operate the LED Tachometer and DC Relay Switch from 24V DC? Here's how to do it:

Tachometer

- Change the 220Ω resistor feeding Zener diode ZD1 to 1kΩ 1W
- Increase the voltage rating of the 100µF 16V capacitor at the input of regulator REG1 to 35V
- Increase the voltage rating of the 470µF 25V low-ESR capacitor following diode D1 to 35V

DC Relay Switch

- Use a 24V relay instead of a 12V relay – eg, 24V 30A relay.
- Increase the voltage rating of all capacitors to 35V.
- Change the 2.2kΩ resistor in series with LED1 to 4.7kΩ 0.25W.

Table 1: Tachometer settings		
Mode	**Possible settings**	**Notes**
1. Cylinder number	From 1-12	Select exact number for a 4-stroke engine or use twice the cylinder number for a 2-stroke engine. Select 11 (or 7) for an asymmetrical 2-cylinder 4-stroke engine, 9 for an asymmetrical 3-cylinder 4-stroke and 6 for a 3-cylinder 2-stroke.
2. No. of red LEDs	From 0-10	Allows changes to red-line bargraph display length.
3. Red-line RPM	From 0 to above 30,000 RPM	Sets red-line RPM at first red LED.
4. RPM/LED	Automatically changed	No manual adjustment; automatically adjusted with changes to Modes 2 and 3.
5. Shift light RPM	From 0 to above 30,000 RPM	If not required, set RPM well above red-line RPM.
6. Limiter RPM	From 0 to above 30,000 RPM	Limiter output changes at limit RPM (see mode 12).
7. Hysteresis	0-255 RPM	Prevents LEDs flickering on and off at threshold. Set at less than the RPM/LED value from mode 4.
8. Display update	0-510ms in 2ms steps	Sets digital display updates to a comfortable rate.
9. Display format	0, 1, 2	1: 9999 RPM, 2: decimal shift from 9.999 to 10.00, 3: 9.99 to 10.00.
10. Fixed digits	0, 1, 10	Use 0 for 1 RPM resolution; 1 to fix units digit at 0 (10 RPM resolution); 10 to fix units and tens digits at 0 (100 RPM resolution).
11. Dot or bargraph	0 or 1	Use 0 for dot bargraph display, 1 for continuous bargraph display.
12. Limiter sense	0 or 1	Use 0 to set limit output normally low (0V). Use 1 to set limit output normally high (ie, +5V).
13. Limiter on Period	0-510ms in 2ms steps	Sets the minimum time that the limiter output is active.

tachometer will light the first of the red LEDs at the red-line RPM.

Mode 4 – RPM/LED: this mode shows the RPM increment for each LED in the bargraph. It is automatically recalculated whenever the number of red-line LEDs is changed (see mode 2) and when the red line RPM is changed (see mode 3).

The calculation subtracts the number of red LEDs from the total of 32 LEDs used in the bargraph and divides this number into the red-line RPM. This then sets the calibration of the tachometer so that the first red LED lights at the correct red-line RPM.

As a result, the number of red LEDs determines the total RPM range of the tachometer. This 'RPM per LED' value is set automatically and cannot be changed manually.

Mode 5 – Shift light: this mode allows the shift-light RPM to be set. It can be altered in 100 RPM steps from the default value of 8000 RPM, over the range from zero to above 30,000 RPM. The setting is in a x1000 RPM format; eg, 8000 RPM is displayed as 8.00.

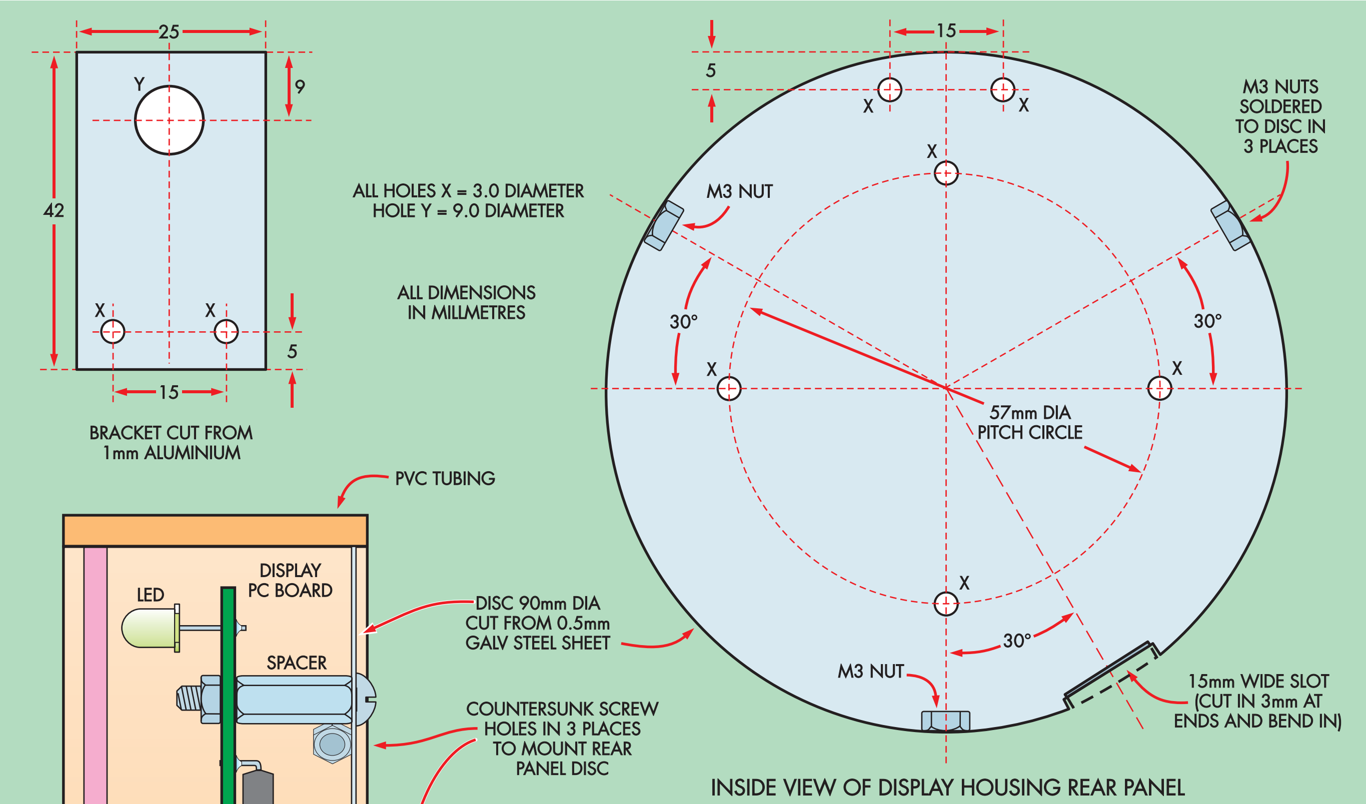
Mode 6 – Limiter RPM: this mode sets the limiter RPM. In operation, the limiter output changes when the measured RPM goes above this setting and the output level depends on the sense setting (see mode 12).

This setting can be altered in 100 RPM steps from the default of 9900 RPM over a range from zero to above 30,000 RPM. Once again, the display is in a x1000 RPM format; eg, 10,000 RPM will be displayed as 10.00.

Mode 7 – Hysteresis: this setting controls the way the LEDs light in the bargraph. As the RPM increases, successively higher LEDs will light up, but at the threshold RPM where a LED just lights, there will tend to be some flicker as engine RPM varies slightly (ie, the LED rapidly switches on and off). To prevent this, you can add hysteresis. The hysteresis does not affect the RPM at which each LED will light with rising RPM, but it prevents the last lit LED from extinguishing unless the RPM drops by the hysteresis RPM setting.

The default hysteresis setting is 50 RPM and this can be altered in 1 RPM steps from 0 to 255 RPM. Note that the hysteresis value must be less than the RPM/LED value (see mode 4).

Mode 8 – Digital display update period: the LED bargraph is updated every 1ms, but this is much too fast for the digital display to be read if there are



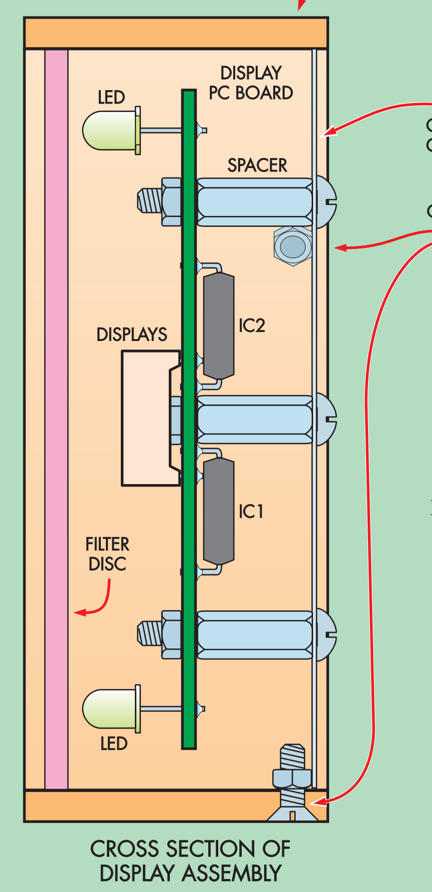


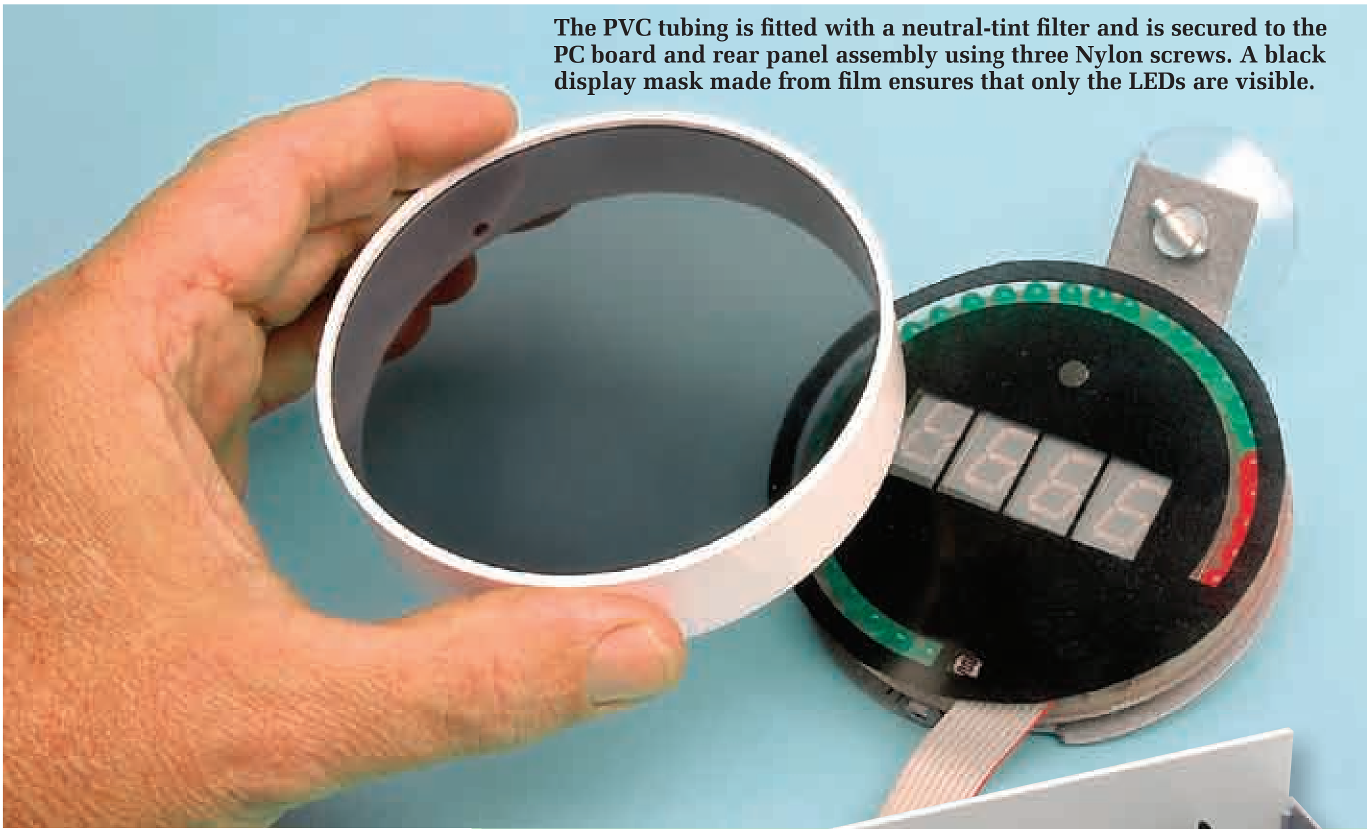
Fig.8: this diagram shows how to make the bracket and rear panel for the display housing, while the cross-section diagram on the left shows how the display assembly goes together.

This is the rear panel (inside view) prior to mounting the PC board. Note the three nuts soldered around the periphery.

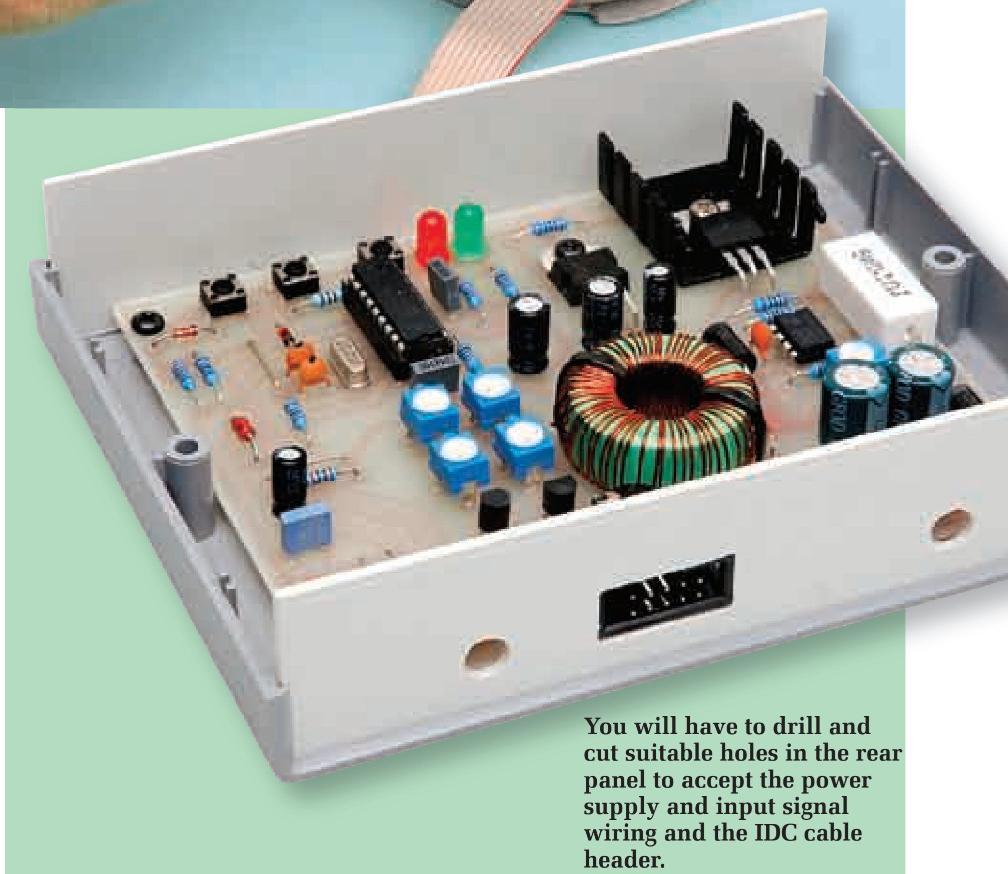
any RPM changes. As a result, the digital display update is slowed down to a more comfortable rate.

Typically, a 200ms update period (or five changes per second) is suitable. It can be altered from the default setting of 250ms in steps of 2 from 0 to 510ms.

Mode 9 – Display format: this adjustment is mainly to cater for engines that rev above 10,000 RPM. The initial setting of '0' sets the display to show



The PVC tubing is fitted with a neutral-tint filter and is secured to the PC board and rear panel assembly using three Nylon screws. A black display mask made from film ensures that only the LEDs are visible.



You will have to drill and cut suitable holes in the rear panel to accept the power supply and input signal wiring and the IDC cable header.

RPM from 0 to 9999 RPM. Above this figure, the display shows a '0' for 10,000 RPM, '1000' for 11,000 RPM etc. Use this setting for engines that do not rev above 10,000, or which only occasionally rev to this RPM level.

For engines that do rev above 10,000 RPM, a '1' or '2' setting will be best. The '1' setting shows the RPM with a shifting decimal point. Below 10,000 RPM the display will show, for example, 9.999 RPM (ie, 9999 RPM), while at 10,000 RPM and above the display decimal point will shift to the right and show the RPM using two digits for the 1000's value.

For example, at 10,000 RPM the display will show 10.00.

If you don't want the shifting decimal point, select '2'. This will fix the decimal point for two 1000's digits so, for example, 9999 RPM will be displayed as 9.99, while 10,000 RPM will be displayed as 10.00.

Note that for a '2' setting, resolution is reduced to 10 RPM (ie, there's no units digit). Similarly, for a '1' setting, the resolution is reduced to 10 RPM for RPM values above 9999.

Mode 10 – Resolution: in some cases, displaying the RPM to 1 RPM resolution will only be a distraction, since the engine may never be stable enough to keep this digit steady – even at a constant throttle. In this case, you can select a '1' for this mode so that the far righthand digit always shows a zero (ie, the resolution is reduced to 10 RPM). Note that this won't change the display for a '2' setting in Mode 8, because the units digit is not shown.

Alternatively, selecting '10' in this mode sets both the units and tens digits to 0. The resolution for the digital display will then be 100 RPM.

Connecting a rev limiter to the LED Tachometer

The limiter output from the tachometer can optionally be used to drive a separate circuit that limits the maximum engine RPM. You can use a fuel control circuit to do this. Let's take a closer look at this option.

Fuel Cut-Out Limiting

A suitable fuel cut-out circuit was published in the August '08 issue of *EPE*. It's called a *DC Relay Switch* and it can be used with the tachometer's limit output to switch off the supply to the fuel injectors.

Note that it is suitable only for cars with injectors that are electrically driven (as used in most cars).

The tacho's limiter output drives the relay board as shown in Fig.9. When the red-line limit is reached, the normally closed (NC) relay contacts open and interrupt the positive supply rail to the fuel injectors.

The unit is easy to install – just break the +12V supply lead to the injectors and connect the supply side to the relay's COM (common, or pole) terminal. The NC (normally closed) contact is then connected to the injectors.

Note that you must set the tachometer's limiter sense to '0' (in Mode 12), so that the limiter output is normally at 0V but goes to +5V at the limit point. You may need to experiment with the limiter on period (set up in Mode 13) for best results. Start with a period of 100ms and decrease or increase this value until you are happy with the limiter action.

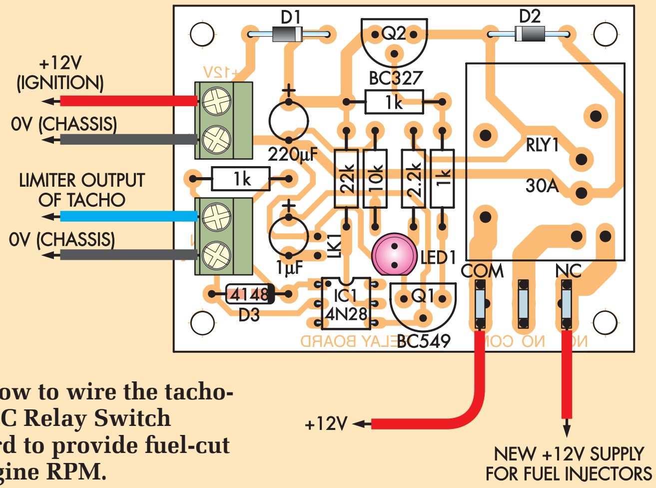


Fig.9: here's how to wire the tachometer to the DC Relay Switch (Aug '08) board to provide fuel-cut limiting of engine RPM.

Mode 11 – Dot or bargraph: you use this mode to select whether the LED bargraph operates in dot mode (ie, one LED lit at any time) or as a continuous bargraph. Select a '0' for dot mode or a '1' for continuous bargraph mode.

Mode 12 – Limiter sense: this mode selects the output sense of the limiter. If '0' is set, the limiter output is normally at 0V and goes to +5V when the RPM rises above the limit setting. Conversely, if '1' is set, the limiter output is normally at +5V and goes to 0V when the limit setting (set in Mode 6) is reached.

Mode 13 – Limiter on period: this sets the minimum period that the limiter output is active in order to reduce engine RPM to a point below the limit setting. We suggest experimenting with the on periods at a low RPM limit setting and then altering the RPM limit (in Mode 6) to its final value afterwards.

That's the set up completed. Now let's finish construction.

Tachometer housing

If you have an old car, you may be able to install the display board within the existing instrument cluster. Depending on the car, it could either be fitted into a blank space or used to replace an unused instrument (eg, a clock).

Alternatively, the display board can be built into a small cylindrical housing (see photos). This can be mounted inside the car by attaching it to the windscreen using a suction cap, or it can be fastened to the dashboard via a custom mounting bracket.

A suitable housing can be made using a 90mm-diameter PVC pipe cut to a length of 21mm. In addition, you will need a 90mm diameter galvanised-steel plate for the rear panel and this should be cut and drilled as shown in Fig.8.

Three M3 nuts are then soldered around the circumference of this disc in the locations shown. Having done that, carefully mark out and drill three 3mm diameter countersinks in the PVC tube, to exactly line up with these nuts. These holes must also be positioned 5mm in from the rear edge of the tube and should all be countersunk using a slightly oversize drill.

Be sure to accurately position these holes around the circumference of the PVC tube, so that they line up with the nuts on the rear plate.

The IDC cable passes through a slot in the edge of the plate. This is made by making two cuts and then folding the edge over, as shown in Fig.8 and accompanying photograph.

That done, fit four M3 × 6mm-long tapped nylon spacers to the four inner holes marked 'X' on Fig.8 and secure them using M3 × 12mm nylon screws. The PC board can then be mounted on these spacers and secured using nylon nuts.

The next job is to make up the aluminium bracket shown in Fig.8. This bracket is attached to the rear plate using M3 nylon screws, nuts and washers and is fitted with a suction cap to secure the display to the windscreen. You will have to bend the bracket by 20 to 30° before attaching it to the end plate, to compensate for the rake of the windscreen.

Note that it may also be necessary to fit a nylon washer between the bracket and the rear panel at each mounting point, so that the bracket clears the rear lip of the PVC tube.

