THE No 1 UK MAGAZINE FOR ELECTRONICS TECHNOLOGY & COMPUTER PROJECTS

# EPE EVERYDAY PRACTICAL ELECTRONICS

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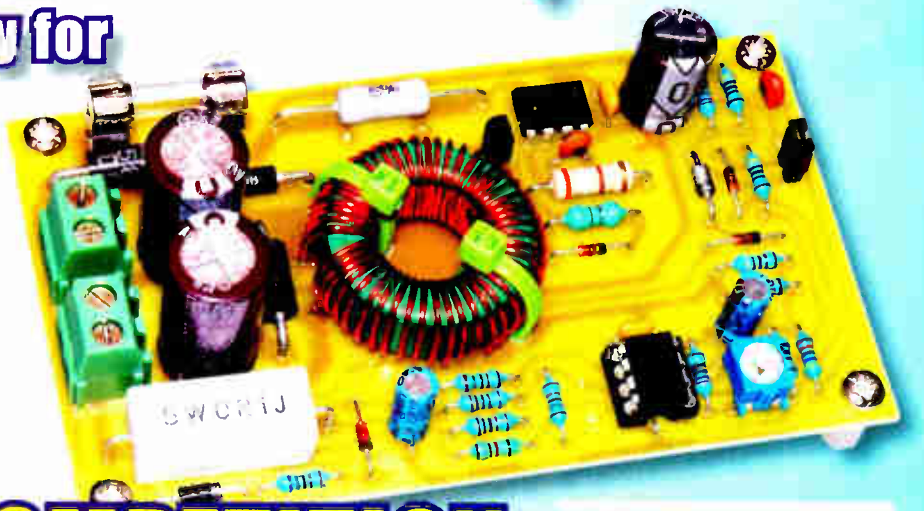
## STUDENTS' AMP

* 14Hz to 100kHz frequency response
* < 0.04% total harmonic distortion
* 105dB signal-to-noise ratio
* 20W RMS output



## STAR POWER

High efficiency supply for Luxeon Star LEDs
Ideal for use in cars, caravans and boats

## FREE ENTRY COMPETITION

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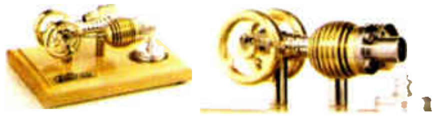
* PIC Polyphonium Pt2 * SMS Controller Pt2

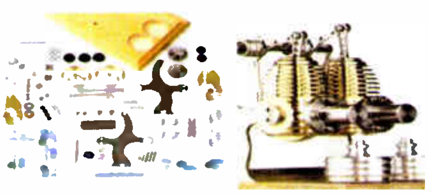


HB7 Stirling Engine
Base measurements: 128 mm x 108 mm x 170 mm, 1 kg Base plate: beech - Working rpm: 2000 rpm/min. (the engine has a aluminium good cooling Cylinder)
Bearing application: 10 high-class ball-bearings
Material: screw, side parts all stainless steel
Cylinder brass, Rest aluminium and stainless steel.
Available as a kit £80.75 or built £84.99
www.mamodspares.co.uk


HB9 Stirling engine
Base measurements: 156 mm x 108 mm x 130 mm, 0,6 Kg Base plate: beech Working rpm: approx. 2,000 min
Bearing application: 6 high-class ball-bearings
Material of the engine: brass, aluminium, stainless steel
running time: 30-45 min.
Available as a kit £97.75 or built £101.99
www.mamodspares.co.uk

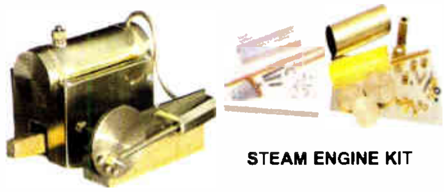

HB10 Stirling Engine
Base measurements: 156 mm x 108 mm x 130 mm, 0,6 Kg Base plate: beech Working rpm: approx. 2,000 rpm
Bearing application: 6 high-class ball-bearings
Material of the engine: brass, aluminium, stainless steel
running time: 30-45 min
Available as a kit £97.75 or built £101.99
www.mamodspares.co.uk

HB11 Stirling Engine
Base measurements: 156 mm x 108 mm x 130 mm, 0,7 Kg Base plate: beech
Working rpm: 2000 - 2500 rpm/min,run Bearing application: 4 high-class ball-bearings Material: screw, side parts total stainless steel Cylinder brass Rest aluminium, stainless steel.
Available as a kit £97.75 or built £101.99
www.mamodspares.co.uk



HB12 Stirling Engine
Base measurements: 156 mm x 108 mm x 130 mm, 1 Kg Base plate: beech Working rpm: 2000 - 2500 rpm/min,Bearing application: 6 high-class ball-bearings
Material: screw, side parts total stainless steel
Cylinder brass Rest aluminium, stainless steel.
Available as a kit £136 or built £140.25
www.mamodspares.co.uk

HB13 Stirling Engine
Base measurements: 156 mm x 108 mm x 150 mm, 0,75 kg Base plate: beech Working rpm: 2000 - 2500 rpm/min, Bearing application: 6 high-class ball-bearings Material: screw, side parts total stainless steel Cylinder brass
Available as a kit £97.75 or built £101.99



**STEAM ENGINE KIT**

Everything in the kit enables you to build a fully functional model steam engine. The main material is brass and the finished machine demonstrates the principle of oscillation. The boiler, uses solid fuel tablets, and is quite safe. All critical parts (boiler, end caps, safety vent etc.) are ready finished to ensure success. The very detailed instruction booklet (25 pages) makes completion of this project possible in a step by step manner. Among the techniques experienced are silver soldering, folding, drilling, fitting and testing. £29.70 ref STEAMKIT Silver solder/flux pack £3.50 ref SSK
www.mamodspares.co.uk

HB14 Stirling Engine
Base measurements: 156 mm x 108 mm x 150 mm, 1 kg Base plate: beech Working rpm: 2000 - 2500 rpm/min, . Incl. drive-pulley for external drives Bearing application: 10 high-class ball-bearings Material: screw, side parts total stainless steelCylinder brass Rest aluminium, stainless steel Available as a kit £140.25 or built £144.50
www.mamodspares.co.uk

HB15 Stirling Engine
Base measurements: 128 mm x 108 mm x 170 mm, 0,75 kg Base plate: beech Working rpm: 2000 rpm/min. (the engine has a aluminium good cooling Cylinder)
Bearing application: 6 high-class ball-bearings
Material: screw, side parts total stainless steel
Cylinder brass Rest aluminium, stainless steel
Available as a kit £97.75 or built £102
www.mamodspares.co.uk

HB16 Stirling Engine
Base measurements: 128 mm x 108 mm x 170 mm, 1 kg Base plate: beech Working rpm: 2000 rpm/min. (the engine has a aluminium good cooling Cylinder)
Bearing application: 10 high-class ball-bearings
Material: screw, side parts total stainless steel
Cylinder brass Rest aluminium, stainless steel.
Available as a kit £140.25 or built £144.50

**2kW WIND TURBINE KIT**
The 2kW wind turbine is supplied as the following kit: turbine generator 48v three taper/ twisted fibreglass blades & hub 8m tower (four x 2m sections) guylines / anchors / tensioners / clamps foundation steel rectifier 2kW inverter heavy-duty pivot tower. £1,499

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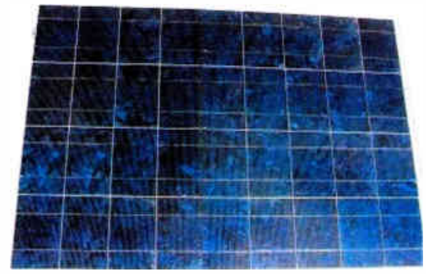
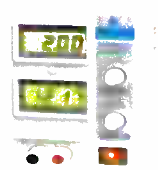


Solar Panels
We stock a range of solar photovoltaic panels. These are polycrystalline panels made from wafers of silicon laminated between an impact-resistant transparent cover and an EVA rear mounting plate. They are constructed with a lightweight anodised aluminium frame which is predrilled for linking to other frames/roof mounting structure, and contain waterproof electrical terminal box on the rear. 5 watt panel £29 ref 5wnav 20 watt panel £99 ref 20wnav 60 watt panel £249 ref 60wnav. Suitable regulator for up to 60 watt panel £20 ref REGNAV

Solar evacuated tube panels
(20 tube shown) These top-of-the-range solar panel heat collectors are suitable for heating domestic hot water, swimming pools etc - even in the winter! One unit is adequate for an average household (3-4people), and it is modular, so you can add more if required. A single panel is sufficient for a 200 litre cylinder, but you can fit 2 or more for high water usage, or for heating swimming pools or underfloor heating. Some types of renewable energy are only available in certain locations, however free solar heating is potentially available to almost every house in the UK! Every house should have one -really! And with an overall efficiency of almost 80%, they are much more efficient than electric photovoltaic solar panels (efficiency of 7-15%). Available in 10, 20 and 30 tube versions. 10 tube £199, 20 tube £369, 30 tube £549. Roof mounting kits (10/20 tubes) £12.50, 30 tube mounting kit £15



BENCH PSU 0-15V 0-2a Output and voltage are both smooth and can be regulated according to work, Input 230V, 21/2-number LCD display for voltage and current, Robust PC-grey housing Size 13x15x21cm, Weight 3,2kg £48 REF trans2

**NEW ELECTRONIC CONSTRUCTION KITS**
This 30 in 1 electronic kit includes an introduction to electrical and electronic technology. It provides components that can be used to make a variety of experiments including Timers and Burglar Alarms. Requires: 3 x AA batteries. £15.00 ref BET1803
**AM/FM Radio** This kit enables you to learn about electronics and also put this knowledge into practice so you can see and hear the effects. Includes manual with explanations about the components and the electronic principles. Req's: 3 x AA batts. £13 ref BET1801
This **40 in 1 electronic kit** includes an introduction to electrical and electronic technology. It provides components that can be used in making basic digital logic circuits, then progresses to using Integrated circuits to make and test a variety of digital circuits, including Flip Flops and Counters. Req's: 4 x AA batteries. £17 ref BET1804
The **75 in 1 electronic kit** includes an nintroduction to electrical and electronic technology. It provides components that can be used to make and test a wide variety of experiments including Water Sensors, Logic Circuits and Oscillators. The kit then progresses to the use of an intergrated circuit to produce digital voice and sound recording experiments such as Morning Call and Burglar Alarm. Requires: 3 x AA batteries. £20 ref BET1806
www.stps.co.uk

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PROJECTS . . . THEORY . . .
NEWS . . . COMMENT . . .
POPULAR FEATURES . . .

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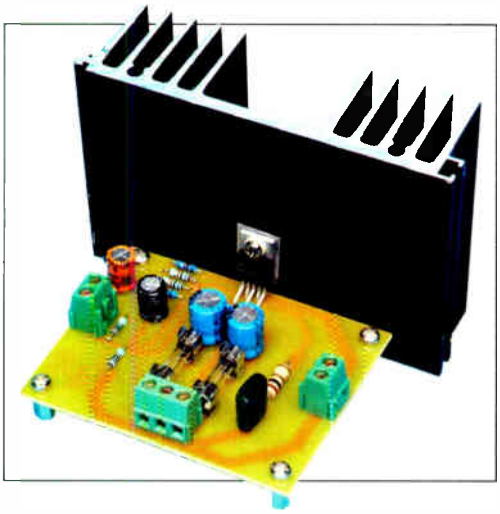

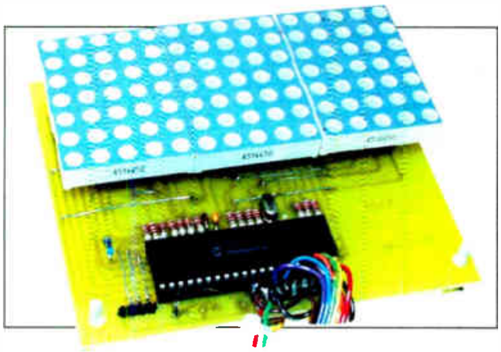

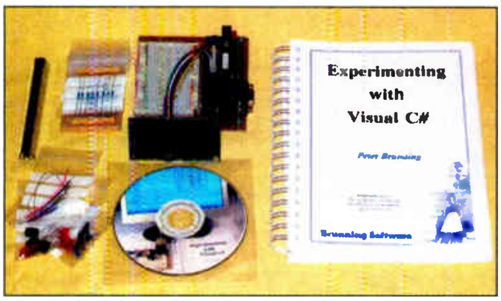




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# Hot New Kits This Summer!

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

### EPE Ultrasonic Wind Speed Meter

Solid-state design wind speed meter (anemometer) that uses ultrasonic techniques and has no moving parts and does not need calibrating. It is intended for sports-type activities, such as track events, sailing, hang-gliding, kites and model aircraft flying, to name but a few. It can even be used to monitor conditions in your garden. The probe is pointed in the direction from which the wind is blowing and the speed is displayed on an LCD display.

**Specifications**

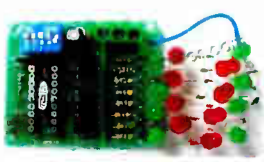
- Units of display: metres per second, feet per second, kilometres per hour and miles per hour
- Resolution: Nearest tenth of a metre
- Range: Zero to 50mph approx.

Based on the project published in Everyday Practical Electronics, Jan 2003. We have made a few minor design changes (see website for full details). Power: 9Vdc (PP3 battery). Main PCB: 50x83mm.
Kit Order Code: 3168KT - **£36.95**

### Audio DTMF Decoder and Display

Detects DTMF tones via an onboard electret microphone or direct from the phone lines through an audio transformer. The numbers are displayed on a 16 character, single line display as they are received. Up to 32 numbers can be displayed by scrolling the display left and right. There is also a serial output for sending the detected tones to a PC via the serial port. The unit will not detect numbers dialled using pulse dialling. Circuit is microcontroller based. Supply: 9-12V DC (Order Code PSU445). Main PCB: 55x95mm.
Kit Order Code: 3153KT - **£20.95**
Assembled Order Code: AS3153 - **£29.95**

### EPE PIC Controlled LED Flasher



This versatile PIC based LED or filament bulb flasher can be used to flash from 1 to 176 LEDs. The user arranges the LEDs in any pattern they wish. The kit comes with 8 super bright red LEDs and 8 green LEDs. Based on the Versatile PIC Flasher, EPE Magazine Dec 02. See website for full details. Board Supply: 9-12Vdc. LED supply: 9-45Vdc (depending on number of LED used). PCB: 43x54mm.
Kit Order Code: 3169KT - **£11.95**

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

# FM Bugs & Transmitters

Our extensive range goes from discreet surveillance bugs to powerful FM broadcast transmitters. Here are a few examples. All can be received on a standard FM radio and have adjustable transmitting frequency.