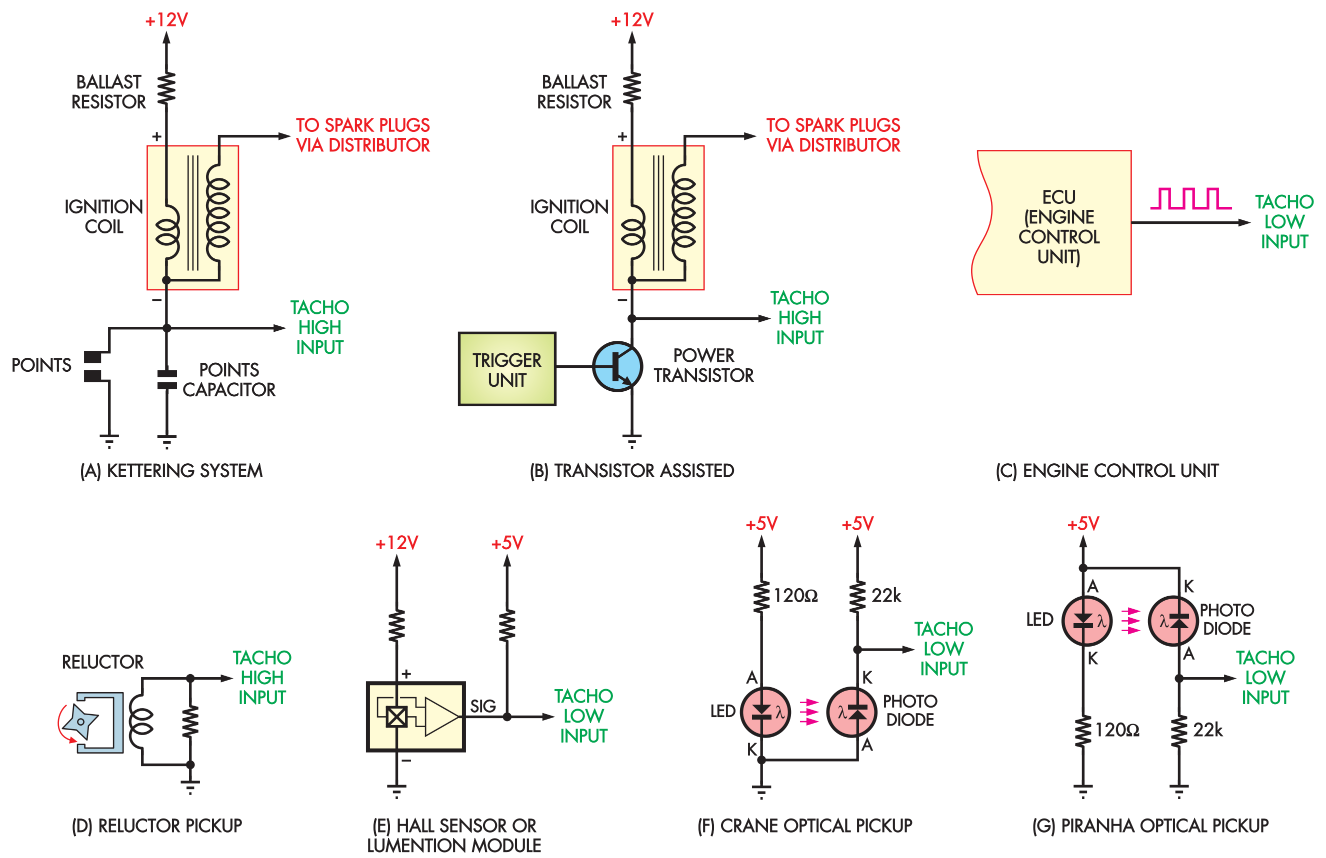


Fig.10: the LED Tachometer can derive its input signal from a variety of trigger sources, as shown here. In most modern cars, you will be able to use the tachometer output signal from the engine control unit (ECU).

Alternatively, you can fashion a suitable bracket to attach the display to the dashboard.

Final assembly

All that remains now is the final assembly. The cross-sectional diagram in Fig.8 shows how it all goes together. As with the rear plate, the neutral-tint front display filter is also 90mm in diameter and should be a tight fit into the PVC tube, so that it stays in place. Apply a couple of small blobs of silicone sealant to the inside rim to secure it in place if it's a loose fit.

If necessary, a black display mask (made from film) can be used to blank out all but the LED displays, so that the PC board and other components cannot be seen through the filter.

Finally, the PC board and plate assembly can be pushed into the PVC tube and secured using three M3 × 12mm countersink nylon screws.

Installation

The first installation task is to mount the control box in a suitable location. This needs to go somewhere under the dashboard in a car or inside the side panels of a motorcycle (use silicone sealant to waterproof the cases).

Power for the unit can be derived from an ignition-switched +12V supply, along with an earth (ie, chassis) connection. In most cars, you will be able to make the +12V connection at the fusebox. Connect to the fused side of the switched +12V supply and use automotive cable and crimp connectors to make the connections.

Depending on the car, the input signal for the tachometer can be obtained from the switched (negative) side of the ignition coil primary, from a reluctor or from a tachometer signal provided by the engine control unit (ECU). It's also possible to use the signals from a Hall effect trigger and from optical triggers. Fig.10 shows all the options.

In most modern cars, you can use the ECU's tachometer signal (C), in which case the link on the control board should be fitted to the LK2 position (ie, to select a low-level input).

The link should also go in the LK2 position if you are deriving the signal from a Hall effect sensor (E) or from an optical pick-up (F and G).

Alternatively, fit the link in the LK1 (high-level signal) position selection if the signal is derived from the switched side of the ignition coil (A or B). This selection should also be suitable for most reluctors (D).

Note that you will need to experiment to determine which lead to use for a reluctor. A reluctor has two leads and only one will have a signal that's suitable for driving the tachometer. If the tachometer only operates at higher revs and stays at 0 RPM at lower revs, then the reluctor signal level may not be high enough for reliable triggering. In this case, change the link to the LK2 position.

Note also that if the tachometer's reading is erratic when connected to an ignition coil, try adding the second 47nF capacitor – see Figs 3 and 5, last month. In stubborn cases, this 47nF capacitor may need to be increased to 100nF. ***EPE***

Recycle It!

BY JULIAN EDGAR

Washing machine pressure switches

Want to control the water level in a tank, or detect a vehicle passing over a small-diameter hose? You can do both these jobs and much more, using pressure switches salvaged from old washing machines and dishwashers.

ALL OLDER WASHING machines and dishwashers use mechanical pressure switches to detect the water level inside the tub. A hose is connected from the base of the tub to the pressure switch, which measures the air pressure being applied by the column of water.

The pressure at the base of a column of water 27.69 inches high is 1psi, or to put it another way, 10.2cm of water exerts a pressure of 1kPa (kilopascal). So, as you can imagine, a switch that's designed to detect when the water level in a washing machine has reached (say) a depth of 38cm (15in) must be capable of accurately measuring pressures of just 0.5 psi (~3.5kPa)!

In other words, the pressure switches in washing machines are among the most sensitive that you can buy. Well, you don't really have to buy them – these switches can be scrounged for literally nothing wherever washing machines are being discarded.

Washing machine pressure switches have three main characteristics:
(1) Very high sensitivity
(2) A 'snap' action, to ensure sharp, decisive switching – they're either on or off
(3) Excellent power handling.

How they work

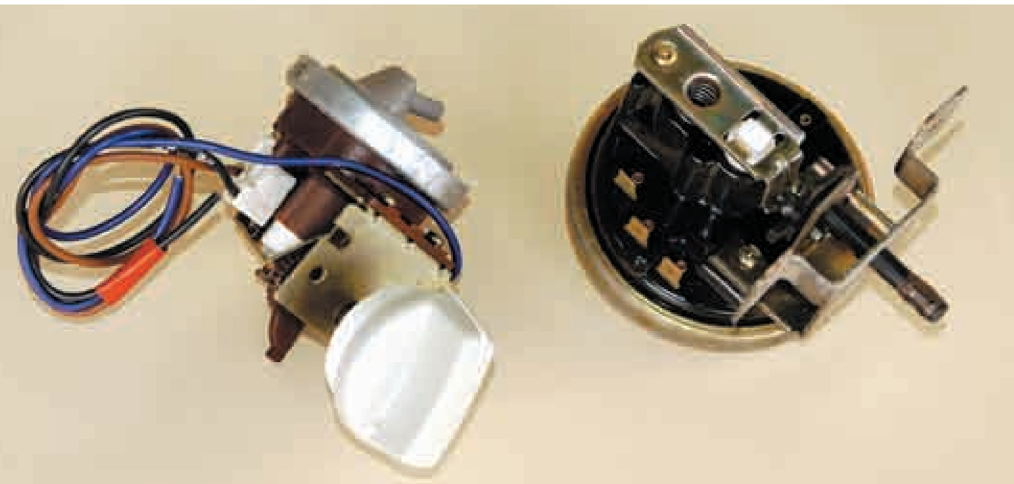
Typically, washing machine pressure switches have a large sensing diaphragm that's about 60mm or so in diameter and three quick-connect male terminals. One connection is common, while the others are for normally open (NO) and normally closed (NC) connections. A set-point adjustment mechanism is built in (it's directly controlled by the 'water level' knob) and the switch opens and closes with audible clicks.

(Note that if the washing machine has digital controls, rather than a mechanical switch, it almost certainly uses an electronic variable pressure sensor to detect the water level. These three-wire sensors are easy to interface, but we'll leave them for another time).

Washing machine pressure switches directly control the hot and cold water inlet solenoids and so are rated for quite high currents – 15A at 230V AC is typical. So for low-voltage DC applications, the switches can certainly cope with (say) 5A. This means that, for most loads, a relay won't be needed.

Dishwashers use pressure switches that are similar to those used in washing machines. However, instead of having one switching point, they have multiple levels. For example, a two-position switch may switch at 10cm and 15cm of water, while a three-position switch may trip at 15cm, 25cm and 35cm of water.

These switches also look a lot like washing machine pressure switches, except they have multiple electrical terminals (six or even nine) and don't have external level adjustment. However, some have screwdriver adjustment for both the trip levels and the hysteresis.



Washing machine and dishwasher pressure switches can be easily scrounged for nothing – you'll find a pressure switch inside nearly every one of these appliances when they're discarded. They are extremely sensitive and their trip points are externally adjustable.

Salvaging pressure switches

When extracting the pressure switch from a washing machine, be careful that you don't also inadvertently remove the adjustment mechanism – it's often part of the bracket holding

This washing machine pressure switch is typical and has single-pole normally open (NO) and normally closed (NC) contacts. When set to minimum pressure, it closes at about 13cm of water and opens at 4cm of water. Conversely, when set to maximum pressure, it closes at about 20cm of water and opens at 14cm of water. Its current rating is 15A at 230V AC.

the switch in place! As for identifying the pressure switch, that's easy. Nine times out of 10, it's directly behind the 'water level' adjustment knob in the top control panel of the machine.

If the machine's upside down or partly destroyed, follow the sensing tube from the base of the wash tub. And while you're at it, it's also usually worth scrounging the tube, which is often a high-quality plastic hose. You never know when it might come in handy.

By contrast, dishwasher pressure switches are normally buried beneath the stainless steel drum. Because they're not externally adjustable, they don't need to be located close to the control panel.

Modifying pressure switches

Depending on your application, you might want your salvaged pressure switch to operate at pressures that are different to its standard range. That's not hard to do if you have a washing machine pressure switch, as they are quite easy to modify.

In standard form, turning the adjustment control typically allows the trip pressure to be set to detect water depths anywhere from 9cm to 20cm. But if you remove the adjustment bracket, you can access the internal spring which sets the sensitivity.

For example, by using a very light spring (ie, one that provides just enough force to return the diaphragm to its un-triggered position when the pressure is removed), it's possible to get a switch to trigger at just 5cm of water (~0.5kPa or 0.08psi). The external adjustment would then typically give a range of about 5cm to 7.5cm of water, but of course, this will vary depending on the unit and the spring used.

Put in a stiffer spring and the adjustment range becomes larger. While we haven't tried it, you could probably stop the switch from closing until you had 15 to 20kPa of pressure. Note, however, that the rubber diaphragm isn't designed to withstand these pressure levels, so there may be some long-term reliability problems.

Using pressure switches

So what uses can be made of these switches? That depends on your imagination, but here are some suggestions:

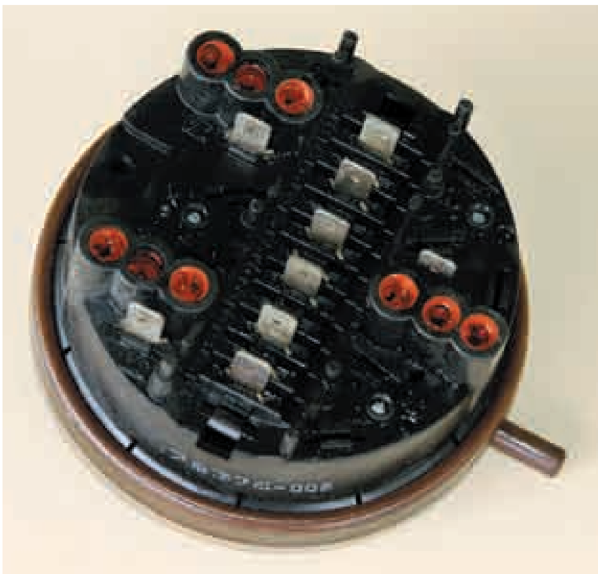
(1). Controlling an electric water pump – eg, to keep a container full of water. Just as in a washing machine, the depth of the water can be sensed from a hose connected to the base of the container. The advantage over a float switch is that the level is easily adjustable.

(2). Providing a low water level warning – eg, the switch could be used to activate a buzzer or light if the liquid level in a tank drops below an adjustable point.

(3). Providing water level indication – eg, by using a dishwasher pressure switch to activate LEDs or lights to indicate the water level in a tank. By using two dishwasher switches and adjusting their individual set-points, it's easy to have six levels indicated. However, you'll need a lot of wires to connect the switches to your display.

(4). Detecting vehicle movement using a washing machine pressure switch. The switch would be triggered by air pressure when the vehicle crosses a hose. Just remember to plug the end of the hose that's not connected to the switch!

So there are four applications but there are lots more. It's certainly worth salvaging these very sensitive switches!



Dishwasher switches have multiple contacts that switch at different pressure levels. This one has three single-pole, normally closed (NC) contacts. Level 1 closes at 18cm and opens at 8cm of water; level 2 closes at 20cm and opens at 18cm of water; and level 3 closes at 34.5cm and opens at 30.5cm of water. Its total current rating is 18A at 250V AC.

Practically Speaking

Robert Penfold looks at the Techniques of Actually Doing it!

IN the early days of electronics, a thermionic valve was at the heart of each stage of a circuit, and there would often be several stages in the complete circuit. The change to transistors did not change things very much, and in essence the circuits remained much the same, but with a transistor at the heart of each stage instead of a valve.

This basic scheme of things remained the norm when integrated circuits first appeared, and for many years after. Even in the computer age it was normal for the microprocessor to be supported by dozens of logic chips and other semiconductor devices.

The situation has changed in recent years, and there are far fewer circuits that rely on the stage-by-stage approach, with a separate semiconductor device at the centre of each stage of the circuit. There are one or two chip solutions to many types of project, either using dedicated integrated circuits or a microcontroller running suitable software. The one or two chips on which the project is based will often be supported by some relatively simple semiconductors, but in general the number of semiconductors per project has reduced significantly over recent years.

Less is more

This is not to say that the range of semiconductors on offer has also shrunk in recent years. The manufacturers and retailers have certainly rationalised their ranges in recent times, and many components that were once in common use have now become obsolete. However, there is no obvious reduction in the number of semiconductor parts on offer in the larger electronic component catalogues. In fact, the range would seem to be as vast as at any time in the past.

Semiconductors are mostly complex devices that have numerous parameters, and they also perform a diverse range of functions. Consequently, they are not listed by value like resistors and capacitors. Instead, they are listed under type numbers, with each type being guaranteed to perform a specific function with certain parameters that are within guaranteed limits. In theory, this should make it easy to obtain the correct component, but in practice matters are not always straightforward, and finding the right semiconductors in component catalogues can be problematic for beginners.

In component catalogues, the semiconductors are usually grouped into several broad categories, with each of these being divided into two or more subcategories. Simply starting at page one of the semiconductor entries and going through the entire list until you find the right one could be very time consuming.

On the face of it, a complete list of all the semiconductors sorted into alpha-numeric order is a better way of locating the right device. This might indeed be the case when a suitable one is available, but for reasons that will be explained later, it will not always provide a quick route to the desired component. The same is also true of the search facilities available when using most online component catalogues and ordering systems.

For the best chance of finding a device, it is necessary to look through the right semiconductor subcategory. For most devices it is not too difficult to find the appropriate main category (transistor, rectifier/diode, integrated circuit etc). The subcategory can be more difficult, but it will usually be fairly obvious (power transistor, rectifier, logic device etc).

It can be much trickier when there are sub-subcategories, which is often the case with integrated circuits. For instance, there are various specialised types of logic device such as converters and computer support chips, plus several large families of general logic devices. These logic families have spawned various ranges of improved devices that have the same basic type numbers as the originals. Therefore, due care has to be taken when ordering semiconductors in general, and logic chips in particular.

Prefix

Finding the right integrated circuit is much easier if you understand the fundamentals of type numbering for this type of component. There are probably exceptions, but practically all integrated circuits have type codes that are made up of three sections. The first of these usually consists of two or three letters that indicate which manufacturer produced the component.

Rather unhelpfully, some devices are produced by more than one manufacturer, with each one using their own version of the type number. Equipment manufacturers prefer having components available from more than one maker so that they are not tied to a single source.

This is known as 'second sourcing', and no doubt it has advantages, such as introducing competition that keeps prices down. On the other hand, having the same component available under slightly different type numbers makes it easy to overlook the right chip, because it has a type number that is slightly different to the one that you are seeking. It can also make it difficult to find the right component when looking through a list of devices that uses some form of alpha-numeric sorting, or when using an online search facility.

The practical consequence of all this is that you can usually ignore the first part of the type number and concentrate on the other two sections. There is probably nothing to worry about if the first two or three letters in the type number of a supplied device are not what you were expecting. If you order an MC1458CP, but are supplied with a CA1458E, or vice versa, there is no need to panic. Both devices are 1458 dual operational amplifiers (op amps), and they are effectively the same component. One is made by Texas Instruments while the other is produced by RCA.

There are some integrated circuits that use Pro Electron type numbers. These use essentially the same system as other chips, but the first part of the type number does not identify the manufacturer. Instead, it is a code that gives some basic information about the function of the device. For example, the first letter is 'S' for a digital device, 'T' for an analogue device, or 'U' for one that is a combination of the two. This coding is of little practical significance though.

End game

In the above example, there is an obvious additional problem, which is that the final parts of the type number are also different. It is only the number in the middle that is common to both components, and the type numbers are clearly more than a little different.

The final part of the type number normally consists of one or two letters, and it indicates the type of encapsulation used for the device. Most *EPE* projects require integrated circuits that are contained in DIL (dual in-line) plastic encapsulations. Dual in-line simply means that the component has two rows of pins.

There is a degree of standardisation for the suffix letters, but there are also plenty of differences. With the example type numbers, the suffix letters are 'CP' and 'E'. In the first type number, the C and P respectively indicate a dual in-line package and that it is made from plastic. The single letter E in the second type number means precisely the same thing.

Other manufacturers utilise different suffixes for this type of encapsulation, such as C, CN, N, CS, P, and G. There are probably many other alternatives in use.

In the past, there were very few devices that were offered to amateur users in anything other than the usual plastic DIL encapsulation.

Matters have changed somewhat in recent times, and some integrated circuits are not produced in plastic DIL versions, making it necessary to use some other kind. Also, if you buy components from suppliers that are primarily selling to the electronics industry rather than the hobbyist, it is likely that most devices will be offered in a range of case styles.

Most chips are listed with two or more case styles, with each one having a different suffix. Some suppliers to the amateur market stock a few surface-mount versions of some integrated circuits.

Clearly, it is now necessary to pay a little more attention to the suffix than it was in the past. The component catalogue should make it perfectly clear which particular type of case each version has. Rather than simply relying on the correct suffix to sort things out, it is probably better to check that the type of encapsulation stated in the catalogue matches that stipulated in the project article.

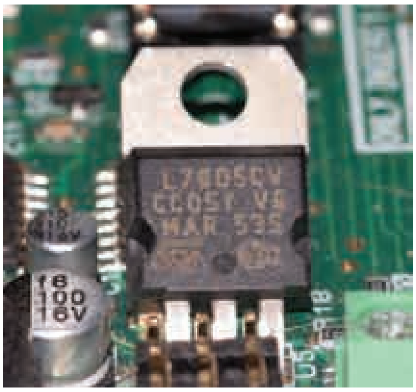


Fig.1. This voltage regulator is a 7805, which means it is a +5V regulator that can handle a maximum current of one amp. The other markings are of no practical importance to users and should be ignored

I suppose that it is possible to have two different integrated circuits that have the same basic part number. However, manufacturers try to avoid duplication of the middle part of a type number, so that the confusion this could cause is avoided.

The convention is for the basic type number to be from three to five characters long, and with a very few exceptions it consists entirely of numerals. It is not totally inconceivable that you could find a semiconductor that has the right basic type number but is completely different to the chip you require. However, the chances of this happening in the real world are extremely low.

Despite this, it is still a good idea to check the descriptions of integrated circuits to make sure that they match up with the specified devices. This might just prevent an expensive mistake. There is clearly an error if a circuit requires a digital-to-analogue converter, but the device you find with the right basic type number is actually an audio amplifier or metal detector chip!

Some further searching for the right component will be required. Bear in mind that many of the basic type numbers for integrated circuits are also used for other types of semiconductor, such as transistors and diodes, so be careful not to jump to conclusions and end up with totally the wrong type of component.

Voltage regulators

The common voltage regulator chips are often referred to using just their basic type numbers, with no prefixes or suffixes being used. This is presumably due to the large number of manufacturers and type numbers for these devices. Sometimes, even the basic type numbers are abandoned, with the output voltage and current ratings being used instead.

Once again, voltage regulators are easier to deal with once you understand the way in which the basic type numbering operates. Type numbers start with '78' for positive regulators, while those for operation with negative supplies have type numbers that commence with '79'. For a one amp device the rest of the type number is two digits that indicate the output voltage. For example, the two digits are '05' for a 5V regulator and '15' for a 15V type. A +5V positive regulator is therefore a 7805, and a –12V type is a 7912. Most suppliers stock a range of devices having about half a dozen or so standard output voltages from five to 30V.

It is possible to obtain alternatives to the original one amp regulator chips, and these have a letter inserted in the middle of the type number to indicate the maximum current rating. The three widely available alternatives to the standard devices are as follows:

Letter	Current Rating
L	0.1 amps (100mA)
M	0.5 amps (500mA)
S	2 amps

A component having 78L12 as its type number would, therefore, be a +12V 0.1A voltage regulator, and one having 79M05 as the type number would be a –5V 0.5A regulator. Bear in mind that this system only applies to the standard ranges of fixed voltage regulators. The normal type numbering rules apply when dealing with the more exotic power supply chips.

Logical approach

Like the 78/79 series of voltage regulators, only the basic type number is used when dealing with the 74 series TTL logic integrated circuits. These chips are mostly sold under a basic type number that starts with '74' and then has a two or three digit serial number.

There is a slight complication caused by the original range of devices becoming largely obsolete, and numerous ranges of improved devices being introduced. Most of these 'new' ranges are now also obsolete. In fact, some were never commercial successes and were short lived.

Essentially, the same numbering system has been retained for the improved devices that survive, but some letters are added between the 74 and the serial number to denote which family the device comes from. This is 'HC' for high-speed CMOS, 'HCT' for the high-speed CMOS devices that operate at normal TTL voltage levels, and 'LS' for the low-power Schottky type. The original 7430 is therefore available as the 74HC30, the 74HCT30, and the 74LS30.

Using a component from the wrong range is definitely not a good idea, because compatibility between the various families is strictly limited. Most importantly, they even have different supply voltage ranges, so using a device from the wrong family could conceivably result in damage to the substituted component. Another point to bear in mind is that logic integrated circuits are widely available in dual in-line and surface-mount versions, so it is important to make sure that the correct type is ordered.

There is another large family of logic integrated circuits, and this is the CMOS '4000' series. These have type numbers starting at 4000, followed by either an 'A' or 'B' suffix letter. The A series have been obsolete for many years now, and all the devices listed in the catalogues are B series chips. All B series CMOS devices should operate properly in an old design where A series chips are specified.

Clocking it

Some computer chips are available in versions that have different maximum clock frequencies, and the basic type number then has an extension that indicates the speed rating of the device. This type of thing is most common with memory, microprocessor, and microcontroller chips such as PICs.

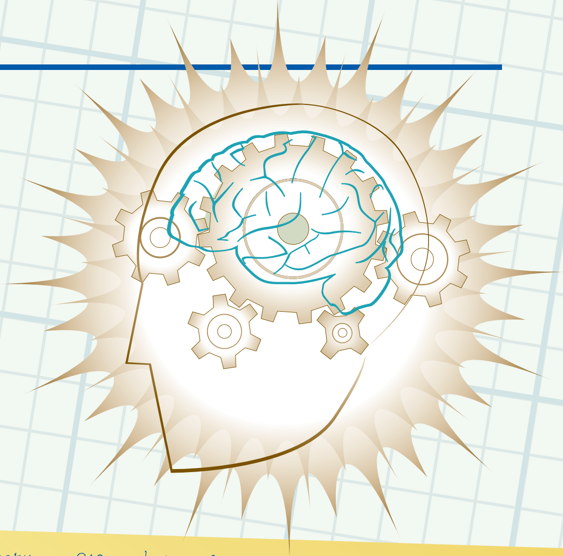
For instance, the PIC16C77 is available as '–04/P' and '–20/P' versions. The P part is the usual suffix and it indicates that the component has a standard plastic DIL encapsulation. The '04' and the '20' indicate that the chips have maximum clock frequencies of 4MHz and 20MHz respectively.

As a general rule, there will be no problems if a component having a higher speed rating is used in place of a slower version. However, faster versions are often much more expensive than the slower ones. Using a chip that has an inadequate speed rating more or less guarantees that the project will not work properly, and in all probability it will not work at all.

Fig.2. Two 74 series logic chips. The 74LS244 (top) has 'LS' in the type number and it is therefore the low power Schottky version of the 74244. The 74HC86 (bottom) is a high-speed CMOS 7486

Ingenuity Unlimited

Our regular round-up of readers' own circuits

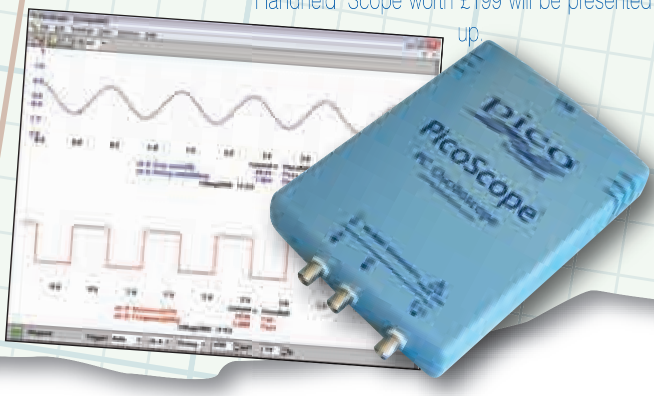


WIN A PICO PC-BASED OSCILLOSCOPE WORTH £799

- 200MHz Analogue Bandwidth Dual Channel Storage Oscilloscope
- Spectrum Analyser
- Frequency Meter
- Multimeter
- USB Interface.

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.

After every 20 published IU circuits, Pico Technology will be awarding a PicoScope 3206 digital storage oscilloscope for the best IU submission. In addition a PicoScope 2105 Handheld 'Scope worth £199 will be presented to the runner up.



We pay between £10 and £50 for all material published, depending on length and technical merit. We're looking for novel applications and circuit designs, not simply mechanical, electrical or software ideas. Ideas must be the reader's own work and **must not have been published or submitted for publication elsewhere**.

The circuits shown have NOT been proven by us. **Ingenuity Unlimited** is open to ALL abilities, but items for consideration in this column should be typed or word-processed, with a brief circuit description (between 100 and 500 words maximum) and include a full circuit diagram showing all component values. **Please draw all circuit schematics as clearly as possible**. Send your circuit ideas to: Ingenuity Unlimited, Wimborne Publishing Ltd., Sequoia House, 398a Ringwood Road, Ferndown, Dorset BH22 9AU. Email: editorial@epemag.wimborne.co.uk.

Your ideas could earn you some cash **and a prize** !

Bass Guitar Headphone Amplifier – *Deeply raised*

The small amplifier's circuit diagram shown in Fig.1 runs from a single PP3-type 9V battery (even an 8.4V rechargeable) and provides adequate volume for practising bass guitar using headphones.

The pickup is fed directly to the unit into IC1b. Here the circuit is a conventional negative feedback amplifier giving a voltage gain of around 20. As the supply is single rail, IC1a provides a stiff ground reference at half supply, with local stabilisation using capacitor C2.

The output stage comprises a high current gain dual Darlington pair in a push-pull configuration, TR1 to TR4. Diodes D1 to D4 minimise crossover distortion. Resistors R6 and R7 maintain current flow through the chain of diodes to keep them in conduction. Finally, R5 provides a negative feedback path that includes the Darlington pairs, so helping to reduce distortion to a minimum.

Stereo Headphones of 32Ω impedance (per ear) were used. These were wired without using the common ground connection of the headphones, so forming a 64Ω load. Capacitors C3 and C4 provide a low impedance return path for this load. Volume and tone controls were considered unnecessary, as these are fitted to the guitar, and the amplifier has virtually no noise or hum when housed in an aluminium case.

The circuit is simple enough to be built in a pocketable enclosure, with all the connections at one end, making it possible to stand with the guitar, wearing headphones and with all cables neatly running into a pocket. On the prototype, the battery was a rechargeable type and an additional connector was fitted to allow the amplifier to be recharged.

Although developed and tested with a bass guitar, no doubt this circuit will work with a treble guitar as well.

Dave Geary, Blackheath, London

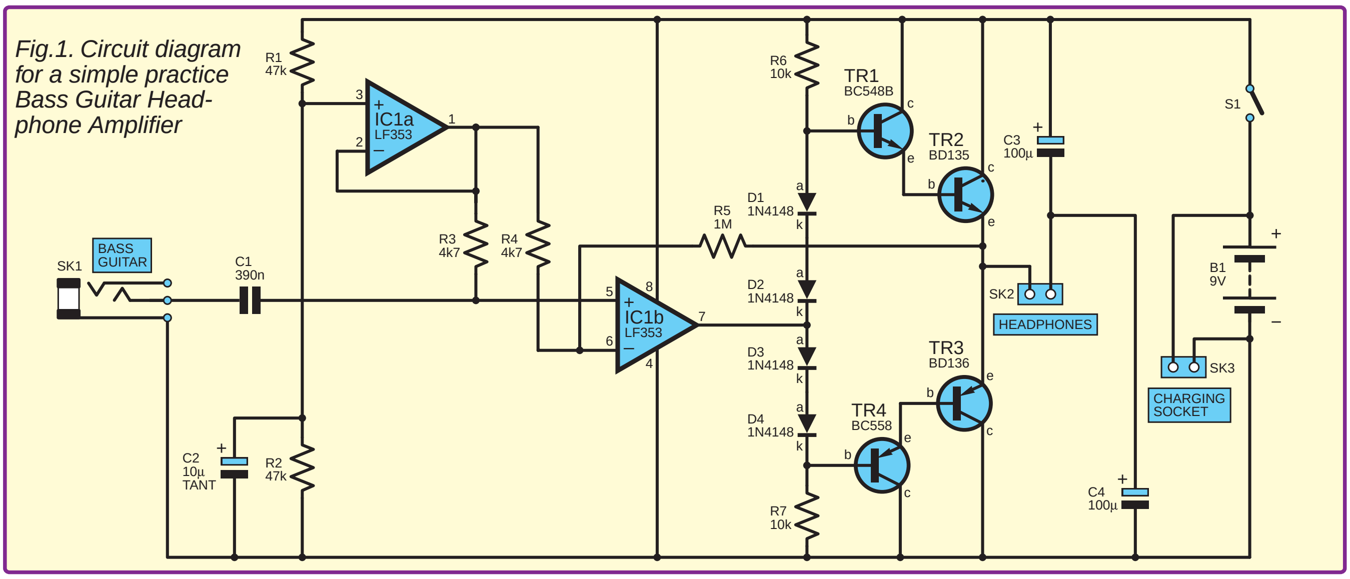
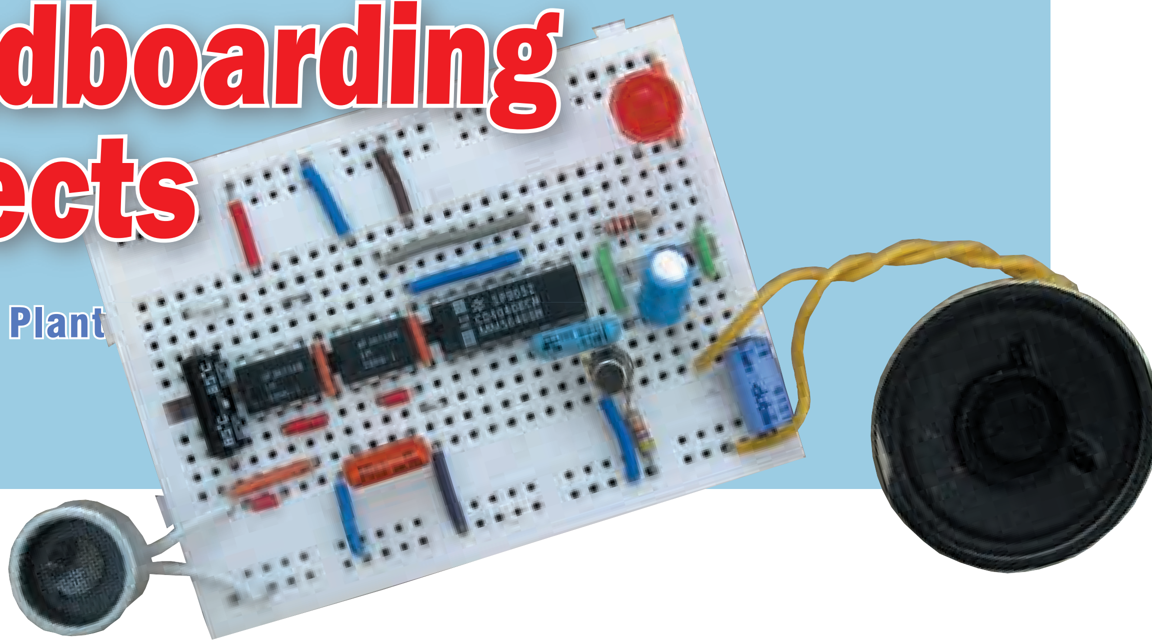


Fig.1. Circuit diagram for a simple practice Bass Guitar Headphone Amplifier

Breadboarding Projects

by Dr Malcolm Plant



A beginner's guide to simple, solder-free circuit prototyping
Part 6: A Bat Detector

Pin back your ears this month – we present a simple breadboard project that allows you to eavesdrop on bats!

Project 11:
Bat Detector

OVER millions of years, bats have developed a superbly sensitive sonar system, which is exquisitely adapted for navigation and finding food while flying in the dark. Their built-in sonar produces bursts of ultrasonic waves which bounce back from

Components needed...

Integrated circuits, IC1 to IC3: type LM386 low power audio amplifier (IC1, IC2); type 4040 CMOS frequency divider (IC3)
Transistor, TR1: type BC108 or similar in T018 style package
Ultrasonic sensor, X1: 40kHz receiver. (Usually only sold as a pair, ie transmitter and receiver. Transmitter can be used in next month's *Ultrasonic Remote Control*.)
Light emitting diode, LED1: red
Loudspeaker, LS1: miniature 8Ω or 16Ω impendance
Capacitors, C1 to C5: values 10µF 16V axial elect. (C1); 100nF polyester (C2, C3); 100µF 16V radial elec. (C4); 22µF 16V axial elect. (C5)
Resistors, R1 and R2: values 4.7kΩ (R1); 220Ω (R2). Both 0.25W 5% carbon film.
Switch, S1 (On/Off): single-pole, single-throw (SPST)
Battery, B1: 9V and connecting leads
Protobloc and wire links

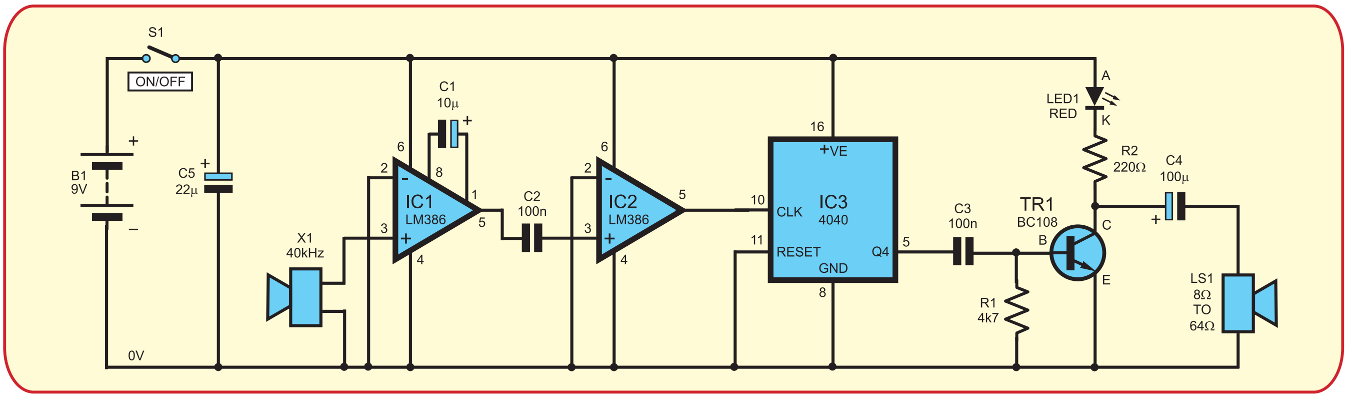


Fig.6.1. Circuit diagram for the simple ultrasonic Bat Detector

objects, including flying insects, to give bats a 'picture' of their surroundings in probably as much detail as our sight gives us.

As a matter of interest, the use of echo location by bats wasn't known until about 1940. Some scientists couldn't believe what they heard. In 1940, sonar and radar were still classified military secrets and the idea that bats had achieved something akin to the latest triumphs of electronic engineering struck them as being rather fanciful daydreaming. So much for open-minded science!

Bat circuit

Given the remarkable sophistication of the ultrasonic sounds that bats make, the circuit shown in Fig.6.1 is hardly a triumph of electronic design, but it does offer a simple and low-cost way of listening in to a bat's 'silent' navigation system. You might like to think of the circuit as an electronic 'translator' that enables you to eavesdrop on a little bit of 'batspeak'.

The ultrasonic detector, X1, picks up the bursts of ultrasonic sound bats make. Since the ultrasonic bursts are weak, they are greatly amplified by the first building block comprising two audio amplifiers, ICI and IC2, connected in series. IC1 provides a voltage gain of about 200 and IC2 a gain of about 20, so the overall voltage gain is an impressive 4000.

Frequency divider

The amplified ultrasonic frequencies are then fed to the second building block, a frequency divider, IC3, which

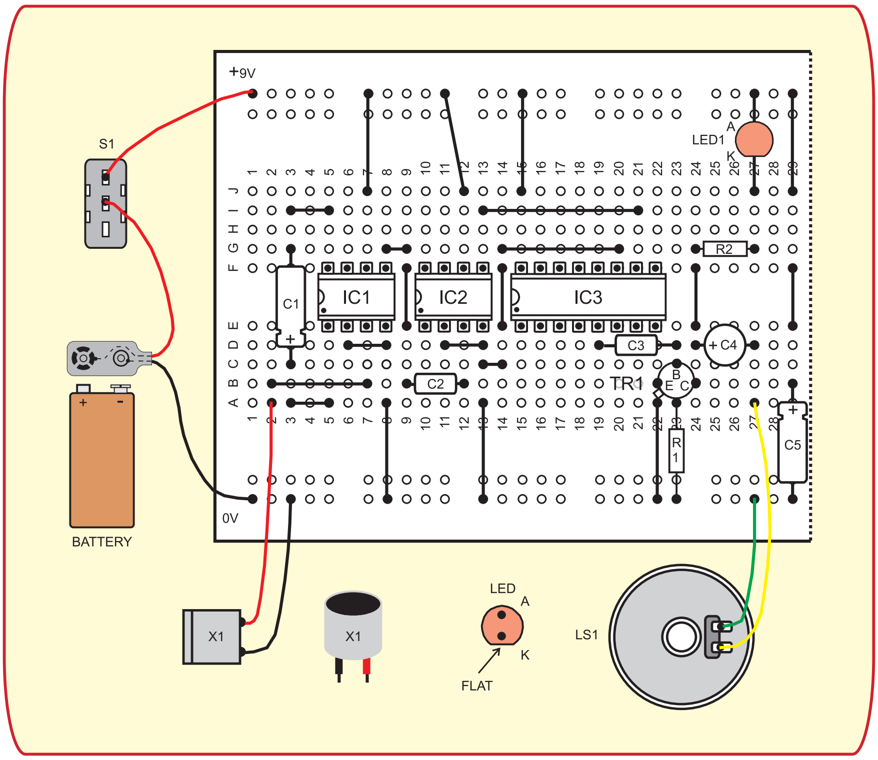
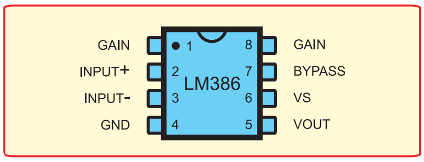


Fig.6.2. Bat Detector Protobloc breadboard component layout and wiring to off-board components. Note, the transducer (X1) pin connected to its case must plug into the board 0V line



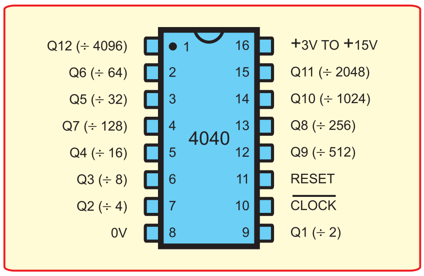


Fig.6.3. Pinout information for the LM386 audio amp and the 4040 frequency divider ICs

Construction brief

To ensure trouble-free assembly, you should try and follow these basic guide lines

Always use single-core 0.6mm diameter plastic-sleeved wire for wire links, not thicker. The ends of the wire should be stripped of plastic for about 8mm. The use of thicker wire can permanently damage the springy sockets underneath each hole.

Never use stranded wire; it can fray and catch in the sockets, or a strand can break off and cause unwanted connections below the surface of the breadboard.

It is very important to make sure that the bared ends of link wires and component leads are straight before inserting them into the breadboard. Kinks in the wire will catch in the springy clip below the socket and damage it if you have to tug to release the wire from the holes.

Make sure that the arrangement of components and wire links is tidy, with components snugly fitting close to the surface of the Protobloc. This usually means providing more link wires than is perhaps necessary, so as to avoid having wires going every-which-way across the board.

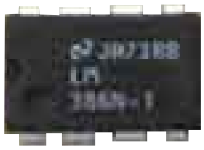
Never connect the battery leads to the top and bottom rails of the breadboard until you have carefully checked that all the component connections correspond to those on the circuit diagram.

Some components, such as switches and relays, do not have appropriate wire leads for insertion into the Protobloc. If you have access to a soldering iron, solder short lengths of single-core 0.6mm diameter plastic-sleeved wire to the terminals of these components.

reduces the inaudible ultrasonic sounds to sounds that humans can hear. Transistor TR1 amplifies these audio frequencies to drive LED1 and to operate loudspeaker LS1. The result is a series of audible ‘click-click-click’ sounds in the loudspeaker.

Component Info

IC1, IC2, type LM386 audio amp



pin 1

Viewed from above, an indented dot and ‘half-moon’ shape at one end indicates pin one. Once pin 1 has been identified, pins are numbered 1 to 8 going anticlockwise, ending up at pin 8 opposite pin 1.

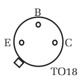
IC2, type 4040 frequency divider

PIN 1

Once pin 1 has been identified, pins are numbered 1 to 16 going anticlockwise.

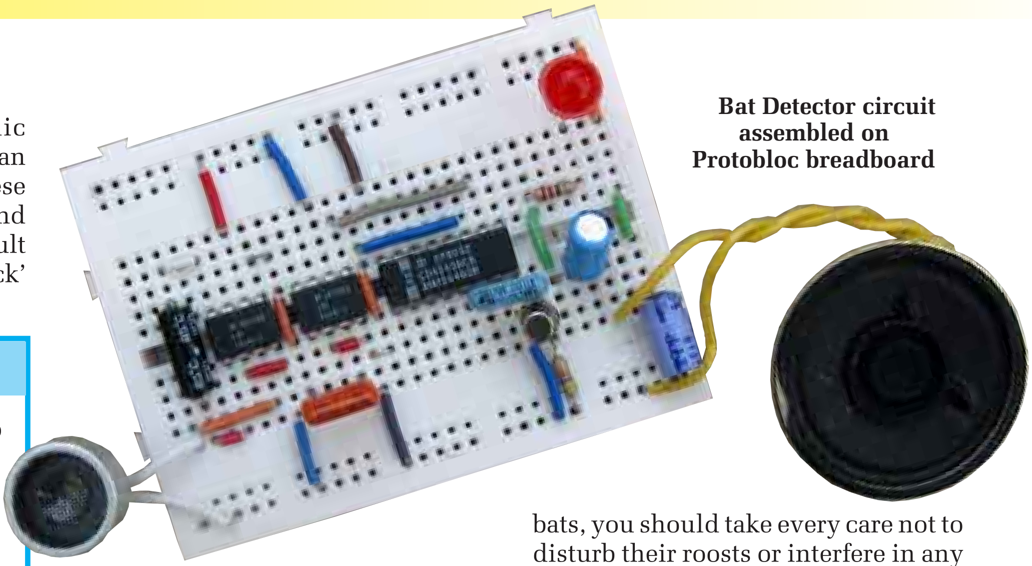
TR1 and TR2, type BC108 *NPN* transistor

Seen from below, the emitter lead is next to the small metal tag. Clockwise from the emitter are the base, and collector leads.



X1, 40kHz ultrasonic receiver transducer

One pin is connected to the case and this must be connected to the 0V supply. Make sure it is the receiver device and not the transmitter. Printed on it will be an ‘R’.