### *MMTX'* Micro-Miniature 9V FM Room Bug

Our best selling bug! Good performance. Just 25x15mm. Sold to detective agencies worldwide. Small enough to hide just about anywhere. Operates at the 'less busy' top end of the commercial FM waveband and also up into the more private Air band. Range: 500m. Supply: PP3 battery.
Kit Order Code: 3051KT - **£8.95**
Assembled Order Code: AS3051 - **£14.95**

### *HPTX'* High Power FM Room Bug

Our most powerful room bug. Very impressive performance. Clear and stable output signal thanks to the extra circuitry employed. Range: 1000m @ 9V. Supply: 6-12V DC (9V PP3 battery clip supplied). 70x15mm.
Kit Order Code: 3032KT - **£9.95**
Assembled Order Code: AS3032 - **£17.95**

### MTTX' Miniature Telephone Transmitter

Attach anywhere along phone line. Tune a radio into the signal and hear exactly what both parties are saying. Transmits only when phone is used. Clear, stable signal. Powered from phone line so completely maintenance free once installed. Requires no aerial wire - uses phone line as antenna. Suitable for any phone system worldwide. Range: 300m. 20x45mm.
Kit Order Code: 3016KT - **£7.95**
Assembled Order Code: AS3016 - **£13.95**

### Wide Band Synthesised FM Transmitter

PLL based crystal-locked wide band FM transmitter delivering a high quality, stable 10mW output. Accepts both MIC audio signal (10mV) and LINE input (1v p-p) for example hi-fi, CD, audio mixer (like our kit 1052) or computer sound card. Supply: 9-15Vdc.
Kit Order Code: 3172KT - **£19.95**
Assembled Order Code: AS3172 - **£32.95**

### 3 Watt FM Transmitter

Small, powerful FM transmitter. Audio pre-amp stage and three RF stages deliver 3 watts of RF power. Use with the electret microphone supplied or any line level audio source (e.g. CD or tape OUT, mixer, sound card, etc). Aerial can be an open dipole or Ground Plane. Ideal project for the novice wishing to get started in the fascinating world of FM broadcasting. 45x145mm.
Kit Order Code: 1028KT - **£23.95**
Assembled Order Code: AS1028 - **£31.95**

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# Electronic Project Labs

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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+.
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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.

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A highly featured, high-precision digital multimeter with a large 4.5 digit LCD display. High accuracy (0.05%). Auto-zeroing, polarity selection and over-range indication. Supplied complete with shrouded test leads, shock-proof rubber holster, built-in probe holder and stand. Supplied fully assembled with holster, battery and presentation box. Features include:
Capacitance • Audio Frequency • Data Hold • hFE / Diode Test • Auto Power Off

**Technical Specifications**
DC voltage: 200mV-1000V • AC voltage: 2V-700V • DC current: 2mA-20A • AC current: 20mA-20A • Resistance: 200Ω-200MΩ • Capacitance: 2nF-20uF • Frequency: 20kHz • Max display: 19999

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| 74HC193 | £0.39 |
| 74HC195 | £0.32 |
| 74HC240 | £0.32 |
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| 74HC244 | £0.40 |
| 74HC245 | £0.34 |
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| 74HC253 | £0.25 |
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| 74HC273 | £0.32 |
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| 74LS09 | £0.15 |
| 74LS10 | £0.27 |
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| 74LS114 | £0.36 |
| 74LS122 | £0.31 |
| 74LS123 | £0.31 |
| 74LS125 | £0.28 |
| 74LS126 | £0.25 |
| 74LS132 | £0.47 |
| 74LS133 | £0.36 |
| 74LS136 | £0.23 |
| 74LS138 | £0.33 |
| 74LS139 | £0.26 |
| 74LS145 | £0.56 |
| 74LS148 | £0.64 |
| 74LS151 | £0.29 |
| 74LS153 | £0.38 |
| 74LS156 | £0.36 |
| 74LS157 | £0.22 |
| 74LS158 | £0.21 |
| 74LS160 | £0.48 |
| 74LS161 | £0.32 |
| 74LS162 | £0.44 |
| 74LS163 | £0.32 |
| 74LS164 | £0.43 |
| 74LS165 | £0.48 |
| 74LS173 | £0.24 |
| 74LS174 | £0.24 |
| 74LS175 | £0.30 |
| 74LS190 | £0.60 |
| 74LS191 | £0.27 |
| 74LS192 | £0.60 |
| 74LS193 | £0.43 |
| 74LS195 | £0.24 |
| 74LS221 | £0.41 |
| 74LS240 | £0.32 |
| 74LS241 | £0.32 |
| 74LS243 | £0.30 |
| 74LS244 | £0.41 |
| 74LS245 | £0.45 |
| 74LS247 | £0.60 |
| 74LS251 | £0.24 |
| 74LS257 | £0.24 |
| 74LS258 | £0.24 |
| 74LS266 | £0.14 |
| 74LS273 | £0.32 |
| 74LS279 | £0.24 |
| 74LS283 | £0.47 |
| 74LS365 | £0.21 |
| 74LS367 | £0.21 |
| 74LS368 | £0.21 |
| 74LS373 | £0.39 |
| 74LS374 | £0.38 |
| 74LS378 | £0.62 |
| 74LS390 | £0.34 |
| 74LS393 | £0.33 |
| 74LS395 | £0.26 |

## 74 Series

| | |
|---|---|
| 7407 | £0.40 |

## Linear ICs

| | |
|---|---|
| AD524AD | £23.04 |
| AD548JN | £2.48 |
| AD590JH | £5.28 |
| AD595AQ | £13.92 |
| AD620AN | £9.88 |
| AD625JN | £16.20 |
| AD633JN | £5.92 |
| AD648JN | £2.57 |
| AD654JN | £5.51 |
| AD711JN | £1.97 |
| AD712JN | £2.51 |
| AD736JN | £5.80 |
| AD797AN | £7.25 |
| AD811N | £6.00 |
| AD812AN | £6.32 |
| AD820AN | £3.41 |
| AD822AN | £5.20 |
| AD829JN | £6.41 |
| AD830AN | £5.44 |
| AD847JN | £5.95 |
| AD9696KN | £7.73 |
| ADEL2020A | £5.06 |
| ADM222AH | £3.55 |
| ADM232AA | £3.55 |
| ADM485JN | £2.97 |
| ADM666AN | £2.72 |
| ADM690AN | £5.13 |
| ADM691AN | £6.48 |
| ADM695AN | £6.48 |
| ADM699AN | £3.58 |
| CA3046 | £0.65 |
| CA3130E | £0.87 |
| CA3140E | £0.63 |
| CA3240E | £0.91 |
| DG211CJ | £1.25 |
| DG411DJ | £2.00 |
| ICL7106CPL | £2.21 |
| ICL7107CPL | £2.06 |
| ICL7109CLP | £5.76 |
| ICL7611DCP | £1.00 |
| ICL7621 | £0.84 |
| ICL7660SCP | £0.80 |
| ICM7555 | £0.41 |
| ICM7556 | £1.04 |
| L165V | £2.36 |
| L272M | £1.21 |
| L293E | £4.20 |
| L297 | £5.12 |
| L298N | £6.67 |
| L4960 | £2.81 |
| L6219 | £4.48 |
| LF347N | £0.46 |
| LF351N | £0.44 |
| LF353N | £0.40 |
| LF356 | £0.52 |
| LM311N8 | £0.17 |
| LM319N14 | £0.90 |
| LM324 | £0.20 |
| LM335Z | £1.12 |
| LM339N | £0.18 |
| LM348N | £0.36 |
| LM35DZ | £0.97 |
| LM358N | £0.13 |
| LM380N | £0.90 |
| LM386 | £0.45 |
| LM392N | £0.79 |
| LM393N | £0.21 |
| LM1881 | £2.90 |
| LM2901N | £0.15 |
| LM2917N8 | £1.98 |
| LM3900N | £0.72 |
| LM3914 | £1.97 |
| LM3915 | £2.24 |
| LM13700 | £1.26 |
| LMC660CN | £1.21 |
| LMC6032IN | £1.55 |
| LP311N | £0.74 |
| LP324N | £0.75 |
| LP339N | £0.75 |
| LT1013CN8 | £4.64 |
| M34-1 | £0.30 |
| M34-2 | £0.30 |
| MAX202CPE | £2.00 |
| MAX208CN | £6.99 |
| MAX220CPE | £5.06 |
| MAX222CPE | £5.06 |
| MAX232CPE | £1.30 |
| MAX483CP | £3.13 |
| MAX485CP | £2.04 |
| MAX631ACP | £4.99 |
| MAX635ACP | £4.99 |
| MAX1232CP | £2.80 |
| MC1458N | £0.27 |
| MC1488 | £0.40 |
| MC1489 | £0.35 |
| MC3302 | £0.56 |
| MC4558P | £0.40 |
| MK484 | £0.66 |
| NE521N | £6.39 |
| NE555N | £0.16 |
| NE556N | £0.24 |
| NE565N | £2.30 |
| NE592 | £0.62 |
| NE5532N | £0.48 |
| NE5534N | £0.54 |
| NE5539N | £4.35 |
| OP27CN | £2.33 |
| OP90GP | £2.91 |
| OP97FP | £1.84 |
| OP113GP | £3.44 |
| OP176GP | £2.09 |
| OP177GP | £2.18 |
| OP200GP | £5.60 |
| OP213FP | £5.20 |
| OP275GP | £2.57 |
| OP282GP | £2.27 |
| OP283GP | £5.20 |
| OP290GP | £4.28 |
| OP297GP | £4.64 |
| OP400GP | £11.81 |
| OP495GP | £8.69 |
| RC4136 | £1.00 |
| SG3524N | £0.82 |
| SG3543 | £6.88 |
| SSM2141P | £3.21 |
| SSM2142P | £6.16 |
| SSM2143P | £3.78 |
| TBA120S | £1.04 |
| TBA800 | £0.75 |
| TBA810S | £0.64 |
| TBA820M | £0.53 |
| TDA1170S | £4.80 |
| TDA2004 | £2.24 |
| TDA2030AV | £1.24 |
| TDA2050V | £2.51 |
| TDA2611A | £1.88 |
| TDA2822A | £0.79 |
| TDA2653A | £2.99 |
| TED3718DP | £5.03 |
| TEA5115 | £3.11 |
| TL061CP | £0.21 |
| TL062CP | £0.21 |
| TL064CN | £0.29 |
| TL071CN | £0.30 |
| TL072CN | £0.40 |
| TL074CN | £0.25 |
| TL081CN | £0.17 |
| TL082CN | £0.32 |
| TL084CN | £0.37 |
| TL7705ACP | £0.82 |
| TLC271 | £0.63 |
| TS272CN | £0.57 |
| TS274CN | £0.50 |
| TS555CN | £0.40 |
| TMP01FP | £5.60 |
| UA741CN | £0.18 |
| ULN2003A | £0.38 |
| ULN2004A | £0.44 |
| ULN2803A | £0.42 |
| ULN2804A | £0.41 |

## EPROM's

| | |
|---|---|
| 24LC08BP | £0.73 |
| 24LC16BP | £0.69 |
| 24LC32AP | £1.14 |
| 27128-200 | £3.99 |
| 27256-200 | £3.99 |
| 27C64A-15F | £3.99 |
| 27C256B-15F | £3.00 |
| 27C512-15F | £2.85 |
| 27C1001-15. | £3.17 |
| 27C2001-15. | £4.41 |
| 27C4001-10F | £5.98 |
| 93C46N | £0.33 |

## RAM

| Part | Price |
|---|---|
| GM76C88. | £3.60 |

## A/D Converters Data Acquisition

| Part | Price |
|---|---|
| AD420AN | £25.38 |
| AD7528JN | £11.42 |
| AD7545AK | £14.04 |
| AD7828KN | £20.33 |
| DAC0800 | £2.40 |
| ICL7109CPL | £7.75 |

## uControllers

| Part | Price |
|---|---|
| AT89C2051 | £6.38 |

## PIC Series

| Part | Price |
|---|---|
| 12C508A04P | £0.78 |
| 12C509A04P | £0.83 |
| 16C54C04P | £1.49 |
| 16C54BJW | £7.60 |
| 16C56A-04P | £1.58 |
| 16F84-04P | £3.14 |
| 16F84-10P | £4.16 |
| 16F627-04P | £1.65 |
| 16F627-20IP | £1.80 |
| 17F628-20IP | £2.40 |
| 16F867-04SP | £5.10 |
| 16F877-20P | £5.79 |

## Voltage Regulators

| Part | Price |
|---|---|
| 7805 | £0.27 |
| 7806 | £0.29 |
| 7808 | £0.27 |
| 7812 | £0.23 |
| 7815 | £0.27 |
| 78L05 | £0.22 |
| 78L06 | £0.32 |
| 78L08 | £0.22 |
| 78L12 | £0.16 |
| 78L15 | £0.26 |
| 78L24 | £0.39 |
| 78S05 | £0.53 |
| 78S12 | £0.42 |
| 78S15 | £0.32 |
| 7905 | £0.23 |
| 7912 | £0.24 |
| 7915 | £0.22 |
| 7924 | £0.38 |
| 79L05 | £0.20 |
| 79L12 | £0.26 |
| 79L15 | £0.28 |
| 79L24 | £0.30 |
| ADM666AN | £3.44 |
| L200CV | £1.67 |
| L296 | £4.42 |
| LM2940CT5 | £0.75 |
| LM317LZ | £0.25 |
| LM317T | £0.30 |
| LM317K | £2.28 |
| LM323K | £2.40 |
| LM334Z | £0.96 |
| LM337T | £0.64 |
| LM338K | £5.31 |
| LM338T | £1.10 |
| LM723 | £0.40 |
| LP2950CZ5.0 | £0.72 |
| REF01CP | £2.31 |
| REF195GP | £3.04 |
| TL431CP | £0.14 |

## Diodes

| Part | Price |
|---|---|
| 1N914 | £0.05 |
| 1N916 | £0.05 |
| 1N4001 | £0.04 |
| 1N4002 | £0.05 |
| 1N4003 | £0.03 |
| 1N4004 | £0.04 |
| 1N4005 | £0.04 |
| 1N4006 | £0.04 |
| 1N4007 | £0.03 |
| 1N4148 | £0.03 |
| 1N4149 | £0.07 |
| 1N5400 | £0.08 |
| 1N5401 | £0.08 |
| 1N5402 | £0.08 |
| 1N5404 | £0.09 |
| 1N5406 | £0.10 |
| 1N5407 | £0.10 |
| 1N5408 | £0.10 |
| 6A05 | £0.27 |
| 6A1 | £0.30 |
| 6A2 | £0.27 |
| 6A4 | £0.28 |
| 6A6 | £0.32 |
| 6A8 | £0.30 |
| 6A10 | £0.35 |
| BA157 | £0.07 |
| BA158 | £0.08 |
| BA159 | £0.13 |
| BAT41 | £0.12 |
| BAT42 | £0.07 |
| BAT46 | £0.12 |
| BAT85 | £0.09 |
| BAV21 | £0.07 |
| BAW62 | £0.07 |
| BAX16 | £0.05 |
| BY127 | £0.18 |
| BY133 | £0.10 |
| OA47 | £0.70 |
| OA90 | £0.33 |
| OA91 | £0.32 |
| OA200 | £0.56 |
| UF4001 | £0.08 |
| UF4002 | £0.08 |
| UF4003 | £0.09 |
| UF4004 | £0.08 |
| UF4005 | £0.10 |
| UF4006 | £0.10 |
| UF4007 | £0.14 |
| Zeners 2.7 to 33V 500mW | £0.06 |
| 1.3W | £0.10 |