Bat Detector circuit assembled on Protobloc breadboard

Breadboard

The Protobloc component layout for the Bat Detector is shown in Fig. 6.2. Electrolytic capacitors C1, C4 and C5 must be inserted on the board with their positive (+) leads positioned as indicated. Connections to S1, X1 and LS1 are also shown in Fig.6.2, which require wires to be soldered to their terminals for insertion into the breadboard.

When soldering the leads to the receiver transducer connecting pins, be as quick as possible, as it does not take kindly to excessive heat. Note that one pin is also connected to the case of the transducer, so make sure this lead is connected to the board 0V line.

Bat sounds

The repetition rate of the bursts of ultrasonic frequencies generated by a bat varies from about 20 to 200 per second depending on the species of bat and what it is doing. For example, when a little brown bat is cruising around looking for an insect, it produces bursts of ultrasonic sound at around 10 per second. But when it detects an insect and starts to move in on an interception course, the frequency of these bursts goes up to 200 per second, the ‘clicks’ merging into a buzz in the loudspeaker.

The frequency of the ultrasonic component of each burst of sound is not fixed but varies from, say, 100kHz to about 20kHz. Because of the limited bandwidth of the ultrasonic sensor used in this circuit, which is centred on 40kHz, the circuit only amplifies a small part of this frequency spread, but you’ll hear enough ‘batspeak’ to make you want to know more about these fascinating animals. When studying bats, you should take every care not to disturb their roosts or interfere in any way with their private lives.

Notes

● Use the simple *Circuit Tester* to identify the base lead of TR1 to confirm that it is an *NPN* transistor as described in Part 1 (Oct ’08). Likewise, find the anode and cathode leads of the light emitting diode, LED1.

● The output signal from pin 5 of IC3 is the input signal from IC2, the frequency of the bat’s sound, divided by 16 as shown in pinout diagram Fig.6.3. Using the diagram as a guide, you might like to experiment with other outputs which provide divisions by more or less than 16. This will have an effect on the pitch of the ‘clicks’ heard.

● Since the voltage gain of this circuit is high and is prone to breaking into oscillation, you should follow the layout of components shown in Fig.6.2. In particular, make sure that the stabilisation capacitor, C5, is in place.

● Test the circuit first by rubbing your fingers or hands together, or rustling some papers, to generate ultrasonic sounds. You will note the LED will flicker and the sound from the speaker will crackle.

● If bats are temporarily elusive, you could build an artificial bat generator, a circuit that generates pulses of 40kHz ultrasonic sound waves to see if the detector works. Try using the *Ultrasonic Transmitter*, described in the next issue as an artificial bat. You can simulate pulses at ultrasonic frequencies by repeatedly making and breaking the power supply lead to this transmitter.

For further information on different bat species and habitats contact: Bat Conservation Trust, 15 Cloisters House, 8 Battersea Park Road, London, SW8 4BG. Web: www.bats.org.uk. Tel: 0845 1300 228 or your local bat group.

ELECTRONICS MANUALS ON CD-ROM £29.95 EACH

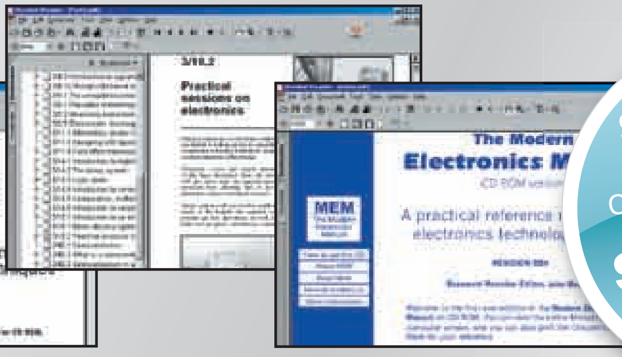
ELECTRONICS SERVICE MANUAL

Everything you need to know to get started in repairing electronic equipment

● Around 900 pages ● Fundamental principles ● Troubleshooting techniques ● Servicing techniques ● Choosing and using test equipment ● Reference data ● Manufacturers' web links ● Easy-to-use Adobe Acrobat format ● Clear and simple layout ● Vital safety precautions ● Professionally written ● Supplements

SAFETY: Safety Regulations, Electrical Safety and First Aid. UNDERPINNING KNOWLEDGE: Electrical and Electronic Principles, Active and Passive Components, Circuit Diagrams, Circuit Measurements, Radio, Computers, Valves and manufacturers' Data, etc. PRACTICAL SKILLS: Learn how to identify Electronic Components, Avoid Static Hazards, Carry Out Soldering and Wiring, Remove and Replace Components. TEST EQUIPMENT: How to Choose and Use Test Equipment, Assemble a Toolkit, Set Up a Workshop, and Get the Most from Your Multimeter and Oscilloscope, etc. SERVICING TECHNIQUES: The Manual includes vital guidelines on how to Service Audio Amplifiers. The Supplements include similar guidelines for Radio Receivers, TV Receivers, Cassette Recorders, Video Recorders, Personal Computers, etc. TECHNICAL NOTES: Commencing with the IBM PC, this section and the Supplements deal with a very wide range of specific types of equipment – radios, TVs, cassette recorders, amplifiers, video recorders etc. REFERENCE DATA: Diodes, Small-Signal Transistors, Power Transistors, Thyristors, Triacs and Field Effect Transistors. Supplements include Operational Amplifiers, Logic Circuits, optoelectronic Devices, etc.

MODERN ELECTRONICS MANUAL



SPECIAL OFFER
Order both Manuals together and
SAVE £10

The essential reference work for everyone studying electronics

● Over 800 pages ● In-depth theory ● Projects to build ● Detailed assembly instructions 1 Full components checklists ● Extensive data tables ● Manufacturers' web links ● Easy-to-use Adobe Acrobat format ● Clear and simple layout ● Comprehensive subject range ● Professionally written ● Supplements

BASIC PRINCIPLES: Electronic Components and their Characteristics; Circuits Using Passive Components; Power Supplies; The Amateur Electronics Workshop; The Uses of Semiconductors; Digital Electronics; Operational Amplifiers; Introduction to Physics, including practical experiments; Semiconductors and Digital Instruments.
CIRCUITS TO BUILD: The Base Manual describes 12 projects including a Theremin and a Simple TENS Unit.
ESSENTIAL DATA: Extensive tables on diodes, transistors, thyristors and triacs, digital and linear i.c.s.
EXTENSIVE GLOSSARY: Should you come across a technical word, phrase or abbreviation you're not familiar with, simply look up the glossary and you'll find a comprehensive definition in plain English.
The Manual also covers **Safety** and provides web links to component and equipment **Manufacturers and Suppliers**.

Full contents list available online at: www.epemag.com

SUPPLEMENTS: Additional CD-ROMs each containing approximately 500 pages of additional information on specific areas of electronics are available for £19.95 each. Information on the availability and content of each Supplement CD-ROM will be sent to you.
PRESENTATION: CD-ROM suitable for any modern PC. Requires Adobe Acrobat Reader which is included on the CD-ROM.

Wimborne Publishing Ltd., Sequoia House, 398a Ringwood Road, Ferndown, Dorset BH22 9AU. Tel: 01202 873872. Fax: 01202 874562.

PLEASE send me

☐ **THE MODERN ELECTRONICS MANUAL CD-ROM**
☐ **ELECTRONICS SERVICE MANUAL CD-ROM**

I enclose payment of £29.95 (for one manual) or £49.90 for both manuals (saving £10 by ordering both together).

FULL NAME ....

ADDRESS ....

....

.... POSTCODE ....

SIGNATURE ....

☐ I enclose cheque/PO in UK pounds payable to Wimborne Publishing Ltd.
☐ Please charge my Visa/Mastercard/Maestro

Card No .... Maestro Issue No ....

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

ORDER FORM

Simply complete and return the order form with your payment to the following address:
Wimborne Publishing Ltd,
Sequoia House, 398a Ringwood Road,
Ferndown, Dorset BH22 9AU
Price includes postage to anywhere in the World

We will happily exchange any faulty CD-ROMs but since the content can be printed out we do not offer a refund on these items.

Your CD-ROM(s) will be posted to you by first class mail or airmail, normally within four working days of receipt of your order

Interconnecting audio equipment

Reader ***Raymond Payne*** wrote to us with the following query about interconnecting audio equipment:

I am looking for a solution relating to personal disc players, which do not have a 'line out socket' – using the earphone socket 4-16Ω into 47kΩ doesn't go – so would you be able to advise a suitable circuit? Maybe a future project for the magazine? I do not possess a computer, so cannot do a 'search'.

Simple answer

The simple answer is that it should be possible to simply connect the earphone output directly to an audio line input, and if you are careful it should be safe to try this. I have done this many times over the years with various pieces of audio equipment and have never experienced any problems. You may need to purchase an appropriate lead, eg one with a miniature stereo jack on one end and two phono (RCA) connectors on the other end, depending on what connectors your equipment has.

Start by setting the headphone output to minimum volume. Set the volume or level on the equipment whose line input you are using to a normal/moderate level. Connect the headphone output directly to the line input.

Start the disc/MP3 player and gradually increase the earphone volume level until you obtain a 'normal' volume or level on the input equipment. If you have to turn the player's output up very high and the signal is distorted, then reduce the headphone volume and increase the volume/level on the amplifier.

Note that the same does not apply to a loudspeaker output – you should not try to connect loudspeaker outputs directly to line inputs.

While writing this article, the compatibility between headphone outputs and line inputs was further confirmed by observing the headphone output of a typical consumer portable CD player/radio (MATSUI CD48D) using an oscilloscope (Tektronix TDS3014B), looking at one stereo channel. Using radio music as a source, the approximate unloaded peak output voltage and a relatively high volume setting (34 out of 40 volume steps) was between 500mV and 1V. With typical consumer headphones (Philips SBC HB400, 32Ω impedance) loading the output, the peak voltage dropped to between 100mV and 200mV.

As would be expected, connecting a 10kΩ resistive load to the output did not cause any noticeable reduction in output voltage. The scope input configuration was 1MΩ impedance with AC coupling. The voltages observed were compatible with line input levels (see later in the article).

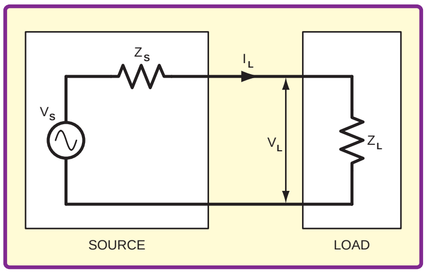


Fig.1. Source and load connected together

Matching signals

Having given a simple answer to this question, it is worth noting that it raises a couple of issues which frequently cause confusion – what signal levels are used for an audio line input, and how do you 'match' audio input and output signals in terms of impedance?

So we will now look at these topics in a little more detail. We will then look at how line output usage is taken into consideration in the design of headphone amplifier ICs.

Consider a source with impedance Z_S connected to a load of impedance Z_L, as shown in Fig.1. The 'matching' problem is basically choosing the most appropriate Z_L, given that we know Z_S. The two impedances form a potential divider. Thus the voltage across the load is given by:

$$V_L = \frac{Z_L}{(Z_S + Z_L)} V_S$$

We get this equation by using Ohm's law to get the current through the two impedances (V_S divided by the total impedance) and applying Ohm's law again to get the voltage drop across Z_L (by multiplying Z_L by the current). From the equation we see that if we want V_L to be as large as possible, then Z_L must be much larger than Z_S (we are assuming Z_S is fixed). If Z_L is very much larger than Z_S then the load voltage is effectively equal to the source voltage.

This is the situation with interconnects for most modern audio equipment, that is high input impedance and low output impedance. It is sometimes called 'voltage matching'. Connecting a headphone output (relatively low impedance) to a line input (high impedance) also results in a 'voltage matching' situation.

So what happens when $Z_S = Z_L$, and why might this be useful? The answer is that maximum power is transferred from source to load (in order to prove this you have to use calculus). This was the case with old telephone systems, which used 600Ω matched input and output impedances, and this in turn led to early audio equipment using the same standard, but this is no longer relevant to modern audio interconnects. However, the power transfer aspect of matching is important in other situations, such as power amplifier output to speakers.

Another matching situation concerns very long wires, or very high frequencies for shorter wires, where the signal takes a significant time to travel down the wire compared to one cycle of the signal's waveform. In this situation, the signal 'sees' different parts of the wire at different times. The signal behaves like a wave travelling in a pipe and the connecting wire is referred to as a 'transmission line'. Transmission lines need to be matched to both input and output to prevent wave reflections, but this is not generally an issue at audio frequencies.

A different question

Thus, it is not necessary to match impedances to connect a headphone output to a line input and Raymond's concern about '*4-16Ω into 47kΩ doesn't go*' is not actually a problem. The headphone amplifier can easily drive the high impedance line input, so the main potential problem is will the voltage output from the headphone amplifier be compatible with standard line voltage levels. This raises the question of what these standard voltages are.

To appreciate the definitions of standard audio line voltage levels we need to know something about decibels and AC power measurement. The definition of a decibel (dB) is based on the logarithm of the *power* ratio of two signals P1 and P2, such that the power ratio in decibels is given by 10 × $\log_{10}$(P2/P1)dB.

If we are expressing power *gain* (eg of an amplifier) then P1 would be the input power and P2 the output power. For measuring a power quantity relative to a reference, P1 would be the agreed reference level and P2 the value we are measuring.

If we have a sinewave signal, then the voltage is $v = V_{peak}\sin(2\pi t/T)$ where *t* is time and V_{peak} is the peak value of the AC voltage. Unlike a fixed DC current, the power at each instance of time *t* is different, so we need somehow to find the 'average' power. A meaningful average is to find the DC level which would have the same heating effect as the AC signal.

The calculations require use of calculus (we have to integrate the signal function) so we will not go into the details here, but for a pure sinewave we get $V_{DCequivalent} = V_{peak}/\sqrt{2}$ or $0.707V_{peak}$.

This is a formula that may be well known to many readers – it is the RMS value of an AC voltage or current. The ratio of a waveform's peak value to its RMS value is known as the crest factor. The crest factor is $\sqrt{2}$ for sinewave.

It is important to understand that $V_{RMS} = 0.707V_{peak}$ is only true for pure sinewaves. For any other wave shape we have to apply the mathematical analysis from scratch.

Power and gain

Power is related to the square of voltage or current. If we square something inside a logarithm it is equivalent to multiplying the log by two (without the square). That is $\log(V^2) = 2\log(V)$. So, to express a voltage gain (V_1/V_2) in decibels we use $20 \times \log_{10}(V_2/V_1)$. Note that we are multiplying by 20, not by 10 as we did with the power gain.

Strictly speaking, this formula is only valid if the two voltages are applied across the same value of resistance, but in many cases we are only interested in the voltage gain (not the power gain) and the $20 \times \log_{10}(V_2/V_1)$ formula is widely used for this purpose (V_2 is the output, V_1 is the input).

Gains in decibels are relatively easy to understand because the ratio is input to output, but for measuring signal level we need to make sure we know what reference level we are dealing with, and whether it is a power or voltage measurement.

If we work with 'matched' systems, where the input and output impedances are all basically the same, then it makes sense to measure signals in power terms (the matching achieves maximum power transfer). This was the case with the old 600Ω matched systems.

For the signals in these systems, one milliwatt was a convenient reference level for decibel power measurement, so the unit dBm (or dBmW) was used for this purpose. Given an impedance of 600Ω, the 1mW reference power corresponds to a voltage of 0.775V (RMS). This is easily verified using $P = V^2/R = 0.775^2/600 = 0.001$mW.

Under these conditions it made sense to use 0.775V RMS as a reference level for decibel voltage measurements. We have to use a different unit for this as dBm is a power measurement not a voltage measurement, so dBu (or dBV) is used. As with other voltage-based decibel measurements, the resistance may be ignored or unspecified, although the dBu unit is often stated as referring to an open circuit situation, that is 'unloaded' or 'unterminated', hence the *u*. Note that 0.775V RMS is about 1.1V peak (not 1.0V) for a sinewave signal. The value 0.775V RMS relates to power into a 600Ω load and not conversion from peak to RMS voltages.

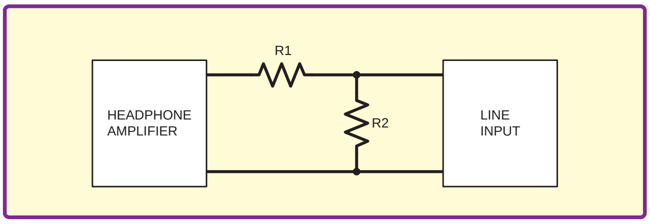


Fig.2. Using a potential divider as an attenuator (only one stereo channel shown)

If you are not using a 600Ω system then, apart from its historical precedence, the 0.775V RMS reference level seems very arbitrary. For this reason, a reference using the 'round number' of 1V RMS is sometimes used instead. The symbol for this is dBV. 1dBV is equal to 2.2dBu (from $20 \times \log10(1/0.775)$) and 1dBu is equal to –2.2dBV (from $20 \times \log10(0.775/1)$). The impedance is not specified for dBV measurements.

Standard signal levels

There are a couple of standard signal levels used for audio equipment. These are +4dBu and –10dBV. The value +4dBu, which is typical for professional audio equipment is 1.23V RMS (20log(1.23/0.775)=4). –10dBV, which is typical for consumer equipment, is 0.316V RMS (20log(0.316/1) = –10). Meters on audio equipment will typically be calibrated to these levels (eg 0dB on the meter is –10dBV or 0.316V signal). Although we have described 0.316V RMS as a standard for consumer line voltage, actual consumer equipment is not particularly consistent with this, however voltages in the range of hundreds of millivolts should work with all systems.

Returning to the measurements made on the CD player/radio, we see that the open circuit output at a relatively high volume was around 500mV average peak on a voice/music signal. A 500mV peak sinewave is 350mV RMS, so we are definitely in the right range for a consumer line voltage input.

It is possible that some headphone outputs may have unloaded output voltages which are higher than typical, and this may cause problems. As there should be a headphone volume control, the line input should not be overloaded if you follow the procedure above, but you may find that you do not have fine enough control over the signal level, or that the audio quality is relatively poor at very low volume levels. If this occurs, then you can insert a potential divider between the headphone amplifier and line input, as shown in Fig.2 (one circuit for each stereo channel).

The headphone signal is reduced by a factor of R2/(R1 + R2), so if, for example, the resistors are equal then the voltage is halved. Choice of resistors values is not particularly critical, but the sum of R1

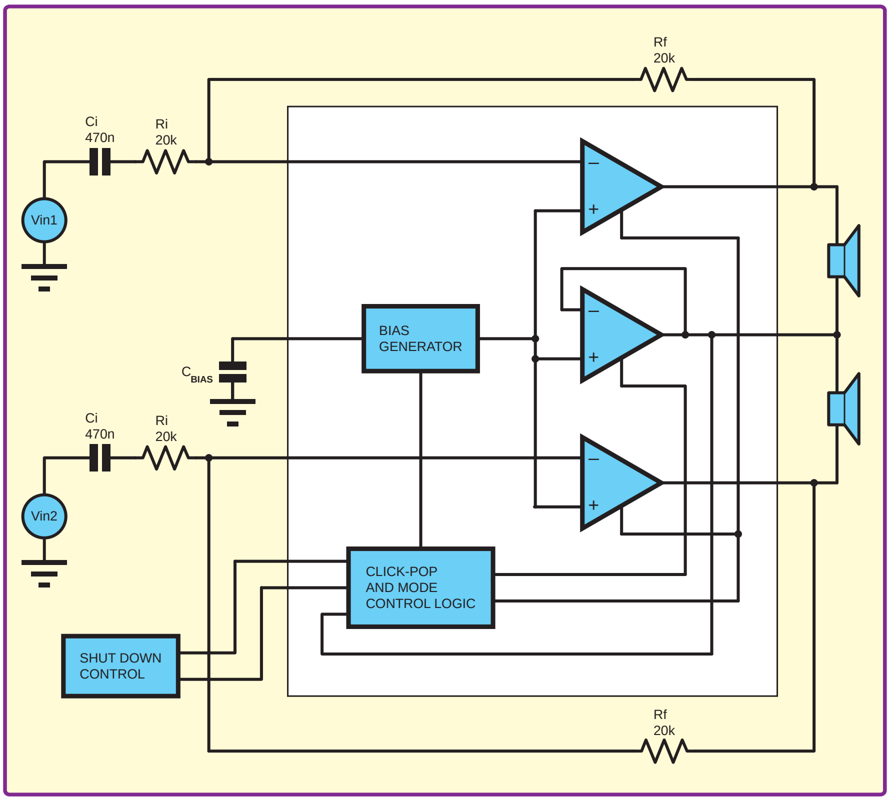


Fig.3. Block diagram of LM4929 headphone amplifier circuit (from National Semiconductor datasheet)

and R2 must be greater than the minimum specified headphone impedance (probably 8 to 16Ω). The sum of R1 and R2 should also be significantly less than the line input impedance (for which Raymond quotes 47kΩ). A total value of a few hundred Ohms is reasonable.

Audio engineers refer to in-line signal attenuators like the one in Fig.2 as pads. The circuit in Fig.2 would be called an L-pad because of the L-shape of the resistors in the schematic. Other pad circuits have more resistors to allow more control over the impedances presented to both the source and input. Also, as many professional audio systems use balanced signals, balanced attenuators are available for this purpose.

Pads are available commercially with accurately set fixed or switchable attenuations of a specific number of decibels. As might be expected, they cost a lot more than just buying a few resistors and wiring them up yourself.

Headphone amplifier ICs

The fact that headphone outputs are commonly connected to line inputs is evident from this being considered in the design of headphone amplifier ICs aimed at consumer audio systems, mobile phones and similar applications. We will look at a couple of examples from National Semiconductor datasheets (**www.national.com**).

LM4929

The LM4929 is a stereo 40mW low-noise headphone amplifier IC branded with National's 'Boomer' trademark. This device features OCL (output capacitor-less) outputs, that is, it does not use DC blocking capacitors on the outputs. Typically, portable personal electronic equipment runs from a single supply derived from the batteries. This means the audio signal is biased around half the supply voltage, so the headphones have to be connected via coupling capacitors to block the DC.

To give good low frequency (bass) performance these capacitors have to have quite a high value (typically 220μF) and are therefore bulky and expensive. The LM4929 overcomes this problem by providing a half supply output reference which is connected to the headphone common (lead shield/sleeve connection) – see the block schematic in Fig.3. The sleeve/shield is not grounded.

The LM4929 datasheet notes that if the headphone output is connected to a line input, then the coupling capacitor in most systems will safely block the DC on the headphone's sleeve/common connection. However, some equipment has line inputs that are not capacitively coupled, which could potentially be damaged if connected to a DC biased source. To prevent this, the LM4929 monitors the current supplied to the headphone jack's shield/sleeve connection. If this current exceeds 500mA peak, the LM4929 shuts down to protect itself and the external equipment.

LM48822

Another 'Boomer' headphone amplifier from National Semiconductor is the LM48822, which is described as a 'ground-referenced, ultra high PSRR, ultra low-noise, 35mW/channel stereo headphone amplifier with common mode sense, and I2C volume control'. This device uses a different approach to avoiding large coupling capacitors to the headphones – it includes a low-noise charge pump to create a negative supply voltage (CPVSS) so that the output signal can be ground referenced (see Fig.4 for the block diagram).

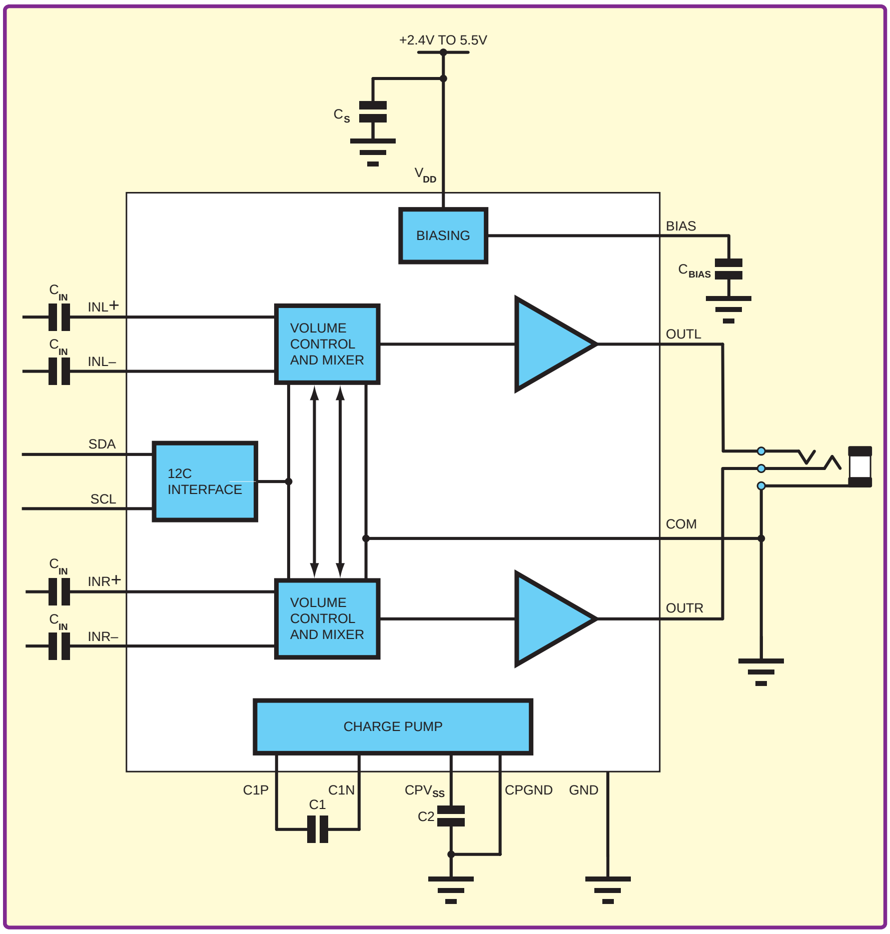


Fig.4. LM48822 block diagram (from National Semiconductor datasheet)

Again, National discusses line output use of their headphone amplifier in the datasheet. The LM48822 features a ground (common mode) sensing feature aimed at situations where the headphone jack is used as a line output. Used this way, noise pick up and ground imbalance can degrade audio quality, so the LM48822 COM input senses and corrects any noise at the headphone return, or any ground imbalance between the headphone return and device ground. The LM48822's COM pin is connected directly to the headphone jack's sleeve/shield connection if this feature is needed.

In conclusion, headphone outputs can almost always be used as audio line outputs and this practice is common enough for it to be taken into consideration in the design of headphone amplifier ICs. For extra safety, start at zero headphone volume when you first connect and if your line inputs are not capacitive coupled check for any DC levels on the headphone socket.

PIC n' Mix

Mike Hibbett

Our periodic column for PIC programming enlightenment

Interfacing PICs to the Internet via Ethernet – Part 6

Before we end this series of articles on interfacing PICs to the Internet via Ethernet – for the time being at least – there are a few issues to go over from last month.

Many readers have contacted us with an interest in constructing the embedded web server circuit. *Pic n' Mix* articles are not normally intended to be full constructional projects, but due to the level of interest over the last few months we will go into a little more detail to simplify the process.

There were a couple of errors in the circuit diagram shown last month in the area of the connection between the ENC28J60 and the Magjack connector, so a corrected diagram is shown this month in Fig.1. Many thanks to Andy Martell for pointing these out.

Thanks also to Diggory Gray for pointing out an error in the description of the router setup, and providing some further explanation of using DHCP. His explanation is quite detailed and you'll find his letter in full in *Readout* elsewhere in this issue.

The pinout of the Ethernet socket is quite complicated, and worth an extra view. Fig.3. shows the view from *above* the connector, so that the pins are not visible. On the Magjack, pin 7 is not connected, which helps in working out the pinout. On

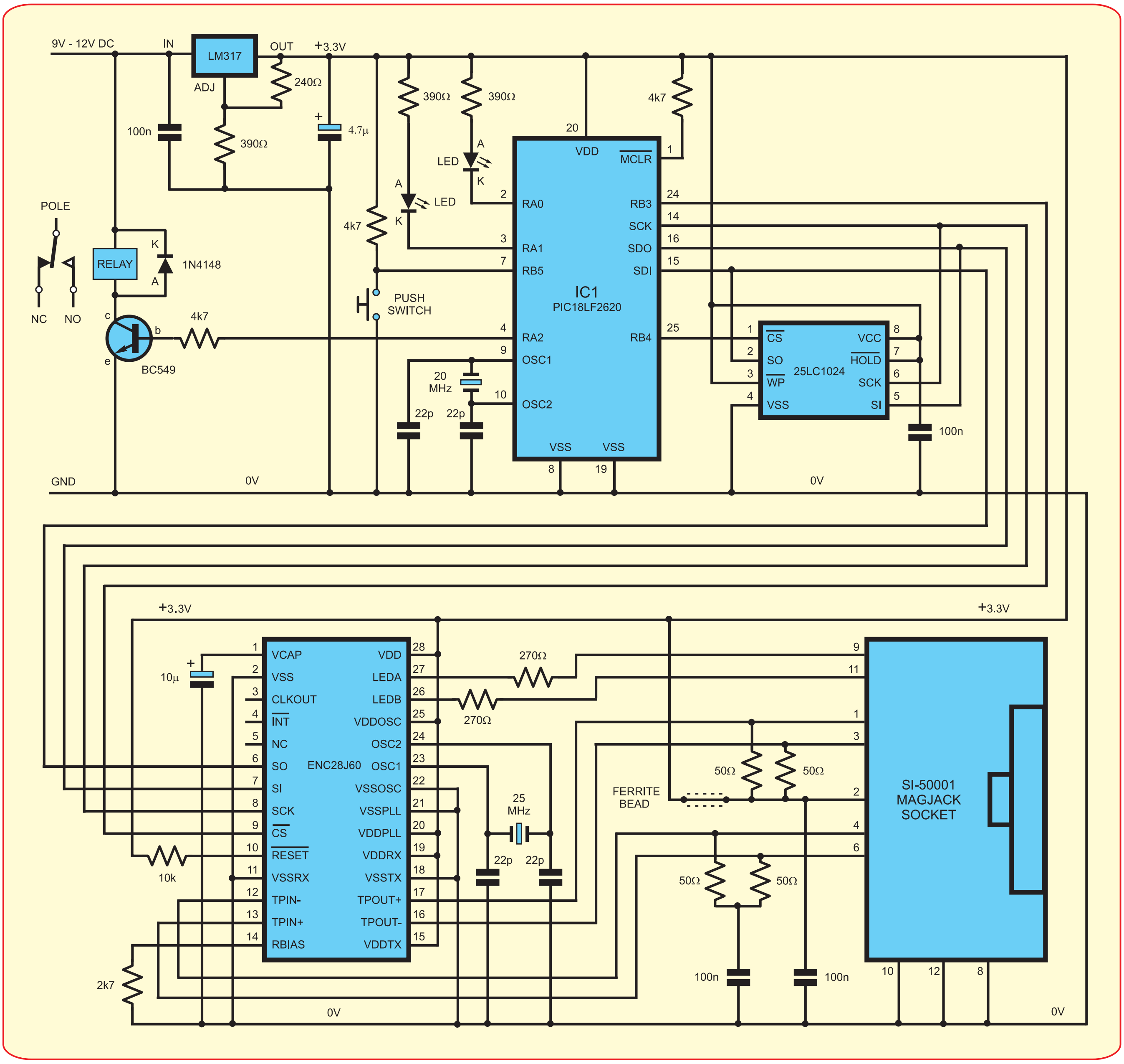


Fig.1. Web server circuit diagram

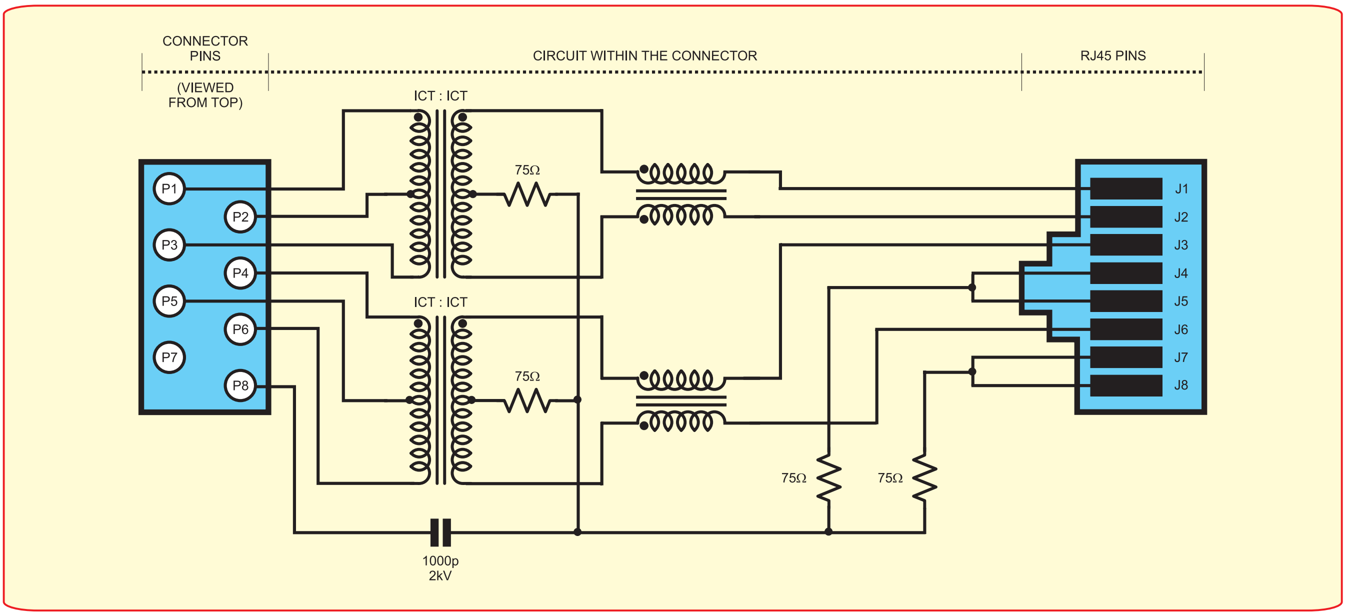


Fig.2. SI-50001 connector internals

other Ethernet connectors, pin 7 may be present, so a careful look at the datasheet may be necessary. Or perhaps use a DVM – the connector contains a transformer, and it should be easy to work out the pinout. See Fig.2 for the circuit inside the SI-50001 connector.

There's quite a lot inside these connectors; certainly more than your average RS232 socket. The transformer provides isolation against electrical noise and helps balance the high speed data signals. As these components are very common in Ethernet interfaces, connector manufacturers provide an integrated solution in a relatively small connector.

Unfortunately, not all RJ45 connectors are the same. They come in different orientations, and with different transformer winding ratios. If you wish to use a different connector to the one we have chosen, make sure it contains a similar circuit to the SI-50001. The SI-60062, and J0011 or J0012 from Pulse appear to be suitable alternatives. Bear in mind that these all have different pinouts compared with the SI-50001.

Webpages

Now, back to the issue of how to control the content of the web server – the webpages that can be 'served up' to a web browser. But before that, let's take a look at how the interaction between a website on the Internet and your PC's web browser works.

Websites are, in general, nothing more than a high specification PC located in the premises of a company offering website 'hosting'. Companies that provide this service operate hundreds of machines, each one capable of hosting multiple websites simultaneously. These PCs are called servers, because they serve up information to other computers. Not very imaginative, but the word has stuck, and we'll use it too.

You typically rent space on a server, and the company provides you with a special login account to allow you to access your files on the server through the Internet. There might be many other websites hosted on each server, all isolated from each other (hopefully!). The hosting company will have a very high speed connection to the Internet, so that they can cope with the thousands of requests *per second* for different webpages coming into their premises.

There are thousands of companies providing website hosting around the world, and they vary in size from small one or two person outfits to huge multinationals. How much you pay depends on the amount of storage you need, and how fast a connection to the Internet (bandwidth) you would like. Prices start from around £2 per month for 100MB storage. The author's website, **www.drivesentinel.co.uk**, is hosted on one of these minimal feature servers.

A website, as seen by a remote end user, is a collection of webpages. A webpage is nothing more than a text file stored on the server. The content of the webpage is formatted in HTML (hyper text mark-up language) which contains not only the text you want to display, but also formatting information such as font size and positioning, and also links to image files and other webpages. The HTML language has evolved significantly over the last decade and webpages can be very complex, but they don't need to be.

There are two types of webpage: static and dynamic. Static webpages are exactly as we described in the previous paragraph; simple text files, the contents of which are simply transferred to the remote web browser for display. Dynamic webpages are first parsed by the web server, additional content added to it, and then the resulting data is passed on to the browser. These days most corporate webpages accessed across the Internet are dynamic.

A program called a 'web server' performs the handling of requests for web pages, parsing the files and then returning the information to the web browser. Web servers can be very simple, and may not even support dynamic pages – in the extreme, a working web server could be written in a few hundred bytes of code.

PIC web server

Although you might think that a web server running on a PIC processor would fall into the latter category, it is in fact surprisingly complicated and can serve up dynamic content. Microchip had to take some poetic licence with the HTML standard to make it work, but the end result is a web server written in a few kilobytes of code that can allow you to write rich, dynamic, interesting webpages. We'll come onto the creation of dynamic content in a minute.

If you are unfamiliar with the process of writing webpages, it's very easy to create static pages on your computer and view them without needing a working web server. Web browsers such as Internet Explorer and Firefox can display pages stored anywhere, and that includes your own hard-drive. This is a great way to test webpages, and hone your HTML skills if you are new to the subject. Let's try a simple one.

Using notepad, write the following text:

<html>
<body>
<h1>Hello!</h1>
</body>
</html>

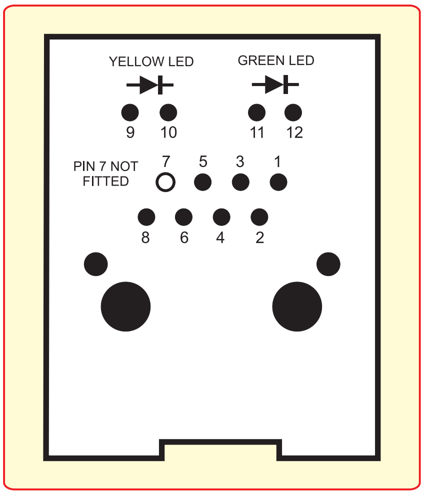


Fig.3. SI-50001 connector pinout

Now, save the file, giving it a name with the extension **.html**. For example, **C:\mypage.html**.

Now start your favourite web browser, and enter **C:\mypage.html** in the webpage address field. Your HTML file will appear. Notice that the page does not look like the text that you typed into notepad; the web browser will have converted the HTML instructions and then displayed the resulting page. So, as you can see, the web server is nothing more than a remote device that can return files back to the web browser on your PC. That's why web servers can be so simple – they really don't have to do very much! And you also have a simple method for experimenting with webpage design. If you edit the file and change the text to:

```
<html>
<body>
<h1>Goodbye!</h1>
</body>
</html>
```

Save the file, and then in your web browser just press the F5 function key to refresh the page; the new text will be displayed. Very simple.

When you connect to a web server, you typically specify just the address of the server itself, and not a file. For example:

www.drivesentinel.co.uk

By default, if a filename is not specified, the web server will automatically return the default 'home' page **index.htm**. You can place links to other pages within there. You will find the example index.html file in the webpages2 sub directory in the Microchip Solutions\TCPIP Demo App directory.

Using HTML

A tutorial on HTML is beyond the scope of this article, but there are many excellent tutorials available on the Internet (references provided at the end). So, instead we will look at the features available within the Microchip web server to allow for dynamic content, including sending control information back to the web server (to enable us to turn our relay on and off).

Microchip has created some special extensions to the HTML standard to allow dynamic information to be exchanged and acted upon. They have done this to minimise the amount of code space required – let's not forget we are using a simple PIC controller, not a PC!

There are two sources of information on how to create dynamic pages; looking at the text in the example webpages in the Webpages2 directory, and reading the help file. Both approaches are a good idea.

The help file can be accessed through the Microsoft Windows Start menu. Select **Start**, then **All Programs**, then **Microchip** followed by **TCPIP Stack v4.51** and finally **TCPIP Stack Help**. This help file covers all the advanced features of the TCPIP Stack, but we are specifically interested in the web server functionality, so select **Module APIs** followed by **HTTP2 Server**. The features section gives an interesting introduction.

Demonstration

Now we have the background information to hand, let's return – finally! – to what we wanted to demonstrate. Adding the facility to remotely switch a relay on or off.

First, let's define exactly what we want to do:

Through a webpage, protected by a username and password, we would like to display the current status of the relay (ON or OFF) and provide some kind of button to toggle the state.

Well, that was simple; but we are new to all this, so how should we proceed? By copying some existing code from the TCPIP Demo App of course!

Using the web server developed in earlier articles, fire it up and connect your web browser to it. In the home page that is displayed, click on the **Authentication** menu item on the left. A webpage is displayed explaining how protection works, and has a link at the bottom – **Access Restricted Page** – to the protected page. Note that the current username and password are displayed. This isn't needed – we are going to add our own – so let's start by deleting it.

Open up the file **Auth.htm** in the webpages2 directory (using Notepad – you will have to right-click on the file, select 'open with' and choose Notepad from the list).

Navigate to the line contain the username and password text, and delete that line completely. Save and close the file.

Now, let's follow the explanation in the webpage to change the user credentials by modifying the **HTTPVerifyAuth routine**. You will find that in the file **CustomHTTPApp.c**. We are going to change these values to 'control' and 'mike'. That gets us our protected webpage with a secret username and password.

Now for displaying the state of the LED. For this, we are going to require a dynamic variable. Once again we can cheat and copy the technique used on the home page to display the Stack build date. It's in **Index.htm**, and the line looks like this:

```
<tr><td><b>Stack Version:</b></td><td> </td><td>~version~</td></tr>
```

We are going to create a new dynamic variable called relaystate, and copy that into the **protect\Index.htm file**. The new line looks like this:

```
<tr><td><b>Relay State:</b></td><td> </td><td>~relaystate~</td></tr>
```

copy it into the webpage just under the 'Login successful' line.

Adding that new variable requires us to make a new C function that will perform the action required. This Help file explains that this routine will be called **void HTTPPrint_relaystate(void)**, and will need to be placed in the **CustomHTTPApp.c** file. It's very simple; it will output the text 'ON' if pin RA2 is set low, or OFF if not. Refer to the project source code on the *EPE* website to see this code.

Finally, we need a button to toggle the state of the relay drive pin. Once again, we look to see what examples we have. On the **Advanced Content** page there is a 'Save' button, that demonstrates posting information back to the web server. Looking up the **Form processing** section in the Help file, the description explains how to use the feature to cause the existing routine **HTTPExecutePost** to be called. We can add our toggle button handler in there, and copy the form post example from **forms.htm** into our **protect/index.html** file. See the source code for the implementation, which is just a few lines of code.

With all the edits completed, it's time to build the code. We have modified both the webpages and the source code, and it is important to build both, in the correct order. First, you must run **Convert WebPages to MPFS.bat** to create an MPFS2 file image containing the webpages. Then, using MPLAB, build the PIC project. Now you can reflash the PIC, boot it up, and then load the MPFS2 image file. If you only change static data there is no need to rebuild the PIC code – just build and upload the MPFS2 image file.

The full source code for this article can be found on the *EPE* website in the download area. Don't forget, you can view the author's version running on the Internet at **mikehibbett.dyndns.org**.

Finally

This has been a simple introduction to the subject of the Web, and we have glossed over and ignored many issues. Although it is perfectly acceptable to produce websites with simple content as defined here, even this lowly PIC web server is capable of much more, and we would encourage interested individuals to look further into the subject. Old introductory texts on HTML are an excellent starting point and libraries will be a good place to look for such books. Of course, nothing works better than just trying things out – enjoy!

References

http://www.w3schools.com/htmL/html_intro.asp

http://htmldog.com/guides/htmlbeginner/

EPE IS PLEASED TO BE ABLE TO OFFER YOU THESE

ELECTRONICS CD-ROMS

ELECTRONICS PROJECTS

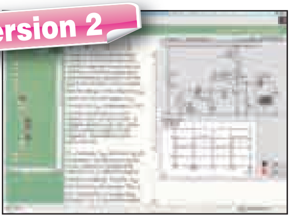

Logic Probe testing

Electronic Projects is split into two main sections: **Building Electronic Projects** contains comprehensive information about the components, tools and techniques used in developing projects from initial concept through to final circuit board production. Extensive use is made of video presentations showing soldering and construction techniques. The second section contains a set of ten projects for students to build, ranging from simple sensor circuits through to power amplifiers. A shareware version of Matrix's CADPACK **schematic capture, circuit simulation** and **p.c.b. design** software is included.

The projects on the CD-ROM are: Logic Probe; Light, Heat and Moisture Sensor; NE555 Timer; Egg Timer; Dice Machine; Bike Alarm; Stereo Mixer; Power Amplifier; Sound Activated Switch; Reaction Tester. Full parts lists, schematics and p.c.b. layouts are included on the CD-ROM.

ELECTRONIC CIRCUITS & COMPONENTS V2.0

Version 2


Circuit simulation screen

Electronics Circuits & Components V2.0 provides an introduction to the principles and application of the most common types of electronic components and shows how they are used to form complete circuits. The virtual laboratories, worked examples and pre-designed circuits allow students to learn, experiment and check their understanding. Version 2 has been considerably expanded in almost every area following a review of major syllabuses (GCSE, GNVQ, A level and HNC). It also contains both European and American circuit symbols. Sections include: ***Fundamentals***: units and multiples, electricity, electric circuits, alternating circuits. ***Passive Components***: resistors, capacitors, inductors, transformers. ***Semiconductors***: diodes, transistors, op amps, logic gates. ***Passive Circuits. Active Circuits***. *The Parts Gallery* will help students to recognise common electronic components and their corresponding symbols in circuit diagrams.

Included in the Institutional Versions are multiple choice questions, exam style questions, fault finding virtual laboratories and investigations/worksheets.