## Bridge Rectifiers

| Part | Price |
|---|---|
| 1A 50V | £0.35 |
| 1A 100V | £0.32 |
| 1A 200V | £0.39 |
| 1A 600V | £0.40 |
| 1A 800V | £0.43 |
| 1.5A 50V | £0.19 |
| 1.5A 100V | £0.11 |
| 1.5A 200V | £0.19 |
| 1.5A 400V | £0.20 |
| 1.5A 600V | £0.24 |
| 1.5A 800V | £0.26 |
| 1.5A 1kV | £0.18 |
| 2A 100V | £0.34 |
| 2A 200V | £0.34 |
| 2A 400V | £0.35 |
| 2A 800V | £0.36 |
| 2A 1000V | £0.45 |
| 3A 200V | £0.34 |
| 3A 400V | £0.40 |
| 3A 600V | £0.33 |
| 3A 1000V | £0.33 |
| 4A 100V | £0.78 |
| 4A 200V | £0.80 |
| 4A 400V | £0.86 |
| 4A 600V | £0.90 |
| 6A 100V | £0.49 |
| 6A 200V | £0.64 |
| 6A 400V | £0.53 |
| 6A 600V | £0.67 |
| 6A 800V | £0.37 |
| 8A 100V | £0.98 |
| 8A 200V | £1.00 |
| 8A 400V | £1.20 |
| 8A 600V | £1.33 |
| 8A 1000V | £1.05 |
| 25A 100V | £1.47 |
| 25A 200V | £1.54 |
| 25A 400V | £1.98 |
| 25A 600V | £1.82 |
| 35A 50V | £1.67 |
| 35A 100V | £1.57 |
| 35A 200V | £1.80 |
| 35A 400V | £1.44 |
| 35A 600V | £1.90 |
| 35A 1000V | £2.32 |

## Thyristors

| Part | Price |
|---|---|
| 2N5060 | £0.19 |
| 2N5061 | £0.19 |
| BT151-500R | £0.65 |
| C106D1 | £0.36 |
| PO102AA | £0.30 |
| TIC106D | £0.49 |
| TIC116D | £0.66 |
| TIC126D | £0.77 |

## Triacs

| Part | Price |
|---|---|
| BT136-500 | £0.58 |
| BT136-600 | £0.50 |
| BT137-600 | £0.58 |
| BT139-500 | £1.00 |
| BT139-600 | £1.20 |
| BTA08-600B | £0.84 |
| BTA08-600BW | £0.76 |
| BTA08-600C | £0.96 |
| BTA08-600SW | £0.93 |
| BTA08-600TW | £1.10 |
| BTA12-600BW | £0.92 |
| BTA16 600CW | £1.45 |
| BTA16-600B | £1.28 |
| BTA26-600B | £2.78 |
| TIC206D | £0.70 |
| TIC206M | £0.75 |
| TIC226D | £0.80 |
| TIC226M | £1.00 |
| TIC246D | £1.00 |
| TIC246M | £1.00 |
| TIC236D | £1.12 |
| ZO105DA | £0.53 |

## Diac

| Part | Price |
|---|---|
| DB3, 32V | £0.08 |

## Transistors

| Part | Price |
|---|---|
| 2N2222A | £0.20 |
| 2N2369A | £0.51 |
| 2N2646 | £1.02 |
| 2N2904A | £0.35 |
| 2N2905A | £0.30 |
| 2N2907A | £0.28 |
| 2N3053 | £0.38 |
| 2N3054 | £0.85 |
| 2N3055 | £0.58 |
| 2N3439 | £0.62 |
| 2N3440 | £0.50 |
| 2N3702 | £0.09 |
| 2N3703 | £0.10 |
| 2N3704 | £0.11 |
| 2N3705 | £0.08 |
| 2N3771 | £1.44 |
| 2N3772 | £1.72 |
| 2N3773 | £2.30 |
| 2N3819 | £0.27 |
| 2N3903 | £0.11 |
| 2N3904 | £0.05 |
| 2N3905 | £0.10 |
| 2N3906 | £0.05 |
| 2N4401 | £0.08 |
| 2N4403 | £0.09 |
| 2N5245 | £0.80 |
| 2N5296 | £0.57 |
| 2N5401 | £0.12 |
| 2N5551 | £0.07 |
| 2N6491 | £1.58 |
| 2N7000 | £0.19 |
| 2SB548 | £0.30 |
| AC127 | £0.50 |
| AC187 | £0.68 |
| AC188 | £0.97 |
| ACY17 | £4.84 |
| AD149 | £1.29 |
| AD161 | £0.73 |
| AD162 | £0.95 |
| BC107 | £0.15 |
| BC107B | £0.14 |
| BC108 | £0.18 |
| BC108B | £0.14 |
| BC108C | £0.18 |
| BC109 | £0.19 |
| BC109C | £0.16 |
| BC114 | £0.19 |
| BC115 | £0.41 |
| BC118 | £0.41 |
| BC132 | £0.36 |
| BC134 | £0.36 |
| BC135 | £0.36 |
| BC140 | £0.75 |
| BC142 | £0.50 |
| BC143 | £0.38 |
| BC159 | £0.17 |
| BC160 | £0.28 |
| BC170B | £0.16 |
| BC171B | £0.16 |
| BC177 | £0.25 |
| BC178 | £0.18 |
| BC179 | £0.15 |
| BC182B | £0.09 |
| BC182L | £0.11 |
| BC183L | £0.09 |
| BC184 | £0.09 |
| BC184L | £0.13 |
| BC206B | £0.72 |
| BC208 | £0.72 |
| BC209A | £0.72 |
| BC212L | £0.09 |
| BC213L | £0.12 |
| BC214 | £0.11 |
| BC214L | £0.10 |
| BC225 | £0.15 |
| BC237B | £0.11 |
| BC238B | £0.11 |
| BC250A | £0.15 |
| BC261B | £0.30 |
| BC262B | £0.24 |
| BC267B | £0.36 |
| BC319C | £0.13 |
| BC327 | £0.08 |
| BC327-25 | £0.08 |
| BC328 | £0.09 |
| BC337-16 | £0.10 |
| BC337-25 | £0.08 |
| BC348B | £0.14 |
| BC357 | £0.25 |
| BC393 | £0.73 |
| BC461 | £0.41 |
| BC463 | £0.29 |
| BC477 | £0.52 |
| BC479 | £0.32 |
| BC516 | £0.21 |
| BC517 | £0.14 |
| BC546B | £0.06 |
| BC546C | £0.08 |
| BC547A | £0.09 |
| BC547B | £0.09 |
| BC547C | £0.10 |
| BC548A | £0.09 |
| BC548B | £0.09 |
| BC548C | £0.08 |
| BC549B | £0.09 |
| BC549C | £0.09 |
| BC550C | £0.11 |
| BC556A | £0.08 |
| BC556B | £0.10 |
| BC557A | £0.09 |
| BC557B | £0.09 |
| BC557C | £0.09 |
| BC558A | £0.08 |
| BC558B | £0.09 |
| BC559A | £0.08 |
| BC560A | £0.09 |
| BC636 | £0.10 |
| BC637 | £0.19 |
| BC638 | £0.21 |
| BC639 | £0.09 |
| BC640 | £0.12 |
| BCY72 | £0.20 |
| BD124P | £6.86 |
| BD131 | £0.48 |
| BD132 | £0.46 |
| BD135 | £0.22 |
| BD136 | £0.21 |
| BD137 | £0.23 |
| BD138 | £0.19 |
| BD139 | £0.19 |
| BD140 | £0.14 |
| BD150C | £0.82 |
| BD201 | £0.40 |
| BD202 | £0.70 |
| BD232 | £0.50 |
| BD237 | £0.32 |
| BD238 | £0.44 |
| BD240C | £0.37 |
| BD245C | £1.10 |
| BD246C | £1.18 |
| BD283 | £0.61 |
| BD284 | £0.61 |
| BD400 | £0.79 |
| BD437 | £0.17 |
| BD438 | £0.22 |
| BD442 | £0.37 |
| BD534 | £0.47 |
| BD535 | £0.50 |
| BD646 | £0.52 |
| BD648 | £0.52 |
| BD650 | £0.53 |
| BDX32 | £1.78 |
| BDX34C | £0.45 |
| BDX53C | £0.53 |
| BDX54C | £0.50 |
| BF180 | £0.31 |
| BF182 | £0.31 |
| BF245B | £0.40 |
| BF257 | £0.33 |
| BF259 | £0.33 |
| BF337 | £0.40 |
| BF422 | £0.15 |
| BF423 | £0.15 |
| BF459 | £0.33 |
| BF469 | £0.36 |
| BFX29 | £0.29 |
| BFX84 | £0.31 |
| BFX85 | £0.33 |
| BFX88 | £0.27 |
| BFY50 | £0.30 |
| BFY51 | £0.22 |
| BFY52 | £0.24 |
| BS107 | £0.21 |
| BS170 | £0.15 |
| BU208A | £1.53 |
| BU326A | £1.40 |
| BU500 | £1.54 |
| BU508A | £1.40 |
| BU508D | £0.98 |
| BU806 | £1.06 |
| BUT11AF | £1.14 |
| BUX84 | £0.78 |
| BUZ900 | £7.68 |
| BUZ900P | £5.60 |
| BUZ905 | £7.68 |
| BUZ905P | £5.60 |
| IRF530 | £0.53 |
| IRF540 | £0.78 |
| IRF630 | £0.42 |
| IRF640 | £0.63 |
| IRF730 | £0.66 |
| IRF740 | £0.91 |
| IRF830 | £0.68 |
| IRF840 | £0.78 |
| MJ2955 | £0.90 |
| MJ2501 | £1.60 |
| MJ3001 | £1.84 |
| MJ11015 | £2.45 |
| MJ11016 | £2.78 |
| MJE340 | £0.33 |
| MJE350 | £0.32 |
| MPSA05 | £0.14 |
| MPSA13 | £0.09 |
| MPSA42 | £0.14 |
| MPSA55 | £0.13 |
| MPSA56 | £0.12 |
| STP14NF10 | £0.49 |
| STW80NE-10 | £3.80 |
| TIP29A | £0.32 |
| TIP29C | £0.33 |
| TIP30A | £0.47 |
| TIP30C | £0.27 |
| TIP31A | £0.23 |
| TIP31C | £0.35 |
| TIP32A | £0.29 |
| TIP32C | £0.30 |
| TIP33C | £0.74 |
| TIP41A | £0.32 |
| TIP41C | £0.32 |
| TIP42A | £0.47 |
| TIP42C | £0.43 |
| TIP50 | £0.28 |
| TIP110 | £0.28 |
| TIP120 | £0.30 |
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# The Future

Over the last couple of months Barry Fox has reported in *News* on the giant Consumer Electronics Show in Las Vegas. As always, the show is the place where innovative new products are placed in front of consumers. We thought it would be interesting to see where the major companies think we will be in, say five years from now, given that developments in electronics seem to go at an ever increasing pace. Jeffrey Belk, one of the Show's panelists, commented "If we would have predicted five years ago what's available today, they probably would have locked us up in a rubber room." So you can see prediction is not an easy task.

The general view seems to be more connectivity – in otherwords our TV, DVD, audio, laptop, phone, MP3, camera, GPS etc., will all talk to each other. One wonders how this will sit when bugs and viruses invade the system, or whether the major companies will ever agree on a standard for communication? Maybe all your equipment will have to come from one manufacturer, in which case we don't see that catching on in five years!

In addition to more connectivity, they also predict more availability, where practically every type of information is available, not just when we want it but where we want it. "Someday, (content transfer) may be embedded in the wallpaper" commented Rudy Provoost of Philips Electronics.

When asked what they feel the buying public wants, the consensus was for more reliability, i.e. cellphones that never drop a call and computers that never crash, plus value for money – more performance for fewer pounds – and greater compatibility. "Affordability and ease of use are two of the biggest issues we have" said Rudy Provoost. I'll second that, having spent hours trying to initialise a wireless router only later to be told by the helpline that the set-up instructions were inadequate. And yes I had (eventually) read them all. Let's hope the "affordability and ease of use" issues are soon improved, and that we will get a standard for communication between equipment without a massive 'standards' battle that helps nobody, least of all the consumer.

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 on-line version can be purchased and downloaded for just $15.99US (approx £9.00) per year available from **www.epemag.com**


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### READERS' TECHNICAL ENQUIRIES

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

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# News . . .

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

# More at CES 2007

**Barry Fox reports on a couple more items he found at this year's CES Show at Las Vegas**

## Dolby Volume

The most common complaint made to broadcasters by listeners and viewers is that the commercials are too loud, or some stations are too quiet to hear, or movies create impact by suddenly blasting high volume sound effects and annoy neighbours, especially late at night. Dolby Labs has already tried to help the industry help itself, by offering graduated sound level meters and advice on how to use them. But largely to no avail, so Dolby has developed a new consumer system called Dolby Volume.

After measuring countless broadcasts, Dolby found that sound levels can vary by as much as 30dB when the viewer switches channels or is hit by an advert. Pyschoaccoustically, 10dB is a doubling of perceived volume, so a 30dB difference is an ear-bending eightfold change. Moreover, because the ear is non-linear, as the sound level drops, the bass and treble drop by a disproportionate amount.

Dolby Volume is a pyschoaccoustic algorithm that will work inside a TV receiver to even out the overall volume level, and compensate for the non-linear effects. The trick, says Brett Crockett, of Dolby's Research Lab in San Francisco, is to make the system track the audio in real time, and apply intelligent compensation so quickly that the listener does not notice. A conventional 'dumb' compressor or automatic gain control makes background noise pump and breathe as the level of speech or music fluctuates.

Dolby Volume works in the digital domain, and can handle any input, up to 24-bit, 96kHz and even beyond. After a one-time calibration set up, when the listener enters personal listening preferences, the system continually buffers and 'listens' to around 200 PCM samples of the sound, while adjusting the output level to suit the listener and compensating for perceptual loss of high and low frequencies at low listening levels. This process adds a delay of only 16ms, which set-makers can trade off against the much longer video processing delays in digital TVs.

The system can be used to balance the different sound levels that an AV amplifier gets from all its many sources, such as radio, TV, DVD, BD, HD-DVD and iPod. Dolby Volume can also be adapted for use in cars, with a microphone measuring background noise and adjusting the Dolby Volume to match.

If Dolby's offer to the electronics industry is taken up, future TV sets and amplifiers will have a Dolby Volume control. The computer code, on which the system relies, will be released to the industry during the next few months. Using the same business model as for other Dolby processing systems, chip-makers will be able to develop and sell chips without paying a royalty. Set makers will then pay a royalty to Dolby when they enable the Volume system. Dolby expects to see the first working sets at CES next year.

"This follows on from all the work we did on analogue noise reduction" says Crockett. "We don't spend time looking for music and speech that makes a system sound good, we spend time looking for material that makes it sound bad. We try to break the system before announcing it".

But if anyone does not like the results, they can disable Dolby Volume and make their volume control work just like it always did. Judging by the press reaction to very impressive demonstrations given in Las Vegas, it is very unlikely many will use the Off switch.

Will broadcasters object? "Currently some of them are annoying listeners to the point of completely skipping or muting adverts" says Crockett. "With Dolby Volume people continue to listen".

## 5.1 Video

Is 5.1 video the next step after 5.1 surround sound? Panasonic's booth at CES sported a small room with one of the most adventurous demonstrations of the show – the 5.1 Vision Jazz Club.