ANALOGUE ELECTRONICS

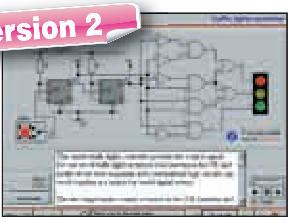

Complimentary output stage

Analogue Electronics is a complete learning resource for this most difficult branch of electronics. The CD-ROM includes a host of virtual laboratories, animations, diagrams, photographs and text as well as a SPICE electronic circuit simulator with over 50 pre-designed circuits.

Sections on the CD-ROM include: ***Fundamentals*** – Analogue Signals (5 sections),Transistors (4 sections), Waveshaping Circuits (6 sections). ***Op Amps*** – 17 sections covering everything from Symbols and Signal Connections to Differentiators. ***Amplifiers*** – Single Stage Amplifiers (8 sections), Multi-stage Amplifiers (3 sections). ***Filters*** – Passive Filters (10 sections), Phase Shifting Networks (4 sections), Active Filters (6 sections). ***Oscillators*** – 6 sections from Positive Feedback to Crystal Oscillators. ***Systems*** – 12 sections from Audio Pre-Amplifiers to 8-Bit ADC plus a gallery showing representative p.c.b. photos.

DIGITAL ELECTRONICS V2.0

Version 2


Virtual laboratory - Traffic Lights

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

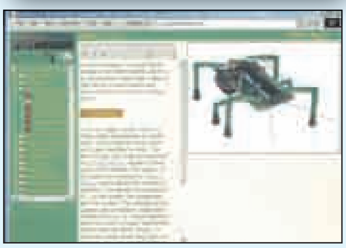
Covers binary and hexadecimal numbering systems, ASCII, basic logic gates, monostable action and circuits, and bistables – including JK and D-type flip-flops. Multiple gate circuits, equivalent logic functions and specialised logic functions. Introduces sequential logic including clocks and clock circuitry, counters, binary coded decimal and shift registers. A/D and D/A converters, traffic light controllers, memories and microprocessors – architecture, bus systems and their arithmetic logic units. Sections on Boolean Logic and Venn diagrams, displays and chip types have been expanded in Version 2 and new sections include shift registers, digital fault finding, programmable logic controllers, and microcontrollers and microprocessors. The Institutional versions now also include several types of assessment for supervisors, including worksheets, multiple choice tests, fault finding exercises and examination questions.

ANALOGUE FILTERS


Filter synthesis

Analogue 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.

ROBOTICS & MECHATRONICS


Case study of the Milford Instruments Spider

Robotics and Mechatronics is designed to enable hobbyists/students with little previous experience of electronics to design and build electromechanical systems. The CD-ROM deals with all aspects of robotics from the control systems used, the transducers available, motors/actuators and the circuits to drive them. Case study material (including the NASA Mars Rover, the Milford Spider and the Furby) is used to show how practical robotic systems are designed. The result is a highly stimulating resource that will make learning, and building robotics and mechatronic systems easier. The Institutional versions have additional worksheets and multiple choice questions.

- Interactive Virtual Laboratories
- Little previous knowledge required
- Mathematics is kept to a minimum and all calculations are explained
- Clear circuit simulations

PRICES

Prices for each of the CD-ROMs above are:
(Order form on third page)

Hobbyist/Student	£44	inc VAT
Institutional (Schools/HE/FE/Industry)	£99	plus VAT
Institutional 10 user (Network Licence)	£249	plus VAT
Site licence	£499	plus VAT

(UK and EU customers add VAT at 15% to 'plus VAT' prices)

PICmicro TUTORIALS AND PROGRAMMING

HARDWARE

VERSION 3 PICmicro MCU development board

Suitable for use with the three software packages listed below.

This flexible development board allows students to learn both how to program PICmicro microcontrollers as well as program a range of 8, 18, 28 and 40-pin devices from the 12, 16 and 18 series PICmicro ranges. For experienced programmers all programming software is included in the PPP utility that comes with the development board. For those who want to learn, choose one or all of the packages below to use with the Development Board.

- Makes it easier to develop PICmicro projects
- Supports low cost Flash-programmable PICmicro devices
- Fully featured integrated displays – 16 individual l.e.d.s, quad 7-segment display and alphanumeric l.c.d. display
- Supports PICmicro microcontrollers with A/D converters
- Fully protected expansion bus for project work
- USB programmable
- Can be powered by USB (no power supply required)

£155 including VAT and postage, supplied with USB cable and programming software

£40 OFF Buy the Development Board together with any Hobbyist/Student or Institutional versions of the software CD-ROMs listed below and take £40 off the total (including VAT) price.

SOFTWARE

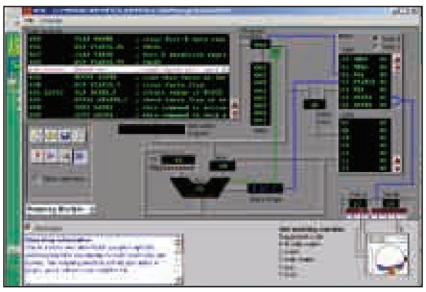
ASSEMBLY FOR PICmicro V3

(Formerly PICtutor)

Assembly for PICmicro microcontrollers V3.0 (previously known as PICtutor) by John Becker contains a complete course in programming the PIC16F84 PICmicro microcontroller from Arizona Microchip. It starts with fundamental concepts and extends up to complex programs including watchdog timers, interrupts and sleep modes.

The CD makes use of the latest simulation techniques which provide a superb tool for learning: the Virtual PICmicro micro-controller. this is a simulation tool that allows users to write and execute MPASM assembler code for the PIC16F84 microcontroller on-screen. Using this you can actually see what happens inside the PICmicro MCU as each instruction is executed which enhances understanding.

● Comprehensive instruction through 45 tutorial sections ● Includes Vlab, a Virtual PICmicro microcontroller: a fully functioning simulator ● Tests, exercises and projects covering a wide range of PICmicro MCU applications ● Includes MPLAB assembler ● Visual representation of a PICmicro showing architecture and functions ● Expert system for code entry helps first time users ● Shows data flow and fetch execute cycle and has challenges (washing machine, lift, crossroads etc.) ● Imports MPASM files.

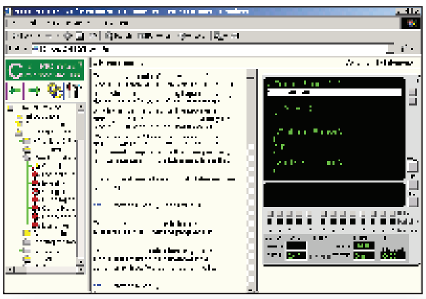


'C' FOR 16 Series PICmicro Version 4

The C for PICmicro microcontrollers CD-ROM is designed for students and professionals who need to learn how to program embedded microcontrollers in C. The CD contains a course as well as all the software tools needed to create Hex code for a wide range of PICmicro devices – including a full C compiler for a wide range of PICmicro devices.

Although the course focuses on the use of the PICmicro microcontrollers, this CD-ROM will provide a good grounding in C programming for any microcontroller.

● Complete course in C as well as C programming for PICmicro microcontrollers ● Highly interactive course ● Virtual C PICmicro improves understanding ● Includes a C compiler for a wide range of PICmicro devices ● Includes full Integrated Development Environment ● Includes MPLAB software ● Compatible with most PICmicro programmers ● Includes a compiler for all the PICmicro devices.



Minimum system requirements for these items: Pentium PC running Windows 98, NT, 2000, ME, XP; CD-ROM drive; 64MB RAM; 10MB hard disk space. Flowcode will run on XP or later operating systems

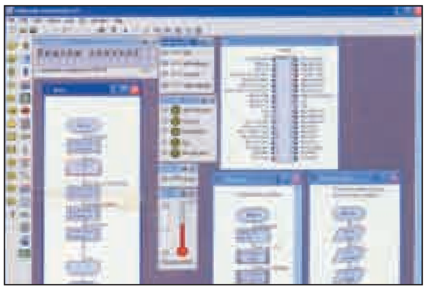
FLOWCODE FOR PICmicro V3

Flowcode is a very high level language programming system for PICmicro microcontrollers based on flowcharts. Flowcode allows you to design and simulate complex systems in a matter of minutes. A Powerful language that uses macros to facilitate the control of devices like 7-segment displays, motor controllers and l.c.d.'s. The use of macros allows you to control these devices without getting bogged down in understanding the programming.

Flowcode produces MPASM code which is compatible with virtually all PICmicro programmers. When used in conjunction with the Version 3 development board this provides a seamless solution that allows you to program chips in minutes.

● Requires no programming experience ● Allows complex PICmicro applications to be designed quickly ● Uses international standard flow chart symbols ● Full on-screen simulation allows debugging and speeds up the development process.

● Facilitates learning via a full suite of demonstration tutorials ● Produces ASM code for a range of 18, 28 and 40-pin devices ● New features in Version 3 include 16-bit arithmetic, strings and string manipulation, improved graphical user interface and printing, support for 18 series devices, pulse width modulation, I2C, new ADC component etc. The Hobbyist/Student version is limited to 4K of code (8K on 18F devices)



PRICES

Prices for each of the CD-ROMs above are:

(Order form on next page)

Hobbyist/Student	£44	inc VAT
Institutional (Schools/HE/FE/Industry)	£99	plus VAT
Institutional/Professional 10 user (Network Licence)	£300	plus VAT
Site licence	£599	plus VAT
Flowcode 10 user (Network Licence)	£350	plus VAT
Flowcode 50 user (Network Licence)	£699	plus VAT

(UK and EU customers add VAT at 15% to 'plus VAT' prices)

SPECIAL PACKAGE OFFER

TINA Pro V7 (Basic) + Flowcode V3 (Hobbyist/Student)

TINA Analogue, Digital, Symbolic, RF, MCU and Mixed-Mode Circuit Simulation, Testing and PCB Design

£50.00 inc. VAT and p&p

TINA Design Suite is a powerful yet affordable software package for analysing, designing and real time testing analogue, digital, MCU, and mixed electronic circuits and their PCB layouts. You can also analyse RF, communication, optoelectronic circuits, test and debug microcontroller applications.

Enter any circuit (up to 100 nodes) within minutes with TINA's easy-to-use schematic editor. Enhance your schematics by adding text and graphics. Choose components from the large library containing more than 10,000 manufacturer models. Analyse your circuit through more than 20 different analysis modes or with 10 high tech virtual instruments. Present your results in TINA's sophisticated diagram windows, on virtual instruments, or in the live interactive mode where you can even edit your circuit during operation.

Customise presentations using TINA's advanced drawing tools to control text, fonts, axes, line width, colour and layout. You can create, and print documents directly inside TINA or cut and paste your results into your favourite word- procesing or DTP package.

TINA includes the following Virtual Instruments: Oscilloscope, Function Generator, Multimeter, Signal Analyser/Bode Plotter, Network Analyser, Spectrum Analyser, Logic Analyser, Digital Signal Generator, XY Recorder.

***Flowcode V3** (Hobbyist/Student) – For details on Flowcode, see the previous page.*

This offer gives you two seperate CD-ROMs in DVD style cases – the software will need registering (FREE) with Designsoft (TINA) and Matrix Multimedia (Flowcode), details are given within the packages.

Get TINA + Flowcode for a total of just £50, including VAT and postage.

PROJECT DESIGN WITH CROCODILE TECHNOLOGY

An Interactive Guide to Circuit Design

Over 150 pages
Over 600 images

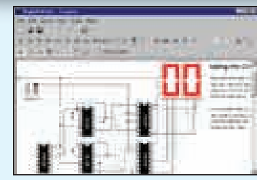
An interactive CD-ROM to guide you through the process of circuit design. Choose from an extensive range of input, process and output modules, including CMOS Logic, Op-Amps, PIC/PICAXE, Remote Control Modules (IR and Radio), Transistors, Thyristors, Relays and much more. Click Data for a complete guide to the pin layouts of i.c.s, transistors etc. Click More Information for detailed background information with many animated diagrams. Nearly all the circuits can be instantly simulated in Crocodile Technology (not included on the CD-ROM) and you can customise the designs as required.*

WHAT'S INCLUDED
Light Modules, Temperature Modules, Sound Modules, Moisture Modules, Switch Modules, Astables including 555, Remote Control (IR & Radio), Transistor Amplifiers, Thyristor, Relay, Op-Amp Modules, Logic Modules, 555 Timer, PIC/PICAXE, Output Devices, Transistor Drivers, Relay Motor Direction & Speed Control, 7 Segment Displays.Data sections with pinouts etc., Example Projects, Full Search Facility, Further Background Information and Animated Diagrams.
Runs in Microsoft Internet Explorer
All circuits can be viewed, but can only be simulated if your computer has Crocodile Technoloy version 410 or later. A free trial version of Crocodile Technology can be downloaded from: **www.crocodile-clips.com. Animated diagrams run without Crocodile Technology.*

Single User £39.00 inc. VAT.
Multiple Educational Users (under 500 students) £59.00 plus VAT. Over 500 students £79.00 plus VAT.
(UK and EU customers add VAT at 15% to "plus VAT" prices)

Minimum system requirements for these CD-ROMs: Pentium PC, CD-ROM drive, 32MB RAM, 10MB hard disk space. Windows 95/98/NT/2000/ME/XP, mouse, sound card, web browser.

DIGITAL WORKS 3.0



Counter project

Digital Works Version 3.0 is a graphical design tool that enables you to construct digital logic circuits and analyze their behaviour. It is so simple to use that it will take you less than 10 minutes to make your first digital design. It is so powerful that you will never outgrow its capability ● Software for simulating digital logic circuits ● Create your own macros – highly scalable ● Create your own circuits, components, and i.c.s ● Easy-to-use digital interface ● Animation brings circuits to life ● Vast library of logic macros and 74 series i.c.s with data sheets ● Powerful tool for designing and learning.

Hobbyist/Student £44 inc. VAT.
Institutional £99 plus VAT.
Institutional 10 user £249 plus VAT.
Site Licence £599 plus VAT.

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).

Now contains Irfan View image software for Windows, with quick-start notes included.

Price **£19.95** inc. VAT

Please send me: CD-ROM ORDER FORM

☐ Electronic Projects
☐ Electronic Circuits & Components V2.0
☐ Analogue Electronics
☐ Digital Electronics V2.0
☐ Analogue Filters
☐ Electronics CAD Pack
☐ Robotics & Mechatronics
☐ Assembly for PICmicro V3
☐ 'C' for 16 Series PICmicro V4
☐ Flowcode V3 for PICmicro
☐ Digital Works 3.0

Version required:
☐ Hobbyist/Student
☐ Institutional
☐ Institutional/Professional 10 user
☐ Site licence

☐ PICmicro Development Board V3 (hardware)

☐ TINA Pro V7 Basic + Flowcode V3 Hobbyist/Student
☐ Electronic Components Photos; Version 1.1
☐ Project Design – Single User
☐ Project Design – Multiple User (under 500 students)
☐ Project Design – Multiple User (over 500 students)

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/Maestro: £ . . . .
Valid From: . . . . Card expiry date: . . . .
Card No: . . . . Maestro Issue No. . . . .
Card Security Code . . . . (The last 3 digits on or just under the signature strip)

ORDERING
ALL PRICES INCLUDE UK POSTAGE

Student/Single User/Standard Version price includes postage to most countries in the world EU residents outside the UK add £5 for airmail postage per order

Institutional, Multiple User and Deluxe Versions – overseas readers add £5 to the basic price of each order for airmail postage (**do not add VAT** unless you live in an EU (European Union) country, then add 15% VAT or provide your official VAT registration number).

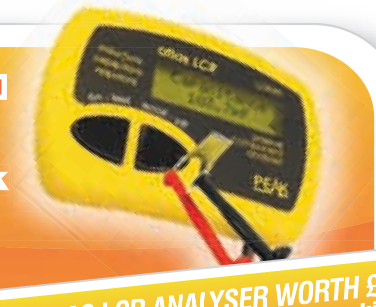
Send your order to:
Direct Book Service
Wimborne Publishing Ltd
Sequoia House, 398a Ringwood Road
Ferndown, Dorset BH22 9AU
To order by phone ring
01202 873872. Fax: 01202 874562
Goods are normally sent within seven days
E-mail: orders@wimborne.co.uk
Online shop:
www.epemag.com

READOUT

Email: editorial@wimborne.co.uk

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

All letters quoted here have previously been replied to directly



WIN AN ATLAS LCR ANALYSER WORTH £79

An Atlas LCR Passive Component Analyser, kindly donated by Peak Electronic Design Ltd, will be awarded to the author of the Letter Of The Month. The Atlas LCR automatically measures inductance from 1mH to 10H, capacitance from 1pF to 10,000µF and resistance from 1Ω to 2MΩ with a basic accuracy of 1%. www.peakelec.co.uk

★ LETTER OF THE MONTH ★

Capacitors must be preheated before soldering

Dear EPE

I read with interest 'How to manually solder SMD parts'. A sub-section of your project entitled *100:1 UHF Prescaler for Frequency Counters*. (Jan '09 issue)

I just want to bring to the attention of the author and readers that this project contains two 1206 SMD capacitor chips. And these cannot be treated the same as all other semiconductors when it comes to soldering.

The use of soldering irons can be very damaging to ceramic chip capacitors due to its direct application of a high temperature to the chip's room temperature leads, setting up unequal temperature conditions within the chip. This results in unacceptable cracking/fissuring of the SMD. At best, a crack will affect a capacitor's value; at worst, it will destroy the capacitor.

There are three possible solutions:

1. The board (PCB) and the capacitor should be pre-heated to at least 100ºC for just over a minute – an ordinary cooking oven is fine. Commercial heaters are available, but are an unnecessary expense

2. The hot air pencil, with its convective nature, essentially eliminates this problem altogether. It is used together with paste (solder) that assists in holding the component in place while soldering (my preference)

3. Reflow oven, an even better alternative, but very much more expensive.

Furthermore use 'no clean' flux on the leads before soldering to assist with solder flow.

Peter Barrett MIEAust, via email

Many thanks for the tips Peter – I like the oven solution (not microwave of course).

Writing on PCBs/quartz watch calibration

Dear EPE

For *Writing on PCBs* (Jan '09 *Readout*), as requested by James Garner, try the very fine indelible black felt-tip pen Edding 8404 – approved by the aerospace industry for inscribing its products. Is this wonderful aviation-approved device an expensive item that's hard to obtain? Just £1.62 plus VAT from CPC (their part LM00372). Small orders also attract a carriage charge. This company is a member of the Farnell group, they don't quite manage the same wide choice of alternatives for each type of electronic component, but their range of different product sectors is enormous and might satisfy James' needs for electronics

hand-tools, including soldering. Contact them by phone: 08701 202530, or view items on-line at: **www.cpc.co.uk**.

Prompted by *Calibrating quartz watches* (also Jan '09 *Readout*), I might have a useful starting-point for Adam Cromarty. Simply applying a telephone pickup coil (CPC part AR71814) as illustrated in the accompanying photo. It was sufficient to see one-per-second electrical 'ticks' from the stepper of my watch on an oscilloscope with the timebase at a very slow setting.

Could a purpose-wound coil, perhaps on a ferrite slug culled from a radio's intermediate-frequency transformer, pick up the master oscillator if the watch were to be opened up to allow access? Alternatively, how about a direct connection feeding an extremely high-impedance op amp to buffer and amplify the signal?

These suggestions could be an experimental starting-point. Note, though, that any attempt to measure the frequency of an oscillator will actually alter that frequency because the oscillator is 'pulled' by the load represented by the measuring probe. Severe loading can even temporarily stop the oscillations. Watch oscillators run at tiny power levels, so I don't know how significant the effect would be.

Godfrey Manning, G4GLM, via email

Basic Soldering Guide

Dear EPE

These days, with abundant Internet information, it's not all that hard to find out about something if you look hard enough. I have been looking (off and on) for the last year or so for a decent soldering guide, and a friend pointed me to your article.

This is a bit embarrassing to admit, but I own a small computer repair shop, and I am not brilliant at soldering. This is merely because I have never been shown how to correctly do it. Not from a lack of trying or trying to find out, but there is literally no place (within driving distance) that even teaches soldering and electronics where I could go to learn. The USA is large, but, that can be a hindrance when you want to learn something, and the nearest place to learn is a large city hours away.

Thankfully, soldering is not really required in computer repairs, as these days it is mainly component replacement, so I've been able to skate along for the last 20 years or so, even with my shortcomings. However, thanks to your online article, I now have a much clearer understanding of basic soldering, which will help me greatly at the office and at home, where I build science fiction models and like to insert lighting into my projects. I am still limited in actual component-level electronics, but I can live with that until I find a solution there as well.

I just wanted to take a moment to write and thank you for a very comprehensive, well-written and illustrated guide that you have thoughtfully shared with those of us who go looking to learn.

I have tried soldering again, with a much higher level of success now that I have read your articles, and I have printed them out and saved them (in several locations) as they are literally a gold mine.

Thank you again, for providing such an excellent free resource.

Henry Prentiss, via email, Maryland, US

Alan responded by email:

Dear Mr Prentiss

I was delighted to receive your comments and I am really pleased that my Basic Soldering Guide *proved helpful. You are not alone in wanting to learn more about the art of soldering. I started at a very early age so the technique comes entirely naturally to me, but I appreciate how difficult it is to learn from scratch, especially if no local educational resources are available.*

I enjoy reading many interesting questions and messages from all manner of visitors, including US Marines trainees, the US Air Force based in Italy, the US Coastguard, and all kinds of industrial and education centres around the world who enjoyed getting started in soldering aided by my guide.

I do intend to update the soldering guide, as it's very old now. I also handle some soldering-related product reviews, and I am writing some new project-building guides as well, so I have a lot to keep me busy this year.

As regards your potential interest in components and electronics, I work for EPE *magazine at* ***www.epemag.com****, which is among the world's largest hobby electronics magazines. A downloadable monthly version is available, and you can join in our free forum at* **www.chatzones.co.uk***, which is under my personal moderation. There you will meet many like-minded electronics enthusiasts, all eager to help.*

My advice would be to buy a very simple kit (including ready-made PCB) with full instructions and try practising soldering on that. If you are more resourceful, then you could consider constructing a magazine project using the assembly details supplied in each project's article. For example, we usually produce some Christmas decoration designs based on LEDs and controlled by microcontrollers that you might enjoy building for next year.

Once again, I really appreciated your feedback and I hope that you will derive much benefit and satisfaction from undertaking more soldering assignments over time as your confidence continues to grow.

Alan Winstanley, On-line Editor

PIC web server

Dear EPE

I am following with great interest the *PIC N' Mix* article on how to build a PIC web server (*EPE* Feb '09) – and hoping to build one myself.

I couldn't help but notice when it mentioned 'the computer user's 192.168.62.62 as a gateway', that the screen shot (Fig. 1 in the article) shows the IP address 192.168.62.62 is actually the PC's network interface. The gateway/router (which you can reach on that interface) has the private IP address of 192.168.62.1.

Mike Hibbett's nifty article mentions that the router's public IP address is often dynamic and thus changes if the router needs to reconnect. I thought it was worth mentioning that most home Ethernet routers have a default setting to give out dynamic private IP addresses too – which is useful to note if you have more than one PC using the router.

Assuming you want a static private IP address for your PIC web server, which doesn't conflict with any private dynamic ones the router might use, you'll want to check which addresses the router will use.