The room had five plasma panels, a 103-inch (261.6cm) display at the front and two 65-inch (165cm) panels at each side of the room, positioned vertically like information panels at an airport. But instead of displaying information, all five panels picture one member of a five-piece jazz group recorded by respected music producer Elliot Sheiner. The front panel shows the pianist, the left side panels show the bass player and guitarist, and the two right side panels show the sax player and drummer.

The 5.1 sound matches the video location so the viewer is quite literally in the middle of the band.

# Radio-Electronics.Com Tutorials

The website Radio-Electronics.Com (**www.radio-electronics.com**) that provides free radio and electronics related information, tutorials and articles, now has more than 400 pages of tutorial content. The site, which is aimed at electronics engineers and students, is run and edited by Ian Poole of Adrio Communications Ltd, and aims to provide concise, useful overviews and tutorials in an easy to read form.

The website covers a wide range of radio and electronics topics, ranging from receiver technology, through antennas, radio propagation, circuits, components, test and measurement to the other technologies including cellular telecommunications, Wi-Fi, Bluetooth, UWB and more. This makes the site a one-stop-shop for information for the electronics engineer and electronics enthusiast. All of the articles and tutorials aim to be written in an easy to read style, making them approachable for most people.

The site prides itself on keeping up with the latest technology and to prove this there are summaries of Wibree (the new low power wireless standard from Nokia) along with summaries of HSDPA and HSUPA being introduced on many cellular networks. With new pages being added all the time, many more new technologies will shortly be covered.

In passing the 400 landmark, the Editor, Ian Poole commented, "Having more than 400 tutorial pages on the site makes Radio-Electronics.Com one of the largest electronics information resources on the Internet. However, we are not going to stop there. Not only will we be putting more tutorial and reference information on the site, but we have more plans to broaden its appeal, and we will be adding some new areas – so keep an eye out on what is happening."

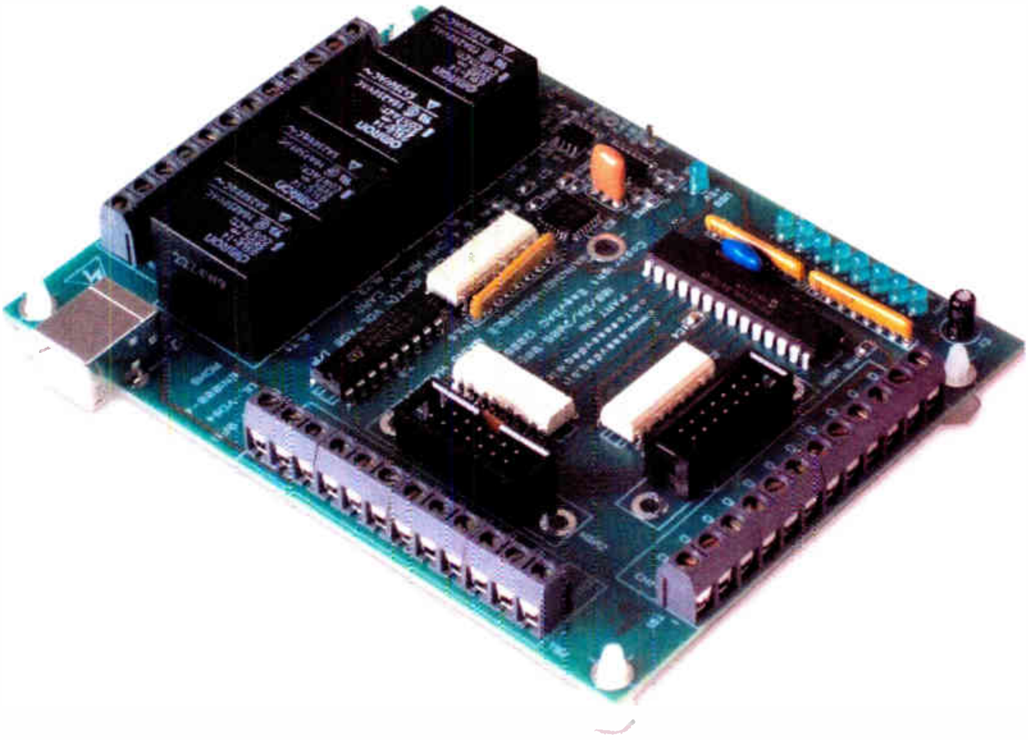
The site has been in existence for over six years and, since its inception, it has grown steadily in size and the number of visitors. It also regularly receives very positive comments from readers who have found it useful in providing the information they need.

## EasyDAQ USB Card

EasyDAQ has announced the launch of a new low cost USB card, adding to its existing range of USB-powered data acquisition and automation/control products. The new USB8VI4DIOR card is available as a general purpose, 8-channel voltage input, 4-channel DIO and 4-channel relay card. Voltage input and DIO/Relay channels are opto-isolated.

Available with a choice of two relay types (10A power or 1A gold contact signal), and either fixed or two-part (male/female) screw terminal connectors. The card is suitable for a wide range of voltage measurement, contact closure applications, signal switching or control, mains voltage power switching purposes etc. It is USB powered and hot swappable, with voltage input, relay channel and USB power status indication LEDs. It is also available with LabView, Visual Basic, Visual C, Agilent VEE and Delphi example programs, or it can be commanded via programs such as Windows HyperTerminal.

For more details and full datasheet, contact EasyDAQ, 14 Brook Lane, Corfe Mullen, Wimborne, Dorset, BH21 3RD. Tel: 01202 600747. Email: info@easydaq.biz. Web: **www.easydaq.biz**.



## Microchip Real ICE Emulator

*Microchip have announced the MPLAB REAL ICE Emulation system. This offers low-cost and faster memory interfacing.*

*The new emulation system is fully integrated into the free MPLAB Integrated Development Environment (IDE) used for writing code, building projects, testing, verification and programming. With MPLAB, the new system supports a wide range of debugging facilities, such as complex breakpoints, application code tracing and data logging, code execution stopwatch and real-time variable monitoring.*

*For further information browse* ***www.microchip.com***.

## BLETCHLEY £10 SEASON TICKET

Bletchley Park, the historic site of secret British code breaking activities during World War II and the birthplace of the modern computer, is launching a brand new Season Ticket initiative that will be of particular benefit to people visiting the area on an overnight break, as well as those who live up to at least two hour's drive from the Park.

Since January 2007, all visitors have the opportunity to convert their one-day £10 adult entry ticket into a 12-month season ticket, which will then allow them to have unlimited and free visits to the Park following their first visit. Visitors will also be given the chance to sign a Gift Aid declaration form enabling Bletchley Park, as a charitable organisation, to recoup around 28 per cent of the ticket value. This will then be ploughed back into the much needed restoration and upkeep of the Park and its facilities.

"Figures show that a large percentage of our visitors have travelled from a wide range of locations throughout the UK, up to at least two hour's drive," says Simon Greenish, director, Bletchley Park. "Once they get here, most admit that there is too much to see in just one day, from our popular guided tours and the Mansion, to Colossus, the Bombe and, of course, Enigma and our various other wartime codebreaking machines.

But with our new 12-month season ticket, visitors will be able to make the journey to Bletchley Park as often as they like and not pay a penny more for the rest of the year, whether they are coming back to see our permanent collections, or for one of our special events, such as the Churchill weekend."

Once again, Bletchley Park has an exciting new programme of special events in 2007, commencing on 9 April with an Easter Eggstravaganza for the kids and a Forties Family Festival on 28 May. Other major events this year include the inauguration of Alan Turing's Hut 8, the launch of Colossus and the Bombe, a Polish Day, Classic Car and Motorbike Picnic, Alice in Wonderland event, Churchill Weekend and Enigma Festival, as well as the annual Blitz Night in November.

Season ticket holders will be eligible to attend most special events for no extra charge. Around Easter the Park will also be launching a brand new restaurant, which will be returning to Hut 4, home of the Naval Enigma.

For further information call 01908 640404 or email info@bletchleypark.org.uk. To purchase tickets in advance through their secure website, go to **www.bletchleypark.org.uk/shop/**.

The standard cost of admission is adults £10, concessions £8 (OAPs and students with valid ID card) and £6 (children aged 12 to 16), children under 12 admitted free of charge. Family Ticket: £25 (two adults and two children aged 12 to 16). Tickets include a guided tour and/or the use of a wand. Car parking is £3.

Bletchley Park is open during 2007 every day except Christmas Day and New Years Day. Weekdays: 10.30am – 4.00pm, last admissions 2.30pm. From 26th March: 9.30am – 5.00pm, last admissions 3.30pm. Weekends/public holidays: 10.30am – 4.00pm, last admissions 2.30pm.

## EDUCATIONAL WEATHER KITS

*Quasar Electronics have introduced a new range of educational weather station kits.*

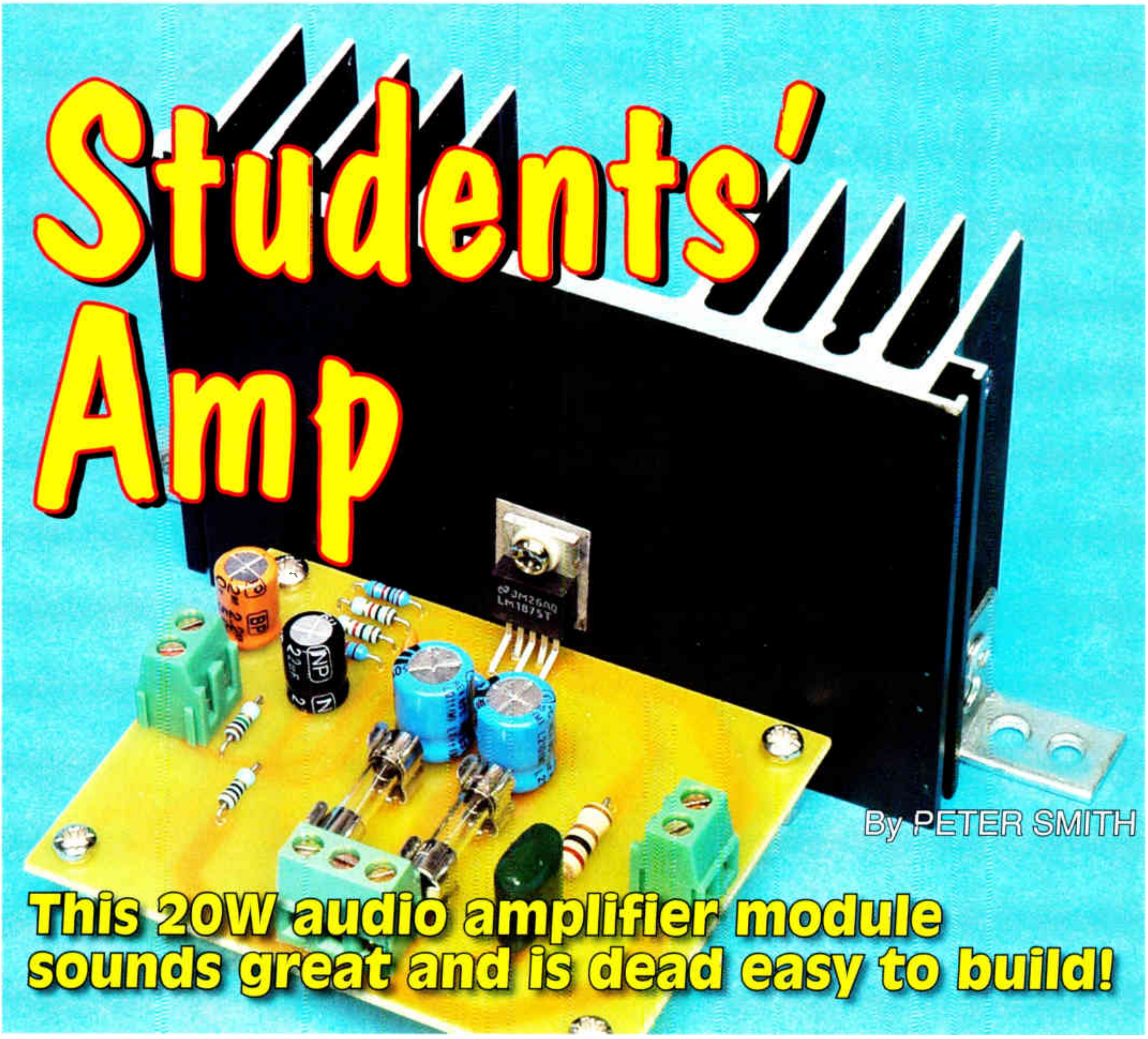
*The* Weather Observatory Starter Kit *encourages young children (8+ years) to learn and understand the science behind different weather conditions. It provides a good range of meteorological measurements and is ideal for use in Primary Schools and at home.*

*Through it, children can perform measurement of temperature, wind direction and rainfall, learn about pH, humidity, air pressure and many more meteorological subjects. It is supplied with an informative activity handbook and costs £9.95 including VAT. For full details see* ***www.quasarelectronics.com/met128.htm***.

*The* Digital Weather Station Kit *is a unique kit that will provide hours of enjoyment while learning and understanding the science behind diverse weather conditions. Quasar say it is a must for Primary Schools and for children at home from the age of 10+.*

*It provides a high precision digital wind speed meter with temperature, relative humidity, wind direction and rainfall measurement. It also helps with understanding pH, pollution, the greenhouse effect, clouds and lightning. Supplied with a colour, easy-to-follow, informative activities handbook, it costs £32.95 including VAT. Full details are at* ***www.quasarelectronics.com/met131.htm***.

*Quasar's full range of science kits can be found at* ***www.quasarelectronics.com/science kits.htm***.




**BUILDING AN AUDIO amplifier** is a popular choice when it comes to the hands-on part of electronics courses. We can well imagine the classroom question "Well, does it work?" answered in a flash with "Listen to this, disbeliever!"

That's the best part of building an audio amp; you and your peers actually get to hear the final work punch out a favourite tune or two hundred!

However, amplifiers that produce more than a few watts of power can be difficult to construct and expensive. This is where our Students' Amp comes in. It features a simple board layout for easy construction, is relatively inexpensive and even includes over-temperature and short-circuit protection.

As power amplifier modules go, this unit may not rank at the top for raw power but you'll be hard pressed to find a simpler circuit. The design is based on a single IC, the LM1875T 20W audio amplifier from National Semiconductor. This IC comes in a TO-220 package and, combined with a handful of other parts and a suitable power supply, delivers over 20W RMS into either a 4Ω or 8Ω loudspeaker.

What's more, the specifications are quite impressive for such a bare-bones circuit. With a signal-to-noise (S/N) ratio of 105dB and a distortion figure of less than 0.04% for 1kHz at 20W (see graphs – Figs.7 to 11), it could well be used as the basis for a hifi stereo amplifier. The frequency response extends from 14Hz to beyond 100kHz when measured at 1W RMS.

The LM1875 includes an internal 4A current limit, preventing damage should the output be accidentally shorted to ground. It also includes 'safe operating area' (SOA) protection, meaning that the current limit is dynamically reduced according to the voltage present at the output.

Because so much power has to be dissipated by such a small package, the LM1875 also has in-built thermal protection. This effectively shuts the device down if there is excess heat build up in the chip itself (at about 170°C).

## Circuit description

The circuit diagram (see Fig.1) for the amplifier module reveals just the LM1875 power amplifier (IC1) and a handful of support components.