The routers settings for private dynamic IP addresses are often found under 'DHCP server', maybe in a section called LAN, 'Advanced' or 'Home Network'. An example might be where a router has the private IP 192.168.62.1 and gives out dynamic addresses from 192.168.62.60 to 192.168.62.254 (ie, 'DHCP range'). So an IP address from 192.168.62.2 to 192.168.62.59 should be OK to use as a private IP address for the PIC web server. Hope that helps.

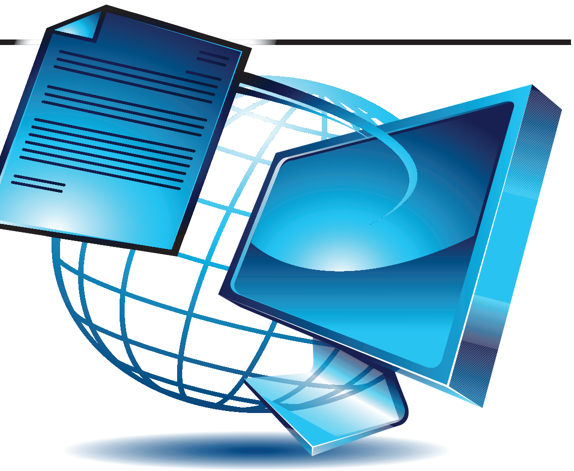
Diggory Gray, Bristol, UK

Mike Hibbett replies:

Thanks for the comments Diggory, and apologies for the typo's in the article. You are correct, of course, and make some very useful points. I avoided going into too much detail of DHCP in the articles as I wanted to keep things fairly high level. TCP/IP can quickly become rather complicated!

The final Pic N' Mix *Ethernet instalment (for the time being) is elsewhere in this issue and I have referred the readers to your letter for your comments on DHCP.*

Mike Hibbett



Net Work

Alan Winstanley

Net Work is our regular column specially written to help *EPE* readers get more out of the Internet. Remember to check out my *Net Work* add-on blog on the *EPE* Online portal website at **www.epemag.com**, which also has all relevant links readymade for you to click on. Fellow contributor Mike Hibbett's *Pic n Mix* blog has recently been launched on *EPE* Online as well.

Last month, I mused on how I decided the time was ripe to unshackle myself from my office PC, so I upgraded my mobile phone to an HTC Tytn II, which has Windows Mobile 6.1 pre-installed along with a portable version of Microsoft Office and Adobe Reader. Apart from fetching mail when out and about, I could now read and write Word documents on the move, ponder Excel spreadsheets and open PDFs directly. If I used Outlook on my PC, I could synchronise with the Outlook address book as well, and there are also options available for 'pushing' email onto the phone, Blackberry-style.

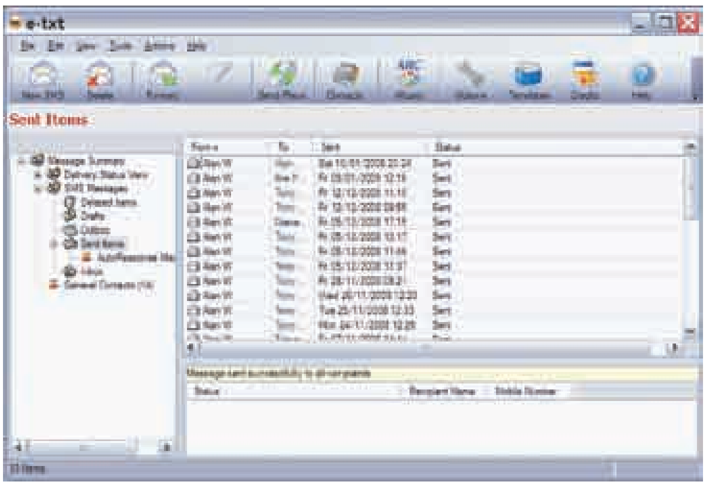
All that is needed to enjoy my new-found freedom is, of course, some mobile connectivity. I can input into the phone the network keys of known networks and connect via wifi when in range, thereby avoiding the phone provider's data transfer costs. Bear in mind the gruesome case of the user who accrued over £30,000 of mobile data costs because they mistakenly used their GPRS data tariff to download gigabytes' worth of TV programmes, rather than connect via a free hotspot or wifi connection.

On the WiFi radar

When I'm stuck in a wifi no-man's land of some High Street or other, a fun way of locating an open wireless connection is to use Pocket WiFi Radar from Makayama. This Windows Mobile software offers a radar screen display (with sound effects) that scans for all available wifi connections. Inaccessible ones generate a red blip on-screen, but a green blip denotes an open connection: you can tap the stylus on the blip for more connection data.

Pocket WiFi Radar can connect automatically to any open hotspots, though discretion may be needed to ensure that insecure bandwidth is not being accessed illegally. It also claims to connect to your secured access point back at the office, but there is some small print: after struggling I found it was only compatible with the older WEP standard – it could not connect to my WPA-protected wireless router, after which I had to restart the phone to enable the built-in connection manager.

Nevertheless, out on the road, Pocket WiFi Radar is a useful little program that may help you pinpoint a suitable connection. Versions for both touch-screen and non-touch screen devices can be downloaded for $14.95 (£12 approx.) from **www.makayama.com/pocketwifiradar.html**. Check out the rest of their interesting smartphone and iPhone range too.



E-Txt from Dynmark enables SMS messages to be sent direct from a PC, or as an email. See Net Work *on* **www.epemag.com** *for more screenshots and clickable hyperlinks*

Time 2 Txt U

Back in the days of expensive contract phones, SMS was a seldom-used business service, but today text messages are a universal way of communicating, and they are frequently more convenient than using email. As we all know, a texting teenager and their mobile phone are inseparable, although many traditionalists look upon the spelling brevity of text messages with some depair!

If I need to get a brief message directly to, say, a technician on-site, then sending a text is an obvious route. When I contacted the local electricity board concerning a power cut, they sent a text message immediately with an update followed by another text confirming the power had been restored. British Telecom also did an excellent job of updating me about a faulty phone line, via text messaging.

Instead of being faced with a messy heap of incoming text messages, though, Windows Mobile 6.1 offers 'threaded' SMS management, sorting texts into chatzone-style conversations that can be followed readily. Text messages can also be sent from the desktop when you are back at the office. While the Tytn II and other mobile phones incorporate a usable sliding keypad (and the Tytn II has remarkable stylus-driven handwriting recognition too), it is easy enough to send text messages to recipients via the Internet, or send an SMS direct from a PC in the form of an outbound email, without struggling with a mobile phone's keypad.

For several years I have used E-Txt by Dynmark International, which allows me to text via the Internet using my PC when my mobile phone isn't to hand. The price of this convenience is that each message costs a 'credit', which is pre-purchased in batches costing between 4p and 7p each, plus VAT. Many mobile phone tariffs have a free text allowance, so if cost is an issue then this service is not for you.

Depending what mode I'm working in, I can send a traditional SMS using E-Txt's text message software, or I can handle it in the form of an email, with the To: address being [recipients phone number]@e-txt.co.uk. The usual SMS restrictions apply: an email must not exceed a maximum of 160 characters (you can choose to split it across several texts) and the Subject line of your email is ignored.

Other options that E-Txt provide include creating a bulk SMS message shot, acquiring your own 'mobile' incoming number to separate the E-Txt service from your regular mobile phone, or creating a Text Shortcode with keyword (you know the sort of thing: text 'EPEISGR8' to 67890) as a chargeable extra. You can download the software and purchase credits from **www.e-txt.com**. An alternative supplier is Bulk SMS, see **www.bulksms.com**, which has not been tried by the writer and has an altogether more complicated tariff.

Don't forget to check the *EPE* Online portal website at **www.epemag.com** for bonus material supporting *Net Work* and *Pic n Mix*. You can email Alan at **alan@epemag.demon.co.uk**

Electronics Teach-In + FREE CD-ROM

Mike Tooley

A broad-based introduction to electronics – find out how circuits work and what goes on inside them. Plus 15 easy-to-build projects. The 152 page A4 book comes with a free CD-ROM containing the whole Teach-In 2006 series (originally published in *EPE*) in PDF form, interactive quizzes to test your knowledge, TINA circuit simulation software (a limited version – plus a specially written TINA Tutorial), together with simulations of the circuits in the Teach-In series, plus Flowcode (a limited version) a high level programming system for PIC microcontrollers based on flowcharts.

The Teach-In series covers everything from Electric Current through to Microprocessors and Microcontrollers and each part includes demonstration circuits to build on breadboards or to simulate on your PC.

In addition to the Teach-In series, the book includes 15 CMOS-based simple projects from the Back-To-Basics series by Bart Trepak, these are: Fridge/Freezer Alarm, Water Level Detector, Burglar Alarm, Scarecrow, Digital Lock, Doorchime, Electronic Dice, Kitchen Timer, Room Thermometer, Daily Reminder, Whistle Switch, Parking Radar, Telephone Switch, Noughts and Crosses Enigma and a Weather Vane. There is also a MW/LW Radio project in the Teach-In series.

152 pages + CD-ROM **Order code ETI** **£8.50**

ROBOTICS

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. Then explains in simple terms how the "brain" of the robot may be programmed on screen using a PC and "zapped" to the robot over an infra-red link. Also, shows how a more sophisticated Windows programming language such as Visual BASIC may be used to control the robots.

Detailed building and programming instructions provided, including numerous step-by-step photographs.

288 pages - large format **Order code BP901** **£14.99**

MORE ADVANCED ROBOTICS WITH LEGO MINDSTORMS – Robert Penfold

Shows the reader how to extend the capabilities of the brilliant Lego Mindstorms Robotic Invention System (RIS) by using lego's own accessories and some simple home constructed units. You will be able to build robots that can provide you with 'waiter service' when you clap your hands, perform tricks, 'see' and avoid objects by using 'bats radar', or accurately follow a line marked on the floor. Learn to use additional types of sensors including rotation, light, temperature, sound and ultrasonic and also explore the possibilities provided by using an additional (third) motor. For the less experienced, RCX code programs accompany most of the featured robots. However, the more adventurous reader is also shown how to write programs using Microsoft's VisualBASIC running with the ActiveX control (Spirit.OCX) that is provided with the RIS kit.

Detailed building instructions are provided for the featured robots, including numerous step-by-step photographs. The designs include rover vehicles, a virtual pet, a robot arm, an 'intelligent' sweet dispenser and a colour conscious robot that will try to grab objects of a specific colour.

198 pages **Order code BP902** **£14.99**

ANDROIDS, ROBOTS AND ANIMATRONS
Second Edition – John Iovine

Build your own working robot or android using both off-the-shelf and workshop constructed materials and devices. Computer control gives these robots and androids two types of artificial intelligence (an expert system and a neural network). A lifelike android hand can be built and programmed to function doing repetitive tasks. A fully animated robot or android can also be built and programmed to perform a wide variety of functions.

The contents include an Overview of State-of-the-Art Robots; Robotic Locomotion; Motors and Power Controllers; All Types of Sensors; Tilt; Bump; Road and Wall Detection; Light; Speech and Sound Recognition; Robotic Intelligence (Expert Type) Using a Single-Board Computer Programmed in BASIC; Robotic Intelligence (Neutral Type) Using Simple Neural Networks (Insect Intelligence); Making a Lifelike Android Hand; A Computer-Controlled Robotic Insect Programmed in BASIC; Telepresence Robots With Actual Arcade and Virtual Reality Applications; A Computer-Controlled Robotic Arm; Animated Robots and Androids; Real-World Robotic Applications.

224 pages **Order code MGH1** **£16.99**

DIRECT BOOK SERVICE

The books listed have been selected by *Everyday Practical Electronics* editorial staff as being of special interest to everyone involved in electronics and computing. They are supplied by mail order direct to your door. Full ordering details are given on the last book page.

FOR A FURTHER SELECTION OF BOOKS SEE THE NEXT TWO ISSUES OF *EPE*

All prices include UK postage

RADIO

BASIC RADIO PRINCIPLES AND TECHNOLOGY
Ian Poole

Radio technology is becoming increasingly important in today's high technology society. There are the traditional uses of radio which include broadcasting and point to point radio as well as the new technologies of satellites and cellular phones. All of these developments mean there is a growing need for radio engineers at all levels.

Assuming a basic knowledge of electronics, this book provides an easy to understand grounding in the topic.

Chapters in the book: Radio Today, Yesterday, and Tomorrow; Radio Waves and Propagation; Capacitors, Inductors, and Filters; Modulation; Receivers; Transmitters; Antenna Systems; Broadcasting; Satellites; Personal Communications; Appendix – Basic Calculations.

263 pages **Order code NE30** **£20.00**

PROJECTS FOR RADIO AMATEURS AND S.W.L.S.
R. A. Penfold

This book describes a number of electronic circuits, most of which are quite simple, which can be used to enhance the performance of most short wave radio systems.

The circuits covered include: An aerial tuning unit; A simple active aerial; An add-on b.f.o. for portable sets; A wavetrap to combat signals on spurious responses; An audio notch filter; A parametric equaliser; C.W. and S.S.B. audio filters; Simple noise limiters; A speech processor; A volume expander.

Other useful circuits include a crystal oscillator, and RTTY/C.W. tone decoder, and a RTTY serial to parallel converter. A full range of interesting and useful circuits for short wave enthusiasts.

92 pages **Order code BP304** **£4.45**

AN INTRODUCTION TO AMATEUR RADIO
I. D. Poole

Amateur radio is a unique and fascinating hobby which has attracted thousands of people since it began at the turn of the last century. This book gives the newcomer a comprehensive and easy to understand guide through the subject so that the reader can gain the most from the hobby. It then remains an essential reference volume to be used time and again. Topics covered include the basic aspects of the hobby, such as operating procedures, jargon and setting up a station. Technical topics covered include propagation, receivers, transmitters and aerials etc.

150 pages **Order code BP257** **£5.49**

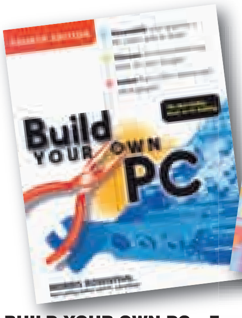
COMPUTERS AND COMPUTING

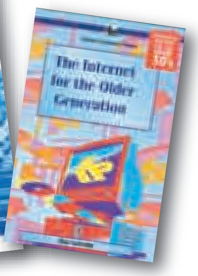
THE INTERNET FOR THE OLDER GENERATION
Jim Gatenby

Especially written for the over 50s. Uses only clear and easy-to-understand language. Larger type size for easy reading. Provides basic knowledge to give you confidence to join the local computer class.

This book explains how to use your PC on the Internet and covers amongst other things: Choosing and setting up your computer for the Internet. Getting connected to the Internet. Sending and receiving emails, photographs, etc., so that you can keep in touch with family and friends all over the world. Searching for and saving information on any subject. On-line shopping and home banking. Setting up your own simple web site.

228 pages **Order code BP600** **£8.99**





BUILD YOUR OWN PC – Fourth Edition
Morris Rosenthal

More and more people are building their own PCs. They get more value for their money, they create exactly the machine they want, and the work is highly satisfying and actually fun. That is, if they have a unique beginner's guide like this one, which visually demonstrates how to construct a computer from start to finish.

Through 150 crisp photographs and clear but minimal text, readers will confidently absorb the concepts of computer building. The extra-big format makes it easy to see what's going on in the pictures. The author goes 'under the hood' and shows step-by-step how to create a Pentium 4 computer or an Athlon 64 or Athlon 64FX, covering: What first-time builders need to know; How to select and purchase parts; How to assemble the PC; How to install Windows XP. The few existing books on this subject, although outdated, are in steady demand. This one delivers the expertise and new technology that fledgling computer builders are looking for.

224 pages - large format **Order code MGH2** **£16.99**

THE PIC MICROCONTROLLER YOUR PERSONAL INTRODUCTORY COURSE – THIRD EDITION
John Morton

Discover the potential of the PIC microcontroller through graded projects – this book could revolutionise your electronics construction work!

A uniquely concise and practical guide to getting up and running with the PIC Microcontroller. The PIC is one of the most popular of the microcontrollers that are transforming electronic project work and product design.

Assuming no prior knowledge of microcontrollers and introducing the PICs capabilities through simple projects, this book is ideal for use in schools and colleges. It is the ideal introduction for students, teachers, technicians and electronics enthusiasts. The step-by-step explanations make it ideal for self-study too: this is not a reference book – you start work with the PIC straight away.

The revised third edition covers the popular reprogrammable Flash PICs: 16F54/16F84 as well as the 12F508 and 12F675.

270 pages **Order code NE36** **£20.99**

PROGRAMMING 16-BIT PIC MICROCONTROLLERS IN C – LEARNING TO FLY THE PIC24
Lucio Di Jasio (Application Segments Manager, Microchip, USA)

FREE CD-ROM

A Microchip insider tells all. Focuses on examples and exercises that show how to solve common, real-world design problems quickly. Includes handy checklists to help readers perform the most common programming and debugging tasks. FREE CD-ROM includes source code in C, the Microchip C30 compiler, and MPLAB SIM software, so that readers gain practical, hands-on programming experience.

Until recently, PICs didn't have the speed and memory necessary for use in designs such as video- and audio-enabled devices. All that changed with the introduction of the 16-bit PIC family, the PIC24. This new guide teaches readers everything they need to know about the architecture of these chips, how to program them, how to test them and how to debug them. Lucio's common-sense, practical, hands-on approach starts out with basic functions and guides the reader step-by-step through even the most sophisticated programming scenarios.

Experienced PIC users and newcomers alike will benefit from the text's many thorough examples, which demonstrate how to nimbly side-step common obstacles and take full advantage of all the 16-bit features.

496 pages +CD-ROM **Order code NE45** **£32.99**

THEORY AND REFERENCE

ELECTRONIC CIRCUITS – FUNDAMENTALS & APPLICATIONS
Third Edition
Mike Tooley

A comprehensive reference text and practical electronics handbook in one volume – at an affordable price!

New chapter on PIC microcontrollers – the most popular chip family for use in project work by hobbyists and in colleges and universities.

New companion website: spreadsheet design tools to simplify circuit calculations; circuit models and templates to enable virtual simulation; a bank of on-line questions for lecturers to set as assignments, and on-line self-test multiple choice questions for each chapter with automatic marking, to enable students to continually monitor their progress and understanding.

The book's content is matched to the latest pre-degree level courses, making this an invaluable reference for all study levels, and its broad coverage is combined with practical case studies, based in real-world engineering contexts throughout the text.

The unique combination of a comprehensive reference text, incorporating a primary focus on practical applications, ensures this text will prove a vital guide for students and also for industry-based engineers, who are either new to the field of electronics, or who wish to refresh their knowledge.

400 pages **Order code NE43** **£23.99**

BEBOP TO THE BOOLEAN BOOGIE
Third Edition
Clive (Max) Maxfield

BOOK + CD-ROM

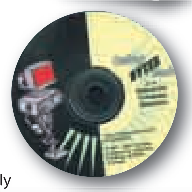
This book gives the "big picture" of digital electronics. This indepth, highly readable, guide shows you how electronic devices work and how they're made. You'll discover how transistors operate, how printed circuit boards are fabricated, and what the innards of memory ICs look like. You'll also gain 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. The author's tongue-in-cheek humour makes it a delight to read, but this is a REAL technical book, extremely detailed and accurate. Comes with a free CD-ROM which contains an eBook version with full text search plus bonus chapter – An Illustrated History of Electronics and Computing.

Contents: Fundamental concepts; Analog versus digital; Conductors and insulators; Voltage, current, resistance, capacitance and inductance; Semiconductors; Primitive logic functions; Binary arithmetic; Boolean algebra; Karnaugh maps; State diagrams, tables and machines; Analog-to-digital and digital-to-analog; Integrated circuits (ICs); Memory ICs; Programmable ICs; Application-specific integrated circuits (ASICs); Circuit boards (PWBs and DWBs); Hybrids; Multichip modules (MCMs); Alternative and future technologies.

500 pages **Order code BEB1** **£32.95**

BEBOP BYTES BACK (and the Beboputer Computer Simulator) CD-ROM
Clive (Max) Maxfield and Alvin Brown

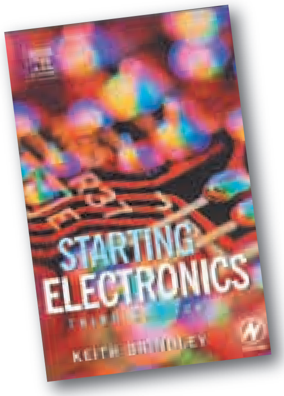
CD-ROM



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 CD-ROM contains a virtual microcomputer, simulating the motherboard and standard computer peripherals in an extremely realistic manner. In addition to a wealth of technical information, myriad nuggets of trivia, and hundreds of carefully drawn illustrations, the CD-ROM contains a set of lab experiments for the virtual microcomputer that let you recreate the experiences of early computer pioneers. if you're the slightest bit interested in the inner workings of computers, then don't dare to miss this!

Over 800 pages in Adobe Acrobat format

CD-ROM **Order code BEB2 CD-ROM** **£21.95**



FUNDAMENTAL ELECTRICAL AND ELECTRONIC PRINCIPLES
Third Edition
C. R. Robertson

Covers the essential principles that form the foundations for electrical and electronic engineering courses. The coverage of this new edition has been carefully brought in line with the core unit 'Electrical and Electronic Principles' of the 2007 BTEC National Engineering specification. This qualification from Edexcel attracts more than 10,000 students per year.

The book explains all theory in detail and backs it up with numerous worked examples. Students can test their understanding with end of chapter assignment questions for which answers are provided. In this new edition, the layout has been improved and colour has been added. A free companion website with additional worked examples and chapters is also available.

368 pages **Order code NE47** **£21.95**

STARTING ELECTRONICS
Third Edition
Keith brindley

A punchy practical introduction to self-build electronics. The ideal starting point for home experimenters, technicians and students who want to develop the real hands-on skills of electronics construction.

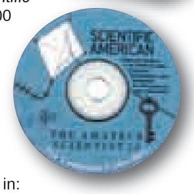
A highly practical introduction for hobbyists, students, and technicians. Keith Brindley introduces readers to the functions of the main component types, their uses, and the basic principles of building and designing electronic circuits.

Breadboard layouts make this very much a ready-to-run book for the experimenter, and the use of multimeter, but not oscilloscopes, and readily available, inexpensive components makes the practical work achievable in a home or school setting as well as a fully equiped lab.

288 pages **Order code NE42** **£12.99**

THE AMATEUR SCIENTIST CD-ROM – VERSION 2

CD-ROM



The complete collection of The Amateur Scientist articles from *Scientific American* magazine. Over 1,000 classic science projects from a renowned source of winning projects. All projects are rated for cost, difficulty and possible hazards. Plus over 1,000 pages of helpful science techniques that never appeared in *Scientific American*.

Exciting science projects in: Astronomy; Earth Science; Biology; Physics; Chemistry; Weather . . . and much more! The most complete resource ever assembled for hobbyists, and professionals looking for novel solutions to research problems. Includes extensive Science Software Library with even more science tools. Suitable for Mac, Windows, Linux or UNIX. 32MB RAM minimum, Netscape 4.0 or higher or Internet Explorer 4.0 or higher. Over 1,000 projects.