The closed loop gain of the amplifier is set to 23 by the 22kΩ and 1kΩ resistors on the inverting input (pin 2), following the standard non-inverting amplifier feedback rules (ie, voltage gain = 22k/1k + 1 = 23).

The 22µF capacitor in series with the 1kΩ resistor sets the lower end of the amplifier's frequency response. Another factor in the low-end response is the high-pass filter in the input signal path, formed by the 2.2µF coupling capacitor and 22kΩ resistor.

Overall, the result is a rapid frequency response roll-off below about 10Hz (see Fig.11). Following this, a 1kΩ series resistor and a 330pF capacitor form a low-pass filter, eliminating problems with high-frequency noise pickup on the input leads.

Non-polarised electrolytic capacitors (marked NP) are used in these positions because the voltages present are too small to polarise conventional electrolytics.

Keen-eyed readers will have detected that the input circuitry is not connected directly to power supply ground but instead goes via a 10Ω resistor. This has little effect in a single (mono) amplifier setup but in a stereo setup, it helps to reduce currents circulating in the ground wiring which can degrade separation between channels.

Finally, a 1Ω 1W resistor in series with a 220nF capacitor at the output of IC1 forms a Zobel network, designed to neutralise the effects of the speaker's voice coil inductance at the higher end of the frequency spectrum.

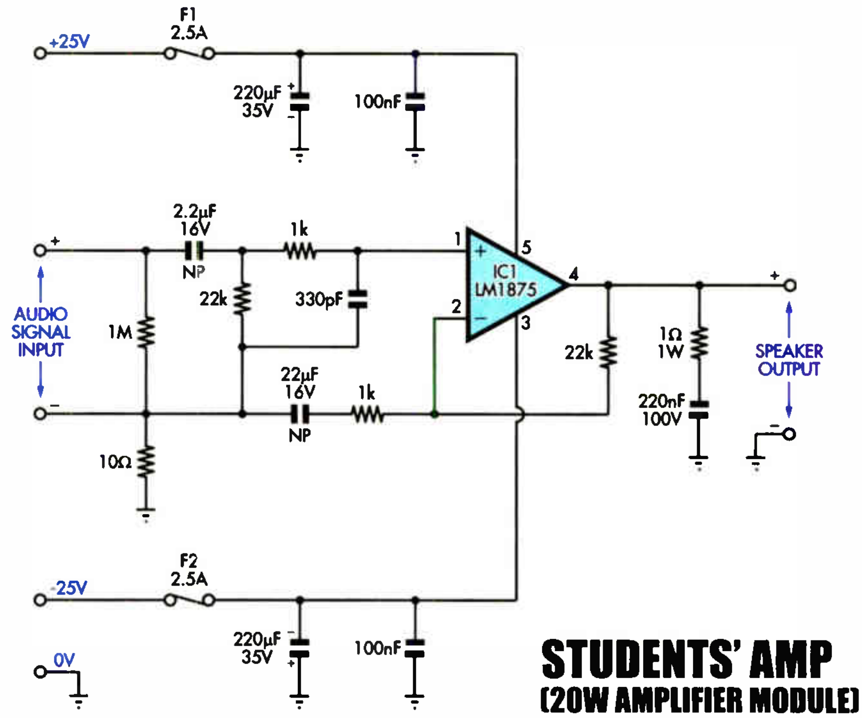
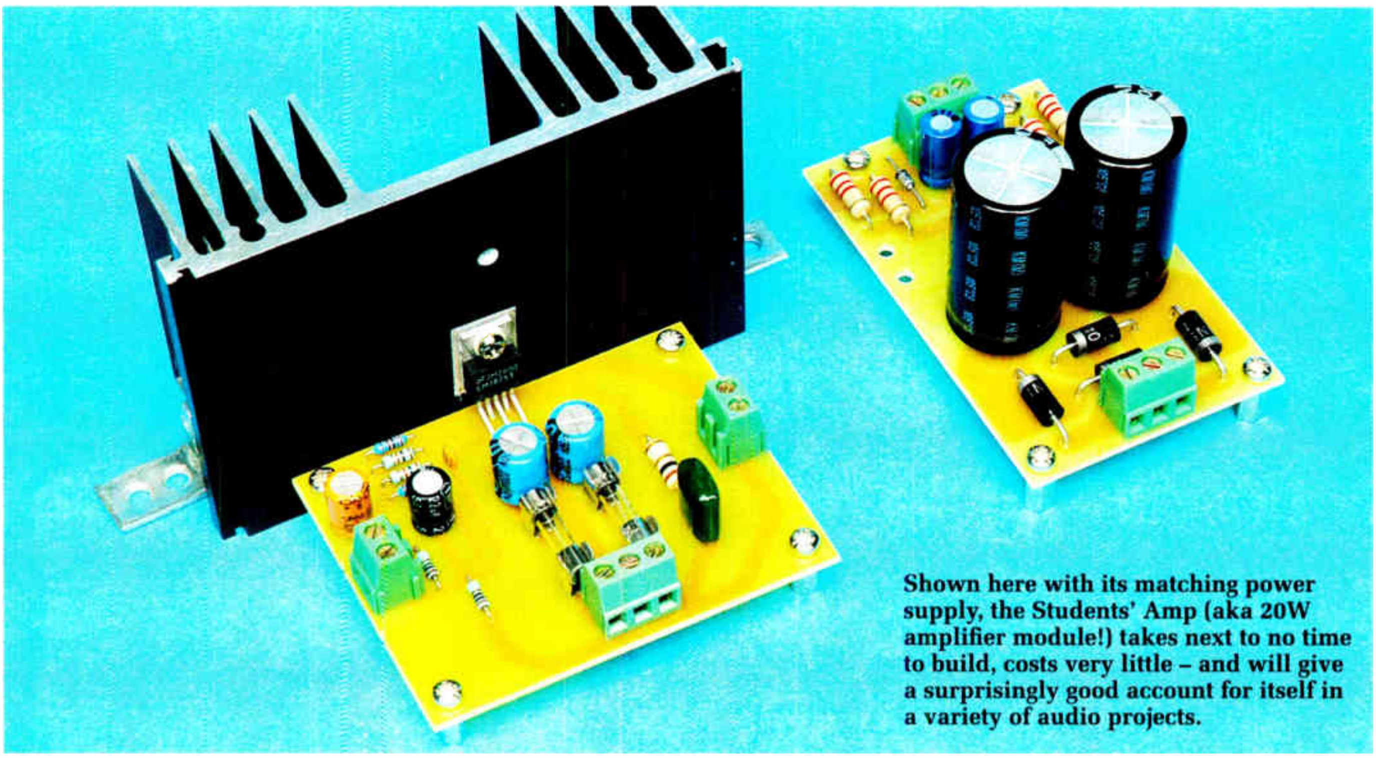



**Fig.1: the circuit consists of little more than the LM1875, which contains a complete low-distortion 20W amplifier, with overload protection, in a 5-pin TO-220 package.**

## Amplifier construction

Construction of the amplifier module is quite straightforward, with all parts mounting on a small PC board. Fig.2 shows the parts layout.

The resistors should be installed first, followed by the capacitors. Use your meter to verify the value of resistors where necessary. Note that the two 220µF capacitors are polarised and must go in with their positive leads oriented as indicated on the component overlay. The remaining two electrolytic capacitors are



**Shown here with its matching power supply, the Students' Amp (aka 20W amplifier module!) takes next to no time to build, costs very little – and will give a surprisingly good account for itself in a variety of audio projects.**

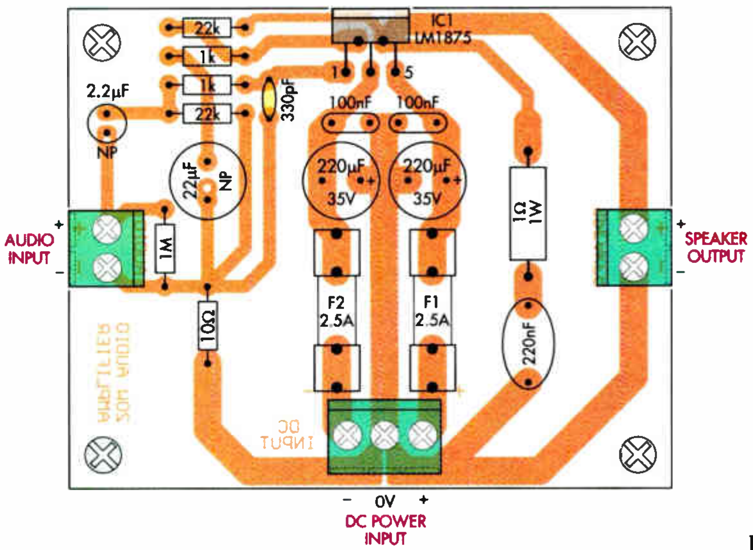



Fig.2: use this diagram when assembling the amp module. Double-check that you have the two 220µF capacitors in the right way around, as indicated by the '+' markings.

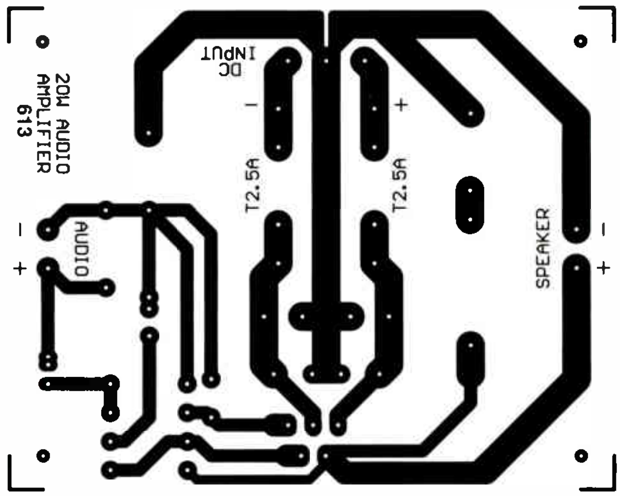



Fig.3: full size PC board pattern for the amplifier. If you're wondering why this looks different to the overlay pattern at left, this view is from the copper side while the overlay is 'through the board' as if an x-ray.

non-polarised and can be installed either way around.

Install the fuse clips and terminal blocks next, pushing them all the way down onto the board surface before soldering. Note the retaining tabs on the fuse clips; be sure to orient these towards the outer (fuse end) side, otherwise you won't be able to plug in the fuses later.

The LM1875 is installed last of all. First, fit 10mm tapped spacers to the corner mounting positions of the board, then slip the LM1875 into position. As its leads are preformed at the factory, they shouldn't require more than minor tweaking for a comfortable fit in the PC board holes.

Make sure that the LM1875 is sitting 'square' (ie, perpendicular to the board surface) and then carefully turn the assembly over and solder only the centre pin of the package. The remaining four pins should only be soldered after attachment to the heatsink, so let's do that next.

## Heatsink mounting

Place the board and heatsink on a flat surface and bring them together, centring the LM1875 in the available heatsink width. Dependent on the particular type of heatsink, it may also be necessary to line up the hole in the tab with a gap between fins. Now gently mark around the inside of the tab hole with a sharp pencil.

Centre-punch the pencilled circle and first drill a 1mm pilot hole, then step up to a 3mm (or 1/8-inch) bit for the final size.

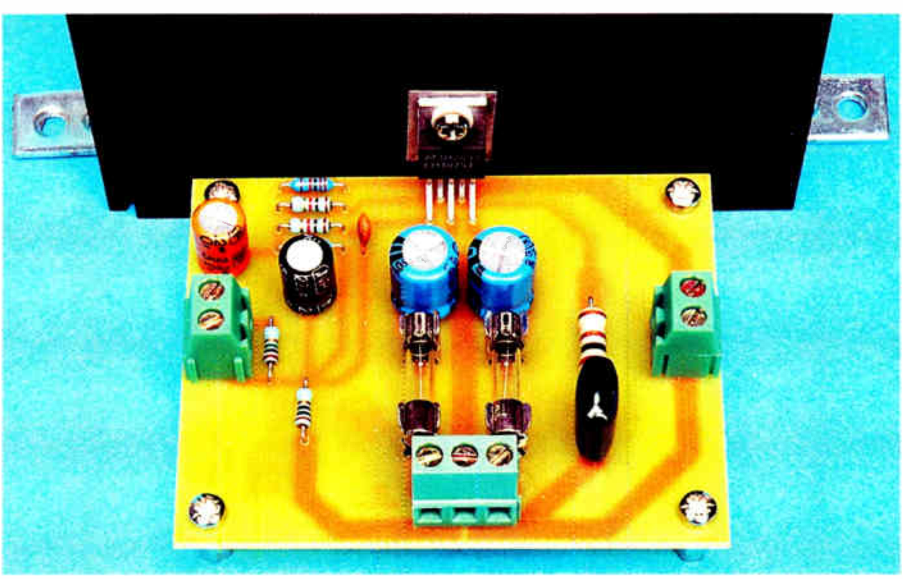
Once drilled, the edges of the hole must be deburred to obtain a perfectly smooth surface. This can be achieved by gently rotating the tip of a much larger drill in the hole opening by hand, held between the thumb and forefinger.

The LM1875 can now be bolted to the heatsink using a TO-220 insulating kit (ie, a mica washer and insulating bush). Fig.12 shows the assembly details. Smear all mating surfaces with a thin film of heatsink compound before bolting the assembly together. Take care not to 'skew' the LM1875 as the screw is tightened.

To complete your work, you must now solder the remaining leads of the LM1875. Gingerly turn the whole assembly over, being careful not to disturb the relationship between the PC board and heatsink.

Place something under the board to support its weight and keep it at right angles to the heatsink while you solder the remaining leads. It's also a good idea to reheat and resolder the centre pin of the IC to relieve any stresses imposed during assembly.

Once done, use your multimeter to confirm that the metal tab of the LM1875 is indeed electrically isolated from the heatsink.



The completed amplifier module is bolted to its heatsink via the LM1875. Take particular care once the amplifier is in this state – it's quite easy to break the legs of the IC if you allow the board to flex with reference to the heatsink.

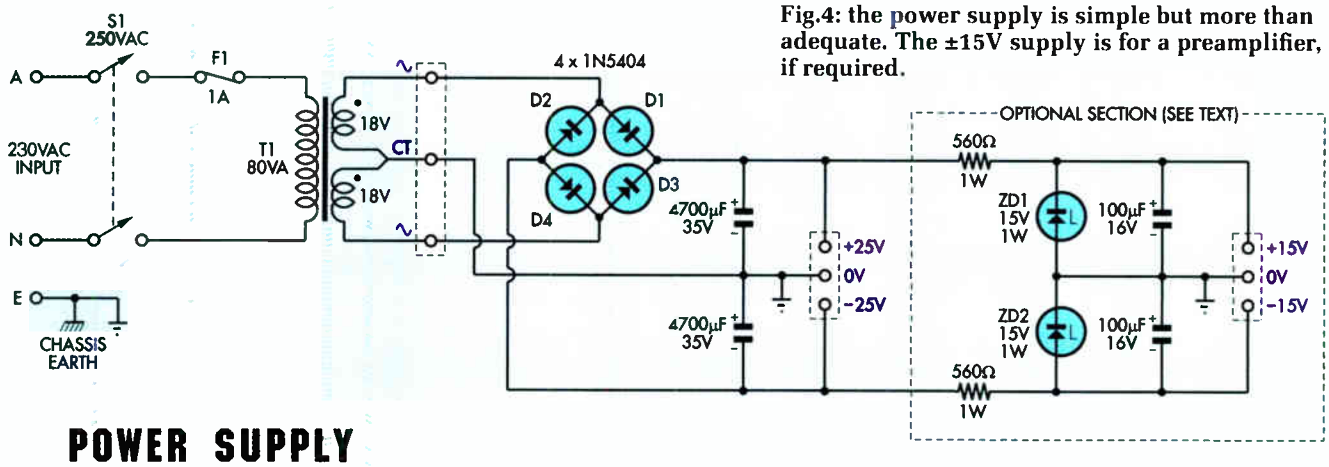



Fig.4: the power supply is simple but more than adequate. The ±15V supply is for a preamplifier, if required.

## Power supply

The power supply circuit for the amplifier module appears in Fig.4. An 80VA mains transformer with two 18V secondary windings or a single 36V centre-tapped winding is used. The secondary feeds a bridge rectifier and filter, formed by diodes D1-D4 and two 4700µF 35V capacitors. The output is about ±25V unloaded and is suitable for powering one or two amplifier modules.

If designing your own power supply, note that the rails to the LM1875 **must not** exceed ±30V. Voltages lower than the recommended ±25V can be used, but the output power will be less than shown in the performance graphs. Refer to the LM1875 datasheet for more information (from **www.national.com**).

The circuit also shows a ±15V preamplifier supply, based on two simple Zener diode regulators. This supply is optional and can be left out if not required.

## Power supply assembly

Fig.5 shows how to assemble the power supply PC board to suit the Students' Amp. Note that the 4700µF capacitors are 35V rated but higher voltage types are fine too.

Install diodes D1 to D4 first, aligning the banded (cathode) ends as shown. Follow these with the two 3-way terminal blocks and then the two 4700µF capacitors. Make certain that you have the positive leads of the capacitors the right way around.

You can leave out all the remaining components unless you specifically require the ±15V supply for a preamplifier.

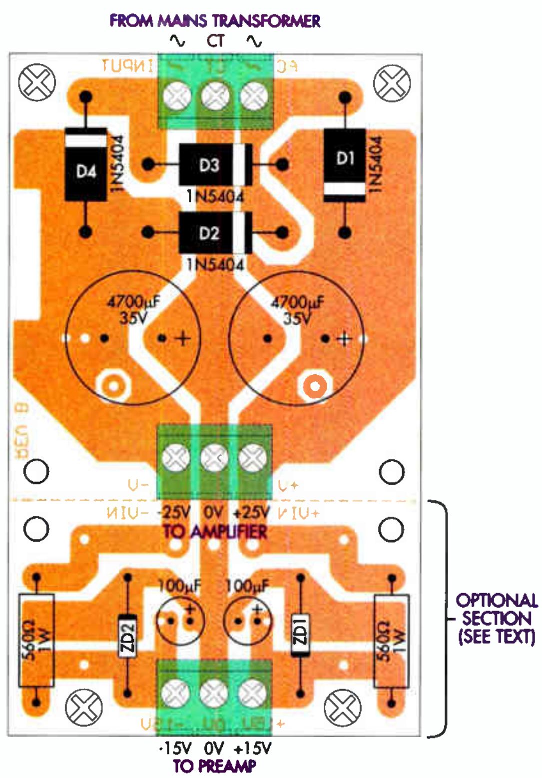
## Wiring

Use heavy-duty (7.5A) multistrand cable for all DC power and speaker connections. The +25V, -25V and 0V wires to the amplifier module should also be twisted together to minimise radiated noise.

Now on the mains (230V AC) side, be sure to use only mains-rated (250V AC) cable and insulate all exposed connections. This includes the use of rubber boots or heatshrink tubing on the rear of IEC sockets, switches and fuseholders. The idea is to ensure that even with the covers off and power on, it is impossible to accidentally make contact with live mains voltages.

The mains earth must be connected to a metal chassis using the arrangement shown in Fig.13. Return all earth wires to this point to eliminate potential earth loops.

When in any doubt, refer your work to an experienced person for checkout



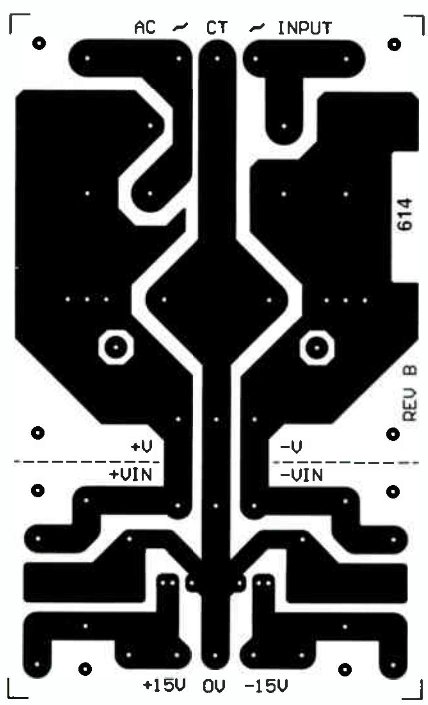




Fig.5: here's how to assemble the power supply board. One of these can power two modules for a stereo set-up. The full size pattern is shown at right (Fig.6).

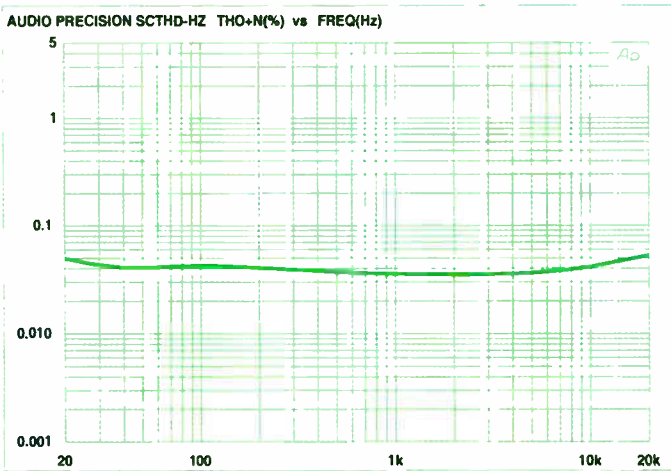



Fig.7: THD versus frequency at 1W into an 8Ω load.

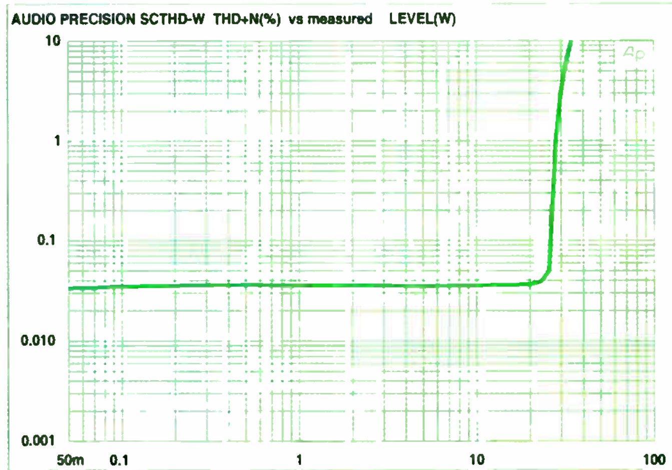



Fig.10: THD versus power at 1kHz into an 8Ω load.

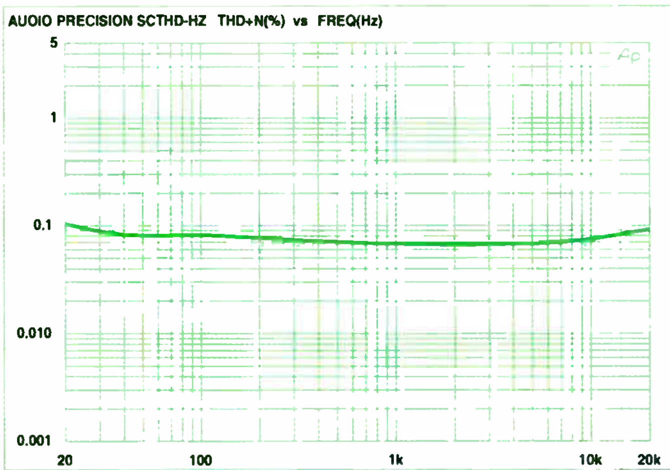



Fig.8: THD versus frequency at 1W into a 4Ω load.

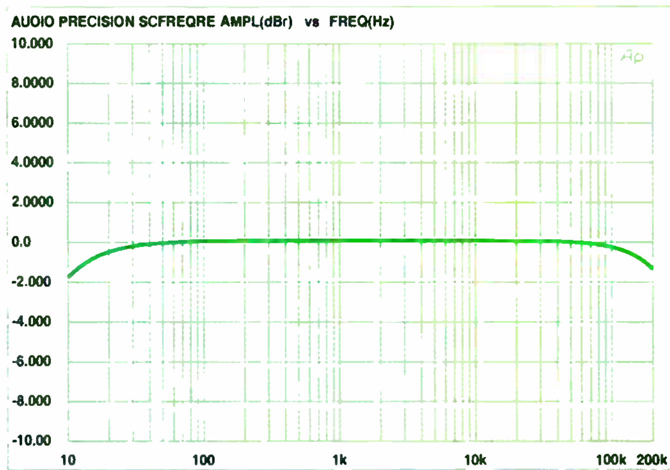



Fig.11: frequency response at 1W into an 8Ω load.

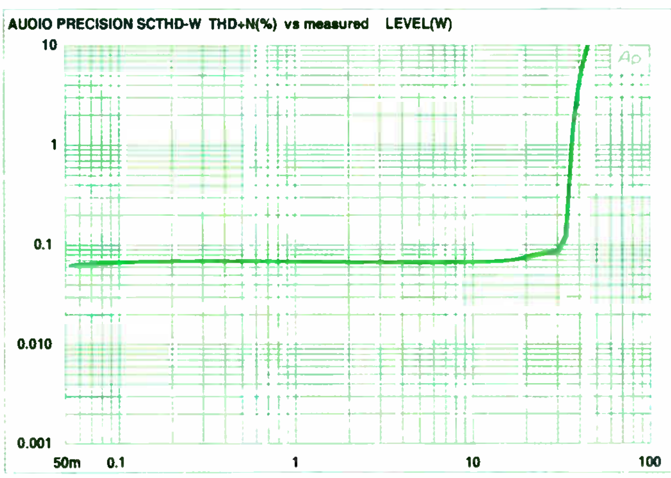



Fig.9: THD versus power at 1kHz into a 4Ω load

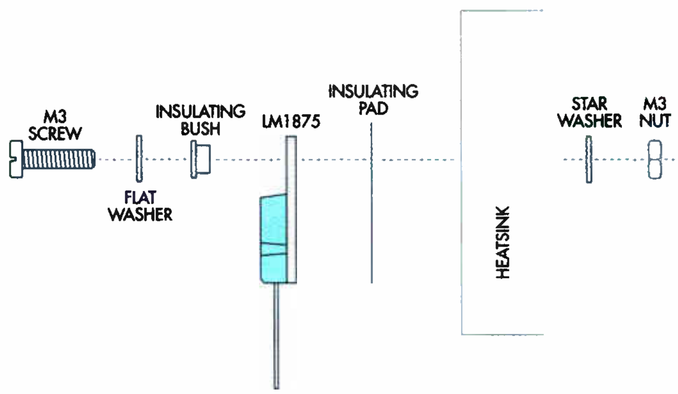



Fig.12: this diagram shows how the LM1875 is attached to its heatsink.

before connecting to the 230V AC mains outlet for the first time. **Never take shortcuts with mains wiring – it could be fatal!**

## Testing

Before applying power, go back over the board and carefully check

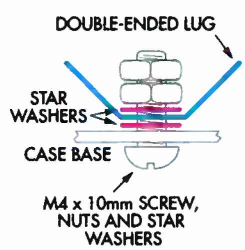



Fig.13: the mains earth must be securely attached to a metal chassis as shown here. Tighten the first nut very firmly before winding on the second 'lock-nut'. The power supply ground (0V) must also be connected to this point.

## Parts List – Students' 20W Amplifier Module

### Amp Module

1 PC board, coded 613, available from the *EPE PCB Service*, size 80mm x 63.5mm
2 2-way 5mm/5.08mm terminal blocks
1 3-way 5mm/5.08mm terminal block
4 M205 PC-mount fuse clips
2 M205 2.5A slow-blow fuses
1 1.4°C/W heatsink
1 TO-220 insulation kit (bush, insulating washer) & heatsink compound
4 M3 x 10mm tapped spacers
4 M3 x 6mm pan head screws
1 M3 x 10mm pan head screw
5 M3 nuts
1 M3 flat washer

**Semiconductors**
1 LM1875T 20W audio amplifier (IC1)

**Capacitors**
2 220µF 35V PC electrolytic
1 22µF 16V non-polarised (bipolar) PC electrolytic
1 2.2µF 16V non-polarised (bipolar) PC electrolytic
1 220nF 100V metallised polyester
2 100nF 50V monolithic ceramic
1 330pF 50V ceramic disc

**Resistors** (0.25W 1%)
1 1MΩ  2 22kΩ  2 1kΩ
1 10Ω  1 1Ω 1W 5%

### Power Supply

1 PC board, coded 614, available from the *EPE PCB Service*, size 90mm x 54.5mm
4 1N5404 3A power diodes (D1-D4)
2 4700µF 35V (or 50V) PC electrolytic capacitors
1 18V+18V 80VA mains transformer
2 3-way 5mm/5.08mm terminal blocks
4 M3 x 10mm tapped spacers
4 M3 x 6mm pan head screws

M4 x 10mm screw, two nuts and star washers, and a double-ended solder lug for securing the metal chasis earthing point

Parts for optional preamp supply section
2 15V 1W Zener diodes (ZD1,ZD2)
2 100µF 16V PC electrolytic capacitors
2 560Ω 1W 5% resistors
1 3-way 5mm/5.08mm terminal block

that all parts are correctly located and oriented. That done, install the fuses and connect the power supply leads, taking particular care that you have the positive and negative leads around the right way!

Do not connect the loudspeaker or an audio input signal at this stage.

Note that you must have the heatsink fitted, as the LM1875 has to dissipate substantial power even without an audio signal present.

Check the supply rail voltages first – these must be within 10% of the nominal value. Finally, check the DC voltage across the loudspeaker terminals. It should be less than ±50mV.

If this checks out, the loudspeaker can be connected (switch off first) and an audio input signal applied for final testing. ***EPE***

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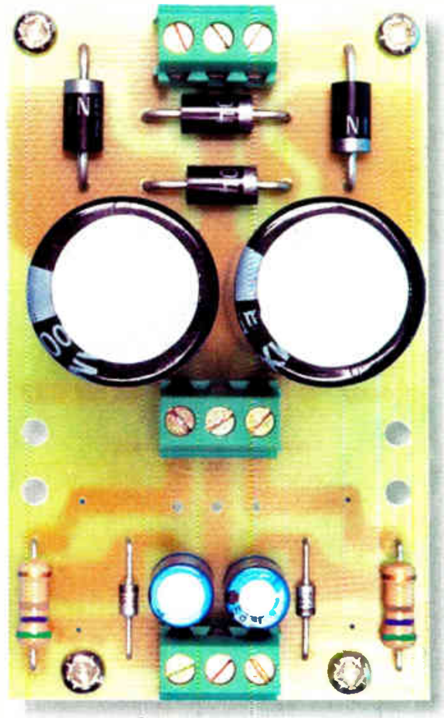

This view shows the completed power supply for the amplifier. The components at the bottom are for the optional ±15V preamp power supply and may be left out if not required.