CD-ROM **Order code ASI CD-ROM** **£19.95**

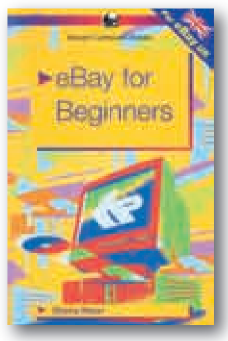
eBAY FOR BEGINNERS
Cherry Nixon

There are two kinds of people, those who are trading on eBay and the rest who are missing out. Though eBay has been embraced by entrepreneurs all over the world, it remains the peoples' site and offers the largest market for the smallest fee.

eBay presents an opportunity for everyone, the trick is to master it. This book shows you how to start trading on eBay UK. It also offers advice on getting organised and tips to put you ahead.

The book has been developed from Cherry's popular hands-on course "Buying and Selling on eBay for Technological Simpletons". In addition to fully explaining eBay and how to trade on it there are sections on Paypal, producing pictures of your sale items, fees and accounts, safety and security, including what to do when things go wrong and what protection is provided.

178 pages **Order code BP551** **£8.99**



MUSIC, AUDIO AND VIDEO

MAKING MUSIC WITH YOUR COMPUTER
Stephen Bennett

Nearly everyone with musical aspirations also has a computer. This same computer can double as a high quality recording studio capable of producing professional recordings. This book tells you what software and hardware you will need to get the best results.

You'll learn about recording techniques, software and effects, mixing, mastering and CD production.

Suitable for PC and Mac users, the book is full of tips, "how to do" topics and illustrations. It's the perfect answer to the question "How do I use my computer to produce my own CD?"

92 pages **Order code PC120** **£10.95**

QUICK GUIDE TO MP3 AND DIGITAL MUSIC
Ian Waugh

MP3 files, the latest digital music format, have taken the music industry by storm. What are they? Where do you get them? How do you use them? Why have they thrown record companies into a panic? Will they make music easier to buy? And cheaper? Is this the future of music?

All these questions and more are answered in this concise and practical book which explains everything you need to know about MP3s in a simple and easy-to-understand manner. It explains:

How to play MP3s on your computer; How to use MP3s with handheld MP3 players; Where to find MP3s on the Web; How MP3s work; How to tune into Internet radio stations; How to create your own MP3s; How to record your own CDs from MP3 files; Other digital audio music formats.

Whether you want to stay bang up to date with the latest music or create your own MP3s and join the on-line digital music revolution, this book will show you how.

60 pages **Order code PC119** **£7.45**

VIDEO PROJECTS FOR THE ELECTRONICS CONSTRUCTOR
R. A. Penfold

Written by highly respected author R. A. Penfold, this book contains a collection of electronic projects specially designed for video enthusiasts. All the projects can be simply constructed, and most are suitable for the newcomer to project construction, as they are assembled on stripboard.

There are faders, wipers and effects units which will add sparkle and originality to your video recordings, an audio mixer and noise reducer to enhance your soundtracks and a basic computer control interface. Also, there's a useful selection on basic video production techniques to get you started.

Complete with explanations of how the circuit works, shopping lists of components, advice on construction, and guidance on setting up and using the projects, this invaluable book will save you a small fortune.

Circuits include: video enhancer, improved video enhancer, video fader, horizontal wiper, improved video wiper, negative video unit, fade to grey unit, black and white keyer, vertical wiper, audio mixer, stereo headphone amplifier, dynamic noise reducer, automatic fader, pushbutton fader, computer control interface, 12 volt mains power supply.

124 pages **Order code PC115** ~~£10.95~~ **£5.45**

ALL PRICES INCLUDE UK POST & PACKING

DATA AND DESIGN

PRACTICAL ELECTRONIC FILTERS
Owen Bishop
This book deals with the subject in a non-mathematical way. It reviews the main types of filter, explaining in simple terms how each type works and how it is used.
The book also presents a dozen filter-based projects with applications in and around the home or in the constructor's workshop. These include a number of audio projects such as a rythm sequencer and a multi-voiced electronic organ.
Concluding the book is a practical step-by-step guide to designing simple filters for a wide range of purposes, with circuit diagrams and worked examples.

88 pages **Order code BP299** **£5.49**

DIGITAL LOGIC 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 explaination of microprocessor techniques as applied to digital logic.

200 pages **Order code PC106** **£9.95**

A BEGINNER'S GUIDE TO TTL DIGITAL ICs
R. A. Penfold
This book first covers the basics of simple logic circuits in general, and then progresses to specific TTL logic integrated circuits. The devices covered include gates, oscillators, timers, flip/flops, dividers, and decoder circuits. Some practical circuits are used to illustrate the use of TTL devices in the "real world".

142 pages **Order code BP332** **£5.45**

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** **£25.99**

RADIO BYGONES

We also carry a selection of books aimed at readers of *EPE*'s sister magazine on vintage radio *Radio Bygones*. These books include Jonathan Hill's excellent Radio Radio, a comprehensive book with hundreds of photos depicting the development of the British wireless set up to the late 1960s.
The four volumes of our own *Wireless For the Warrior* by Louis Meulstee are also available. These are a technical history of radio communication equipment in the British Army and clandestine equipment from pre-war through to the 1960s.
For details see the shop on our UK web site at www.epemag.com or contact us for a list of *Radio Bygones* books.

PROJECT BUILDING AND TESTING

ELECTRONIC PROJECT BUILDING FOR BEGINNERS
R. A. Penfold
This book is for complete beginners to electronic project building. It provides a complete introduction to the practical side of this fascinating hobby, including the following topics:
Component identification, and buying the right parts; resistor colour codes, capacitor value markings, etc; advice on buying the right tools for the job; soldering; making easy work of the hard wiring; construction methods, including stripboard, custom printed circuit boards, plain matrix boards, surface mount boards and wire-wrapping; finishing off, and adding panel labels; getting "problem" projects to work, including simple methods of fault-finding.
In fact everything you need to know in order to get started in this absorbing and creative hobby.

135 pages **Order code BP392** **£5.49**

ELECTRONIC PROJECTS FOR EXPERIMENTERS
R. A. Penfold
Many electronic hobbyists who have been pursuing their hobby for a number of years seem to suffer from the dreaded "seen it all before" syndrome. This book is fairly and squarely aimed at sufferers of this complaint, plus any other electronics enthusiasts who yearn to try something a bit different. No doubt many of the projects featured here have practical applications, but they are all worth a try for their interest value alone.
The subjects covered include:- Magnetic field detector, Basic Hall effect compass, Hall effect audio isolator, Voice scrambler/descrambler, Bat detector, Bat style echo location, Noise cancelling, LED stroboscope, Infra-red "torch", Electronic breeze detector, Class D power amplifier, Strain gauge amplifier, Super hearing aid.

138 pages **Order code BP371** **£5.45**

PRACTICAL FIBRE-OPTIC PROJECTS
R. A. Penfold
While fibre-optic cables may have potential advantages over ordinary electric cables, for the electronics enthusiast it is probably their novelty value that makes them worthy of exploration. Fibre-optic cables provide an innovative interesting alternative to electric cables, but in most cases they also represent a practical approach to the problem. This book provides a number of tried and tested circuits for projects that utilize fibre-optic cables.
The projects include:- Simple audio links, F.M. audio link, P.W.M. audio links, Simple d.c. links, P.W.M. d.c. link, P.W.M. motor speed control, RS232C data links, MIDI link, Loop alarms, R.P.M. meter.
All the components used in these designs are readily available, none of them require the constructor to take out a second mortgage.

132 pages **Order code BP374** **£5.45**

GETTING THE MOST FROM YOUR MULTIMETER
R. A. Penfold
This book is primarily aimed at beginners and those of limited experience of electronics. Chapter 1 covers the basics of analogue and digital multimeters, discussing the relative merits and the limitations of the two types. In Chapter 2 various methods of component checking are described, including tests for transistors, thyristors, resistors, capacitors and diodes. Circuit testing is covered in Chapter 3, with subjects such as voltage, current and continuity checks being discussed.
In the main little or no previous knowledge or experience is assumed. Using these simple component and circuit testing techniques the reader should be able to confidently tackle servicing of most electronic projects.

96 pages **Order code BP239** **£5.49**

BOOK ORDERING DETAILS

All prices include UK postage. For postage to Europe (air) and the rest of the world (surface) please add £2 per book. For the rest of the world airmail add £3 per book. CD-ROM prices include VAT and/or postage to anywhere in the world. Send a PO, cheque, international money order (£ sterling only) made payable to **Direct Book Service** or card details, Visa, Mastercard or Maestro to: **DIRECT BOOK SERVICE, WIMBORNE PUBLISHING LIMITED, SEQUOIA HOUSE, 398a RINGWOOD ROAD, FERNDOWN, DORSET BH22 9AU**.

Books are normally sent within seven days of receipt of order, but please allow 28 days for delivery – more for overseas orders. *Please check price and availability (see latest issue of* Everyday Practical Electronics*) before ordering from old lists.*

For a further selection of books see the next two issues of *EPE*.
Tel 01202 873872 Fax 01202 874562. E-mail: dbs@wimborne.co.uk

Order from our online shop at: www.epemag.com

BOOK ORDER FORM

Full name: ....

Address: ....

....

....

.... Post code: .... Telephone No: ....

Signature: ....

☐ I enclose cheque/PO payable to DIRECT BOOK SERVICE for £ ....

☐ Please charge my card £ .... Card expiry date..............................

Card Number .... Switch/Maestro Issue No..................

Valid From Date .... Card Security Code .... (The last three digits on or just below the signature strip)

Please send book order codes: ....

....

Please continue on separate sheet of paper if necessary

PCB SERVICE

Printed circuit boards for most recent *EPE* constructional projects are available from the *PCB Service*, see list. These are fabricated in glass fibre, and are fully drilled and roller tinned. Double-sided boards are **NOT plated through hole** and will require 'vias' and some components soldering to both sides. All prices include VAT and postage and packing. Add £1 per board for airmail outside of Europe. Remittances should be sent to **The PCB Service, Everyday Practical Electronics, Wimborne Publishing Ltd., Sequoia House, 398a Ringwood Road, Ferndown, Dorset BH22 9AU. Tel: 01202 873872; Fax 01202 874562; Email: orders@epemag.wimborne.co.uk. On-line Shop: www.epemag.com**. Cheques should be crossed and made payable to *Everyday Practical Electronics* **(Payment in £ sterling only)**.

NOTE: While 95% of our boards are held in stock and are dispatched within seven days of receipt of order, please allow a maximum of 28 days for delivery – overseas readers allow extra if ordered by surface mail.

Back numbers or photocopies of articles are available if required – see the Back Issues page for details. WE DO NOT SUPPLY KITS OR COMPONENTS FOR OUR PROJECTS.

Please check price and availability in the latest issue. A large number of older boards are listed on, and can be ordered from, our website.

Boards can only be supplied on a payment with order basis.

PROJECT TITLE	ORDER CODE	COST
NOVEMBER '07		
Vehicle Voltage Monitor	642	£6.34
★ USB Electrocardiograph	643	£7.61
★ Inductance & Q-Factor Meter	644	£7.93
Experimenter's Audio System – Main Board	645	
– PSU	646 } set	£7.61
★ Teach-In '08 – Master Control Board	647	£7.93
DECEMBER '07		
iPod or MP3 Player Charger	648	£5.87
AVR ISP Socketboard	649	£7.61
★ PIC Speech Synthesiser – Playback	650	£6.03
– Record	651	£6.66
JANUARY '08		
★ Serial I/O Controller	652	£11.90
★ MIDI Drum Kit – Main Board	653	£11.58
– Display	654	£7.61
Phone/Fax Missed Call Alert	655	£6.66
★ PIC Carillon	656	£7.30
FEBRUARY '08		
MIDI Drum Kit – Optical Sensor	657	£5.39
Studio Series – Stereo Preamplifier – Pre Amp	658 } set	£9.51
– PSU	659	
Electrosmog Sniffer	660	£5.71
MARCH '08		
Fluorescent Tube Driver	661	£7.13
Studio Series – Stereo Headphone Amplifier	662	£8.24
APRIL '08		
★ Studio Series – Remote Control Module	663	£7.13
★ MIDI Activity Detector	664	£6.34
PIC In-Circuit Programming Add-On	665	£5.39
★ PC-Controlled Burglar Alarm – Main Board	666 } set	£11.89
– Display Board	667	
MAY '08		
★PC-Controlled Burglar Alarm – Keypad	668	£6.18
★Electric Mobility Buggy Monitor	669	£6.02
Mini Theremin	670	£10.15
JUNE '08		
★ Monopoly Money	671	£7.30
★ Universal High-Energy LED Lighting System	673	£6.82
JULY '08		
★ PIC MIDI Sound Wave Generator	672	£11.20
Galactic Voice	674	£6.82
Coolmaster	675	£6.34
AUGUST '08		
Four-Channel A/V Selector	676	£9.51
DC Relay Switch For High Current Loads	677	£6.02
Versatile Temperature Switch	678	£6.66
★ Mains Monitor – Monitor	679	£7.13
– Interface	680	£5.71
SEPTEMBER '08		
Magnetic Cartridge Preamplifier	681	£7.45
★ Super Speedo Corrector	682	£6.66
Ultrasonic Eavesdropper	683	£6.82
S-Video To Composite Video Converter (double-sided)	684	£9.98
OCTOBER '08		
★ Inteligent Car Air-Conditioner Controller	685	£6.66
★ Cordless Power Tool Charger Controller	686	£6.18
20W Class-A Amplifier Module – Left Channel	687	£7.29
– Right Channel	688	£7.29
– PSU	689	£6.50
NOVEMBER '08		
★ 50MHz Frequency Meter – Mk. 2		
– Version 1	581	£6.66
– Version 2	582	£6.66
– Version 3	583	£6.66
Variable Turbo Boost Control	690 } set	£6.34
Fuel Cut Defeater	691	
DECEMBER '08		
★ Christmas Star	692	£6.97
20W Class-A Amplifier – Speaker Protector & Muting	693	£6.66
Radar Speed Gun – Head	694 } set	£14.95
– Display	695	
JANUARY '09		
20W Class-A Amplifier		
– Preamplifier and Remote Volume Control	696	£7.93
1000:1 UHF Prescaler (double sided)	697	£12.05
FEBRUARY '09		
1.3V To 22V Regulated Power Supply	698	£5.39
★ LED Tachometer – Control Board	699 } set	£9.52
– Display Board	700	
MARCH '09		
Tank Water Level Indicator	701	£6.34
★ Digital Stereo VU/Peak Meter – Main Board	702 } set	£8.24
– Switch Board	703	

EPE SOFTWARE

★ All software programs for *EPE* Projects marked with a star, and others previously published can be downloaded free from the Library on our website, accessible via our home page at: **www.epemag.com**

PCB MASTERS

PCB masters for boards published from the March '06 issue onwards can also be downloaded from our website (**www.epemag.com**); **go to the 'Library' section.**

EPE PRINTED CIRCUIT BOARD SERVICE

Order Code **Project** **Quantity** **Price**

. . . .

Name . . . .

Address . . . .

. . . .

Tel. No. . . . .

I enclose payment of £ . . . . (cheque/PO in **£ sterling only**) to:

Everyday Practical Electronics

Card No. . . . .

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

Card Security No. . . . . Maestro Issue No. . . . . . .

Signature . . . .

Note: You can also order PCBs by phone, Fax or Email or via the Shop on our website on a secure server:

http://www.epemag.com

EPE EVERYDAY PRACTICAL ELECTRONICS

Everyday Practical Electronics **reaches more UK readers than any other UK monthly hobby electronics magazine, our sales figures prove it. We have been the leading monthly magazine in this market for the last twenty-three years.**

If you want your advertisements to be seen by the largest readership at the most economical price our classified page offers excellent value. The rate for semi-display space is £10 (+VAT) per centimetre high, with a minimum height of 2·5cm. All semi-display adverts have a width of 5.5cm. The prepaid rate for classified adverts is 40p (+VAT) per word (minimum 12 words).

All cheques, postal orders, etc., to be made payable to Everyday Practical Electronics. **VAT must be added**. Advertisements, together with remittance, should be sent to Everyday Practical Electronics Advertisements, Sequoia House, 398a Ringwood Road, Ferndown, Dorset BH22 9AU. Phone: 01202 873872. Fax: 01202 874562. Email: epeads@wimborne.co.uk. For rates and information on display and classified advertising please contact our Advertisement Manager, Stewart Kearn as above.

BTEC ELECTRONICS TECHNICIAN TRAINING

NATIONAL ELECTRONICS
VCE ADVANCED ICT
HNC AND HND ELECTRONICS
FOUNDATION DEGREES
NVQ ENGINEERING AND IT
DESIGN AND TECHNOLOGY

LONDON ELECTRONICS COLLEGE
20 PENYWERN ROAD
EARLS COURT, LONDON SW5 9SU
TEL: (020) 7373 8721
www.lec.org.uk

THIS SPACE COULD BE YOURS FOR JUST £30

Contact Stewart on 01202 873872
stewart.kearn@wimborne.co.uk

RSH ELECTRONICS

UK & International Suppliers of Electronic Components & Kits
Capacitors Resistors Transistors Optoelectronics PCBs Breadboard Solder Switches Cable Batteries Tools CMOS ICs Potentiometers
Exclusive Distributors of 'The Electronics Club' Project Kits
P&P £2.50 (orders over £25 free P&P) No Min Order. No VAT
www.rshelectronics.co.uk

CPS Solar

Solar panels, solar cells, and many more alternative energy products for battery charging etc, please visit our website for further info or call
Tel: 0870 765 2334.
www.solarpanelsonline.co.uk

Versatile Programmable PIC On Screen Display System
Display text over any composite video signal

- Fully programmable
- I/O for sensor interfaces
- PIC 16F628A micro
- User definable fonts

Example code for MSF, cash register, 1-wire & GPS data display

WWW.PIC-OSD.COM

The British Amateur Electronics Club

Archive Website. Archiving extracts for 140+ Newsletters from 1966-2002. Currently have interesting and useful selected articles from 19 Newsletters.

Also a section about built electronics projects with schematics and photos. Plus useful info., downloads and links. "NO ADVERTS!"

Website Address: http://baec.tripod.com

www.partridgeelectronics.co.uk

Special End of Season Bargains.

N.R. BARDWELL Ltd – est 1948
Electronic Component Supplies

LED's, Semis, IC's Resistors, Caps, etc.
1000's bargains at our secure site:
www.bardwells.co.uk
288, Abbeydale Rd. Sheffield. S7 1FL
0845 166 2329 (local rate)

CANTERBURY WINDINGS

UK manufacturer of toroidal transformers (10VA to 1kVA)
All transformers made to order. No design fees. No minimum order.
www.canterburywindings.co.uk
01227 450810

BOWOOD ELECTRONICS LTD

Suppliers of Electronic Components
Place a secure order on our website or call our sales line
All major credit cards accepted
Web: www.bowood-electronics.co.uk
Unit 10, Boythorpe Business Park, Dock Walk, Chesterfield, Derbyshire S40 2QR. Sales: 01246 200222
Send 60p stamp for catalogue

Miscellaneous

VALVES AND ALLIED COMPONENTS IN STOCK. Phone for free list. Valves, books and magazines wanted. Geoff Davies (Radio), tel. 01788 574774.

KITS, TOOLS, COMPONENTS. S.A.E. Catalogue. SIR-KIT ELECTRONICS, 52 Severn Road, Clacton, CO15 3RB, www.geocities.com/sirkituk

1 RPM MAINS MOTORS 240V 4W. Body 50mm diameter × 25mm with lugs. Shaft 7mm diameter. £9.85 including postage. C. Brittain, 12 Marina Drive, Wolverton, MK12 5DW. 07986 824998

EPE Online
www.epemag.com

Get your magazine 'instantly' anywhere in the world – buy and download from the web.

TAKE A LOOK, A FREE ISSUE IS AVAILABLE

A one year subscription (12 issues) costs just $18.99(US)

Back issues are also available

EVERYDAY PRACTICAL ELECTRONICS

NEXT MONTH

OSCAR NOUGHTS AND CROSSES MACHINE

Modern electronics have been used to update 'Oscar' a 1960s machine that played Noughts and Crosses. The original was the size of a fridge – this easy-to-build PIC-based project does it with a handful of components and a small battery. The modern equivalent of one of the world's first 'computer games'.

SUPER-ACCURATE GPS-BASED FREQUENCY REFERENCE

Do you need a source of very accurate 10MHz and 1MHz signals for calibrating frequency counters, radio receivers and signal generators? If so, then this is just what you've been looking for. It uses the Global Positioning System (GPS) satellites, and takes advantage of their highly accurate on-board caesium-beam atomic clocks.

VERSATILE 4-INPUT MIXER

This low-cost 4-input mixer features low-noise input preamps, each of which can be configured to suit a wide range of signal sources: microphones, guitar pick-ups, tape decks, synthesisers or CD players. Other features include a built-in equaliser with bass, midrange and treble controls, along with a stereo headphones monitoring amplifier.

RECYCLE IT!

This month's recycle project shows you how to build a highly sensitive vibration detector – as usual, for next to nothing.

APRIL '09 ISSUE ON SALE MARCH 12

ADVERTISERS INDEX

AUDON ELECTRONICS 47
BRUNNING. 23
COMPACT CONTROL DESIGN. 57
CRICKLEWOOD 47
DISPLAY ELECTRONICS 72
ESR ELECTRONIC COMPONENTS . . . . . . 6, Cover (iii)
FERYSTER 30
JAYCAR ELECTRONICS 4/5
JPG ELECTRONICS 72
LABCENTER . . . . . . Cover (iv)
LASER BUSINESS SYSTEMS 60
MAGENTA ELECTRONICS 47
MICROCHIP. . . . . . Cover (ii)
NURVE NETWORKS LLC 56
PEAK ELECTRONIC DESIGN. 65
QUASAR ELECTRONICS 2/3
SHERWOOD ELECTRONICS 47
STEWART OF READING. 21

ADVERTISEMENT OFFICES:

Sequoia House, 398a Ringwood Road, Ferndown, Dorset BH22 9AU
PHONE: 01202 873872 Fax: 01202 874562
EMAIL: epeads@wimborne.co.uk

For Editorial address and phone numbers see page 7

Published on approximately the second Thursday of each month by Wimborne Publishing Ltd., Sequoia House, 398a Ringwood Road, Ferndown, Dorset BH22 9AU. Printed in England by Apple Web Offset Ltd., Warrington, WA1 4RW. Distributed by Seymour, 86 Newman St., London W1T 3EX. Subscriptions INLAND: £19.95 (6 months); £37.90 (12 months); £70.50 (2 years). OVERSEAS: standard air service, £23.00 (6 months); £44.00 (12 months); £83.00 (2 years). Express airmail, £32.00 (6 months); £62.00 (12 months); £119.00 (2 years). Payments payable to "Everyday Practical Electronics", Subs Dept, Wimborne Publishing Ltd. Email: subs@epemag.wimborne.co.uk. EVERYDAY PRACTICAL ELECTRONICS is sold subject to the following conditions, namely that it shall not, without the written consent of the Publishers first having been given, be lent, resold, hired out or otherwise disposed of by way of Trade at more than the recommended selling price shown on the cover, and that it shall not be lent, resold, hired out or otherwise disposed of in a mutilated condition or in any unauthorised cover by way of Trade or affixed to or as part of any publication or advertising, literary or pictorial matter whatsoever.