# All Change

**Automotive electronics looks set to change gear, as Mark Nelson reports**

FEW of the technologies in daily use change dramatically, although you might say the transition to digital photography from analogue film was pretty fundamental. More often it's evolution rather than revolution, as with cars. But automotive electronics looks shortly set to change gear quite significantly.

Ask most car enthusiasts what's going on in their world from a technology perspective and they'll probably mention the dash for diesel or perhaps a move to biofuels. We certainly need to make our cars more economical; currently only some 40 percent of British cars run on diesel although across the Channel in France the figure is closer to 70 percent. We also need to make our cars more economically; more than 90 percent of the energy consumed by a car goes up in smoke during the manufacturing process itself, which is why scrapping still viable cars to buy less thirsty new ones doesn't make a huge lot of sense.

## ADAS unveiled

Crucial as fuel systems and energy efficiency are, let's leave them for a moment and consider how we can make drivers more efficient and effective. They have an equal role to play.

The buzzword today is Advanced Driver Assistance Systems – ADAS for short – electronic systems designed to help the driver in his or her process of driving. The German multinational company Siemens explains the need and advantages of ADAS like this. Complex traffic situations with increasing numbers of traffic participants always demand full attention. Intelligently linked comfort and safety systems support the driver and convey a more confident driving experience.

This is a diplomatic and very positive description of the benefits of ADAS but others put it more bluntly, that ADAS may be the only way to reduce the carnage on the roads. Road accidents are a frighteningly prolific cause of death according to the World Health Organization, racing from ninth most common reason worldwide in 1990 to third place in 2010.

Automobile manufacturers, equipment suppliers, governments and academics are in broad agreement that ADAS technologies represent our best hope of automotive accident avoidance (the positive spin) or reducing the severity and lethality of car crashes (the negative presentation).

## Sleeping at the wheel

So what kind of electronics can we expect to find in ADAS? The key thing to grasp is that ADAS do not reduce driver responsibility. They are neither a control mechanism nor even an automatic pilot or failsafe system. So no sleeping at the wheel. Instead, ADAS alert drivers to facts they may be unaware of, providing drivers with all the information they need to know. Active intervention systems may come later but it's unlikely that the first generation of ADAS will dare go this far.

Cunningly, they avoid 'information overload' by prioritising the information you need to know. As the Siemens literature explains, all the information collected is evaluated continually and imperceptibly for the driver, presenting only what he or she needs to know. A clearly defined prioritisation process decides how relevant each kind of information is in each respective situation and which system should be used to alert the driver. Depending on the requirement, it can be a head-up-display appearing 'inlaid in light' on the windscreen, an LED in the door frame out of direct vision or perhaps a discreet steering correction.

## Elementary stuff

So what are the main elements of ADAS? Chief among these are:

- Adaptive cruise control
- Drowsiness detection, with audible alarms and a blast of icy air
- Blind spot detection
- Parking assistance
- Night vision
- Pedestrian and cyclist detection
- Lane-change warning
- Traffic sign (speed limit) recognition
- Minimum distance maintenance in slow-moving traffic to avoid low-speed crashes.

This is by no means an exhaustive list, but it gives you a good flavour of what's feasible. Ignoring the information processing techniques, the data gathering devices are quite fascinating. Traffic sign recognition and lane-change warning will rely on miniature CMOS cameras, whilst enhanced night vision will use infrared sensors. Adaptive cruise control will most likely employ radar, whilst parking assistance will make use of ultrasound.

Digital signal processing will underpin all of these processes, which is where companies such as Siemens and Texas Instruments are in the lead with dedicated data acquisition devices, signal processors and the digital media processors necessary for handling and presenting the output of all this processed information.

All of which sounds very good, especially if ADAS live up to their promise and manufacturers can agree on standard interfaces and electrical interchangeability. We can all look forward to safer and calmer motoring, as well as fascinating new articles in this magazine once low-cost video, radar and ultrasound modules filter down into our domain.

## Boon or gimmick?

What we don't know yet is how the public will react to ADAS. Will they pay the extra for what will presumably be an optional extra? Will they scorn devices that call into question their driving skills or disable anything they think might reduce their control? Or might ADAS lull drivers into a false sense of security or reduce individual responsibility, leaving all that to the magic box?

Research undertaken into public attitudes by P.T. Blythe and A. Curtis of Newcastle upon Tyne University indicates that ADAS should find ready acceptance. Most people have little awareness of ADAS applications but perceive them to offer both safety plus ease and comfort benefits. The academics say attitudes are favourable towards such systems providing they can be switched off by the driver and negative when they cannot. Nonetheless, people are only willing to pay for those applications that they can easily and readily identify as having a clear and direct benefit for them, and even then they are reluctant to fork out much for these advantages.

Blyth and Curtis suggest that if ADAS applications are to find commercial success, good public education is vital, possibly with tax advantages for those prepared to take them up. Possibly the greatest barrier to the introduction of ADAS will lie not in public attitudes but determining where legal responsibility would lie should the systems fail. Watch this space!

## Great balls of, er, silicon?

New research has been published on ball lightning, which you may remember we discussed last year. Brazilian scientists are the latest team to have created ball lightning artificially and according to physicist Antonio Pavão and doctoral student Gerson Paiva of the Federal University of Pernambuco, the physical manifestation that others and I have seen is silicon vapour. They postulate the silicon vapour is created when forked lightning hits soil in the ground and effectively burns it in the air.

According to *National Geographic* magazine, Pavão and Paiva simulated the process using electrodes to shock silicon wafers with enough electricity to create a silicon vapour. Most of the artificial orbs lasted two to five seconds.


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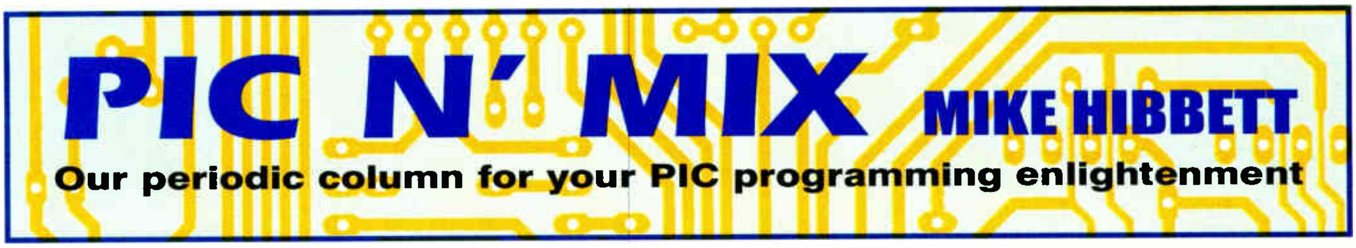


## PICs and USARTs – A PICs USART is another valuable internal peripheral facility

LAST month we discussed Timers, a frequently used internal peripheral. This month we look at another popular peripheral, the USART. Unlike a timer, the USART provides an external interface for the microcontroller and finds uses in many projects that require connection to a PC or another complex electronic device.

Before we dive in, however, we should discuss what the acronym USART stands for, and describe the operating modes. The details appear complex but like many aspects of microcontroller design, its application to a project can be quite straightforward, as we will see later.

### The USART

USART stands for Universal Synchronous/Asynchronous Receiver Transmitter. A bit of a mouthful and somewhat misleading, since many of us associate receivers and transmitters with radios. Here, it refers to data – sending and receiving information over port pins using some kind of protocol. (Protocol means 'an agreed method of exchanging information', a term stolen from diplomacy circles.)

As you might guess from the name, a USART supports two modes of communication: Synchronous and Asynchronous. Both use a single pin to transfer data in a serial fashion, bit by bit. Both the transmitter and the receiver need to agree on the rate at which the data bits are transferred, and this is where the two modes differ.

Fig.1 shows data communication in synchronous mode. Only one pin is used for transferring data, but another is used to send a 'clock' signal to the receiver so it knows when to sample the data line. This way the two devices do not need to share knowledge of the data rate; the clock, generated by the master, synchronises the receiver to the incoming data.

In synchronous mode the USART peripheral uses only two port pins for communication, so transmission and reception cannot occur simultaneously. One must transmit, then change to receive mode to get any returned data. This is called 'half-duplex' communication.

The additional benefit of synchronous communication is that the speed at which communication occurs can be varied dynamically, since data is only latched into the receiver on a clock edge.

Asynchronous communication on the other hand does not have a separate clock signal to indicate each data bit. The port pin previously used to provide the clock signal can now be used as another data signal, allowing simultaneous, bi-directional communication (referred to as 'full-duplex'.)

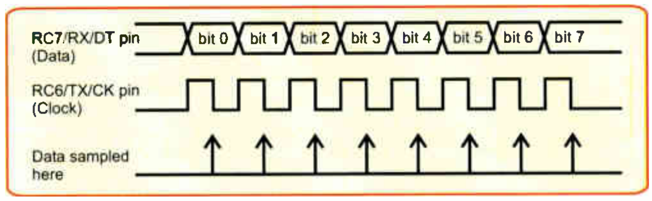


*Fig.1. Synchronous communication*

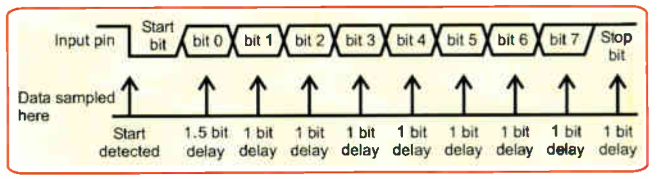


*Fig.2. Asynchronous communication*

Fig.2 demonstrates the reception of an asynchronous signal. The eight data bits are 'framed' by a start bit and a stop bit. The start and stop bits are the same size as a data bit. As there is no clock signal the receiver uses the initial negative transition of the start bit as a 'marker' for the incoming data. The receiver then delays by 1.5 times the length of a data bit, and takes a sample of the signal, by now hopefully in the middle of the first data bit.

This all relies heavily on the receiver and transmitter agreeing on the exact data rate, and having accurate internal timing (from a crystal oscillator for example) to ensure that one device does not drift relative to the other. The absence of a dedicated clock signal forces a requirement on the design to use precision oscillators. As most microcontroller designs do use precision oscillators anyway, this is not normally an issue.

### Synchronous mode

Where synchronous operation scores over asynchronous is that the rate at which the data bits are transferred from one chip to another is controlled by the master device. The receiver neither knows nor cares what the speed of the transfer will be; it will shift in a data bit only when the transmitter's clock signal toggles. This greatly simplifies the design of the interface (especially in smaller devices such as EEPROM memory) since the receiver does not need to generate an accurate clock signal that is precisely aligned to the other communicating device.

This benefit does come at the cost of an extra I/O pin needed for the clock signal, but that is a small price to pay in some circumstances. That is why you don't see asynchronous interfaces on small low cost devices like EEPROM memory – providing an accurate oscillator would cost more than the actual memory!

Examples of synchronous communication protocols include SPI and I²C. These are such common interfaces that Microchip provides a dedicated peripheral for those, so the USART is not often used in this mode. With speeds of up to 10M bits/second, however, synchronous mode is ideal for transferring data at high speed. Perfect for processor-to-processor communication in a PIC-based parallel computer for example (very definitely a subject for another article!).

### USART variants

The PIC range of microcontrollers implement a number of variants of the USART, including none at all on the smaller parts. (This is not necessarily a problem; there are ways to implement a software USART, as we will see later.) The differences are minor and once you have understood how to use one USART, you will have no trouble adapting to a different type on another processor.

The Addressable USART, or AUSART, provides a mechanism for adding a 'message address' byte into a transmission. Rather than generate interrupts on every byte detected over the serial interface, only bytes marked as address bytes will generate an interrupt. This is particularly useful in a multi-drop serial link where several devices are connected to the same serial bus. The microcontroller can ignore all data bytes except address bytes; when one of these is received, the processor can check to see if the address is for itself, and if so, enable normal data reception. It reduces the amount of time a processor spends processing data bytes that are not intended for itself, thereby freeing up time to do other important tasks, or remain in a low power mode.

The Enhanced USART, or EUSART, extends the AUSART features by adding automatic Baud rate detection into the hardware of the USART peripheral. Combined with a little software, it is possible for a slave device to align its Baud rate to that of a transmitter. It's a niche feature and in the author's opinion, best ignored.

Stick with a known Baud rate and crystal oscillators!

By far the most common use for the USART is as an asynchronous RS232 link to a PC. Despite seeming to be coming to the end of its life as a result of the USB standard, the ancient RS232 interface is still with us and likely to remain so for supporting legacy devices. An RS232 interface to a PC can be a valuable debugging aid during software development, enabling you to display memory, status messages or even the content of SFR registers. Although this sounds rather primitive, it's a technique that is frequently used in professional embedded software development.

The RS232 standard was created in the early 1960's and typically used to talk to modems, video terminals and their predecessors, teletype printers. The standard is now formally called EIA232 but most of us still refer to it by its original name. Linking to a PC is not the only use for a USART, however, as it is also a popular interface to GPS receivers and RF modems and so will continue to be an important interface for years to come.

## RS232 interface

A complete RS232 interface consists of several signals, not just receive and transmit data. Some of these signals are used for 'flow control' so that a receiver can instruct the transmitter to pause data transfer while it processes the data. These signals, called 'request to send' (RTS) and 'clear to send' (CTS) are not part of the USART peripheral and must be implemented using standard port I/O pins, should you wish to use them.

For most applications, however, hardware flow control is unnecessary as the handshaking can be done by the 'protocol' used to transfer data. Send some data, wait for an acknowledgement and then continue. It reduces the maximum data transfer rate, but simplifies the hardware and software design.

There is a surprising problem that should be taken into consideration when transferring data from a PIC-based design to a PC – if you transmit data from the PIC without delays between bytes the PC can lose data, since it is unable to respond fast enough to the data appearing on its serial port. This is a rather bizarre problem when one thinks about it; a PC running at 1GHz can be outgunned by a humble 4MHz PIC. This is because the PC has many other things to do (such as managing a TCP/IP stack, or running a virus scan in the background.) This can be avoided by adding a delay between bytes being sent out, or requiring an acknowledgement before continuing.

## USART use

So that's an overview of the USART and the different communication modes it can work in. Now, how do we use it?

The first place to start at is the block diagram in the datasheet, as we did with Timers last month. We are going to look at the Enhanced addressable USART in the PIC18F2420, a favourite of the author. The receiver and transmitter sections operate independently, and are shown as two separate block diagrams in Fig.3 and Fig.4. The block diagrams follow a similar style to the timer block diagram; the words in capitals are either special function register names or bits in registers.

The USART itself is really just a shift register, 'clocking' bits out onto a pin in the case of the transmitter, and clocking them in, in the case of a receiver. The rate at which this clocking occurs is determined by the Baud Rate Generator shown at position A in the diagrams. This is a register (or pair of registers, in the case of the PIC18F2420) that controls a divider circuit that reduces the main oscillator frequency down to the data rate required. There is a single Baud rate generator shared between the receiver and transmitter, but otherwise the receiver and transmitter are independent.

There are two pins associated with the USART, normally PORTC6 and PORTC7. These are multi-function pins that can be used for I/O if the USART functionality is not required.

In synchronous mode, port pin PORTC6 becomes the clock signal, and PORTC7 is either the receiver input or the transmitter output depending on the mode selected.

With asynchronous communication, reception is more complicated than transmission. The edge of the start bit marks the beginning of a data byte, and the CPU then samples the input pin at 16 different points within each data bit time period and the average used to decide if the signal is high or low at that point. As you might guess, the transmitter and receiver must have very similar Baud rates, otherwise the receiver will 'drift' and over the eight data bits being received will start to record incorrect data.

Problems like these can be very difficult to find, so it is best to make sure that both transmitter and receiver use good clock sources, such as a crystal or ceramic oscillator. A rule of thumb is that the clocks of the two communicating devices should be within 2% of each other, which rules out resistor-capacitor (RC) or inductor-capacitor (LC) circuits. Although an RC oscillator can be calibrated it will exhibit too large a variation across temperature and voltage extremes.

## Physical linking

Before setting up a USART, you need to make some decisions about how the physical link will operate. There are many options, and sometimes several ways to achieve the same result. Let's assume that the link will be asynchronous and not require any hardware flow control (the common setup), and that we are using a PIC18F2420 running at 20MHz. We need to consider the following:

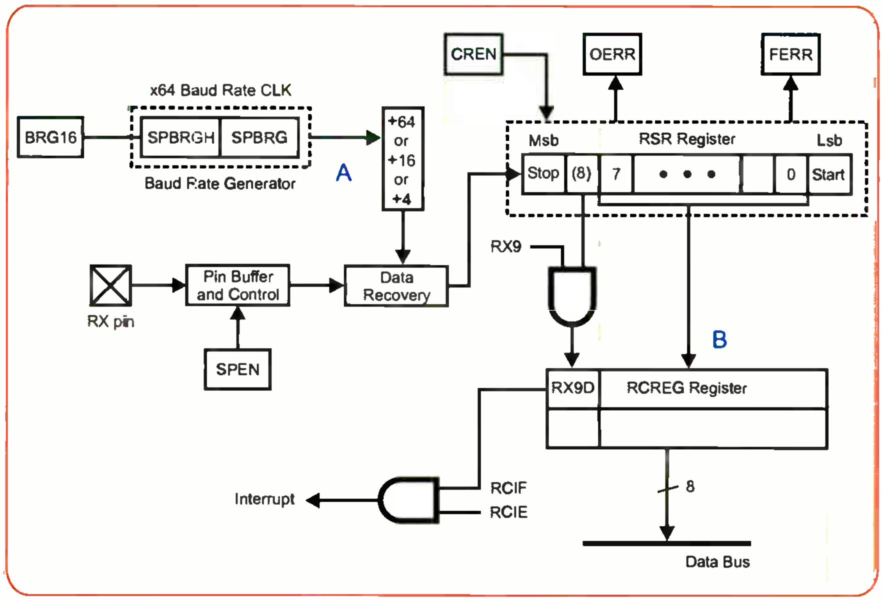


*Fig.3. USART receiver*

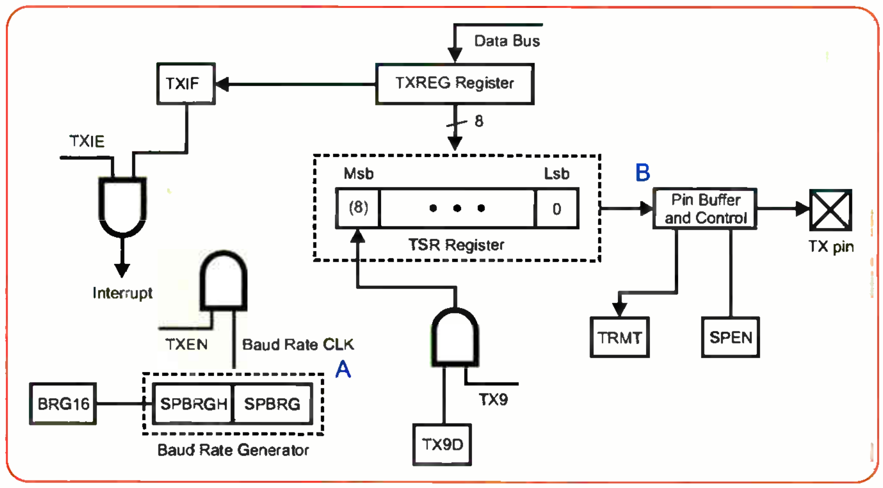


*Fig.4. USART transmitter*

**Baud Rate:** How fast do you want your link to run? Will you use a standard speed? If your interface is going to connect to a PC then you should ideally use one of the standard Baud rates such as 4800, 9600 or 115200. If the interface is going to display a simple text based menu on a PC then 9600 will be fine, although 115200 would be better, and easily achievable if you are running your processor off a fast enough clock.

**Baud Rate Settings:** There are three options for selecting the Baud rate, to give you the greatest flexibility in selecting a Baud rate for a given oscillator frequency. These are determined by the BRG16 and BRGH bits in the TXSTA and BAUDCON registers.

**Data Width:** Eight data bits is the standard, but you may want to add a 9th bit and use it for parity indication. A parity bit can help you identify a corrupted byte, but it isn't very effective and requires additional software written by yourself. You may have to use it if you are connecting to a third-party device that insists in transmitting parity (some magnetic card readers require this.)

**Address Recognition:** Are you connecting several devices to the same serial bus (like in RS485) and want to have hardware support for recognising address bytes? This is a useful feature in that case, but is not normally used in point-to-point links.

**Interrupts:** Are you going to have a simple system for sending and receiving data that just 'polls' the USART for status changes, or will you use interrupts? Interrupts complicate the coding effort but simplify the design, and allows for a more efficient use of the processor.

## Example

To start off with, let's decide on 115200 Baud, eight data bits, no parity, no address recognition and no interrupts. There are several special function registers that we need to set up before we can start using the USART.

The order in which we do them is like this:

Set PORTC6 to input
Set PORTC7 to input
Load SPBRG register
Load SPBRGH register
Set options in BAUDCON
Set options in TXSTA
Set options in RXSTA
Set CREN bit in RXSTA

The difficult part is in deciding what values to use for SPBRG and SPBRGH. There are three register bits that determine how these values are calculated and fortunately the datasheet gives a series of tables with example values for different clock sources (Table 18-3 in the PIC18F2420 datasheet.) These tables offer different SPBRG values for different settings of the SYNC, BRGH and BRG16 bits.

Taking our 20MHz clock source as an example, we can look at the various tables to find a match with our desired Baud rate of 115200. The first table gives an SPBRG value of 2 for that Baud rate, but with an error of 9.58%. That's not going to be good enough, so looking on two tables down, a value of 10 for SPBRG gives a 1.38% error (an actual Baud rate of 113636), close enough for our needs. To use this value the BRGH bit must be set, and BRG16 cleared (meaning that the BRG register is only 8 bits wide, not 16).

This is what the initialisation code would look like:

```
movlw  0xC0
movwf  TRISC
clrf   SPBRGH
movlw  0x0A
movwf  SPBRG
bsf    BAUDCON, BRG16
bsf    TXSTA, BRGH
bcf    TXSTA, SYNC
bsf    RCSTA, SPEN
bsf    RCSTA, CREN
```

To receive a byte, poll the RCIF bit in the PIR1 register, which will be set when a byte has been received. Before reading the byte it is important to check for any errors that may have occurred. To do this, read the RCSTA register and check the FERR and OERR bits. If either of these are set you must clear the error, otherwise the receiver will go 'mute' and ignore any further data. To clear an error issue the following instructions:

```
bcf    RCSTA, CREN
bcf    RCSTA, OERR
bcf    RCSTA, FERR
bsf    RCSTA, CREN
```

Transmitting a byte is somewhat easier; simply write the byte to be sent into the transmit register TXREG. Before writing a byte, however, one should check that the transmit shift register is not still busy sending a previous byte. This is done by polling the TXIF bit in the PIR1 register:

```
wait:
btfss  PIR1,TXIF
goto   wait
```

While using polling during transmission is quite reasonable, it is often impractical for reception. To enable interrupt processing, simply set the interrupt enable flags for PEIE, RCIE and the global interrupt enable flag GIE:

```
bsf    PIE1, RCIE
bsf    INTCON, PEIE
bsf    INTCON, GIE
```

Then within your interrupt routine, simply test the receiver flag:

```
int:
btfss  PIR1, RCIF
bra    otherCode

; check for error
; read byte
```

## Bit-bashing

It is possible to enable interrupts on other actions, such as the transmitter becoming empty, which would make a fully interrupt driven serial transmit and receive system possible. While the peripheral provides the interrupt events, you must write the software to support them yourself. Fortunately, as previously mentioned, there are many examples of code available.

Of course, it is possible to implement a USART in software without any special peripheral hardware support, by 'bit-bashing' the signal. This technique is used on smaller devices with no hardware support, or on larger parts when two or more USARTs are required. The *EPE CameraWatch2* project did this; it used the hardware USART for communicating with an embedded GPS module, and a 'bit-bashed' interface for providing an interface to a PC.

Bit-bashed transmission is straight forward. The algorithm would look like this:

```
INITIALISATION
set pin to output
set pin high

TRANSMIT
set pin low
delay 1 bit time
for each bit
  set pin to bit value
  delay 1 bit time
end for
set pin high
delay 1 bit time
```

You just need to ensure that the 1-bit delay is accurate, and that interrupts are not enabled during the transmission of a byte.

The receiver section of a bit-bashed USART is similar:

```
INITIALISATION
set pin to input

RECEIVE
wait for pin going low
delay 1.5 bit time
for each bit
  test input pin
  store bit level
  delay 1 bit time
end for
test input pin
if low, ignore data
```

Although this technique works, it has a few flaws. The error detection is not very good – a spurious glitch on the receive line would be detected as a data byte, and also the sampling of each data bit occurs only once in the middle of each bit. A real USART will take several samples in each data bit time, and average the samples.

Bit-bashing is also very time consuming since the CPU cannot do any other work while bytes are being transmitted. Since you have to perform very accurate delays in software, you cannot have interrupts enabled during transmission or reception. However, these limitations can often be acceptable.

## Application notes

The Microchip website **www.microchip.com** has a number of application notes on serial communications.

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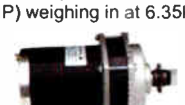

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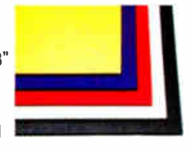

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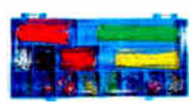

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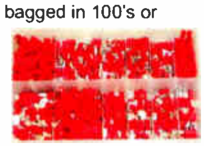

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Please check our website for opening hours and if making a long journey, we suggest phoning first to ensure stock availability. If ordering on-line, 90% of orders dispatched within 2 working days.


The photo at left shows the completed power supply module. Position the inductor (L1) so that it's well clear of surrounding components and secure it to the PC board using small cable ties. At right is a 5W Luxeon star LED, shown about 50% larger than actual size.

# STARPOWER

## High-efficiency supply for Luxeon Star LEDs

**Based on a switching regulator IC, this simple project is just the job for powering 1W to 5W ultrabright Luxeon Star LEDs. It's easy to build, runs off 12V DC and can be easily tailored to suit your requirements.**

By PETER SMITH

BACK IN THE October 2006 issue, we presented a simple linear power supply for powering 1W Luxeon Star LEDs from a 12V supply. Predictably, we've already received requests for a version that will drive the, brighter 3W and 5W Stars.

In addition, many constructors want a higher efficiency supply for use in boats, caravans and cars. This new design fits the bill and includes low battery cutout as well.

Unlike the original design, which is based on a linear regulator, this new supply employs a step-down switching regulator. The advantages of this method include much improved efficiency and significantly reduced heat generation.

In fact, when driving a single 3W Star, this supply is at least twice as efficient as a linear supply or simple current-limiting resistor. Obviously, this means longer battery life. Lower heat generation also means that you can build the supply into a case without the need for additional heatsinking.

The project can be powered from any 12V DC (nominal) supply and can be set up to source 350mA, 700mA or 1000mA of regulated current to suit the Luxeon Star LED range.

### Block diagram

The circuit is based around a Motorola MC34063 DC to DC converter IC. This chip contains all of the functions necessary to construct a complete low-power step-down switchmode regulator – see Fig.1.

A simplified block diagram of the step-down regulator appears in Fig.2. Essentially, when transistor Q1 switches on, current though the series inductor (L1) increases with time, storing energy in its magnetic field. When Q1 is switched off, the magnetic field collapses and the energy is discharged into the output filter capacitor and load via diode D3.

A free-running sawtooth oscillator in the MC34063 determines the maximum switch 'on' time. The 'on' time of the switch (Q1) versus its 'off' time determines the fraction of the input voltage that appears at the output.

IC1 controls the 'on' time by monitoring the voltage on its feedback pin. As this voltage falls below 1.25V, Q1's 'on' time increases. Conversely, as the feedback voltage increases, the 'on' time decreases. Complete 'on' cycles are skipped if the feedback voltage remains above the 1.25V set point for the duration of the 'on' period.

In a typical implementation, the feedback pin would be connected to the output via a voltage divider to regulate the output voltage. However, our design regulates output current instead.

Current through the LED(s) is sensed via resistor R1 and then amplified by op amp IC2. The result is applied to the feedback pin of IC1 via a trimpot, VR1,

## Main Features

- Powers one or two 1W or 3W Stars, or a single 5W Star
- High efficiency for minimum battery drain
- Low battery cutout (11.5V)
- Input polarity and transient protected
- Output short-circuit protected
- Ideal for use in boats, caravans and cars

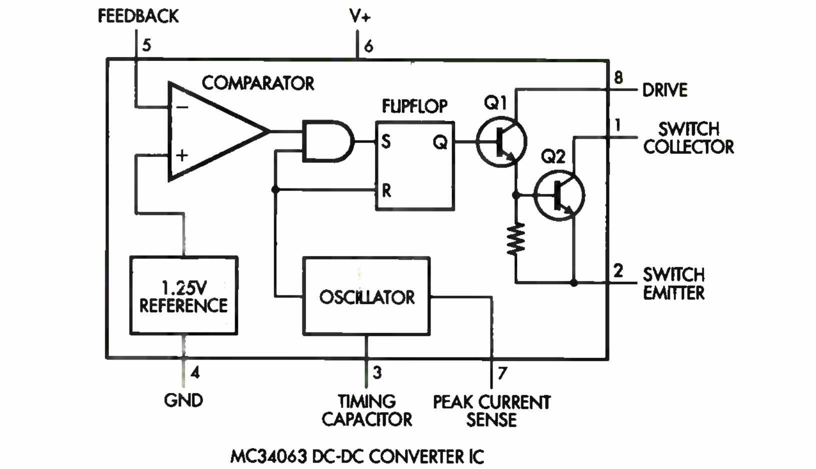



**Fig.1: inside the MC34063 DC-DC Converter IC. It contains the circuitry to build a step-up, step-down or inverting switching regulator.**

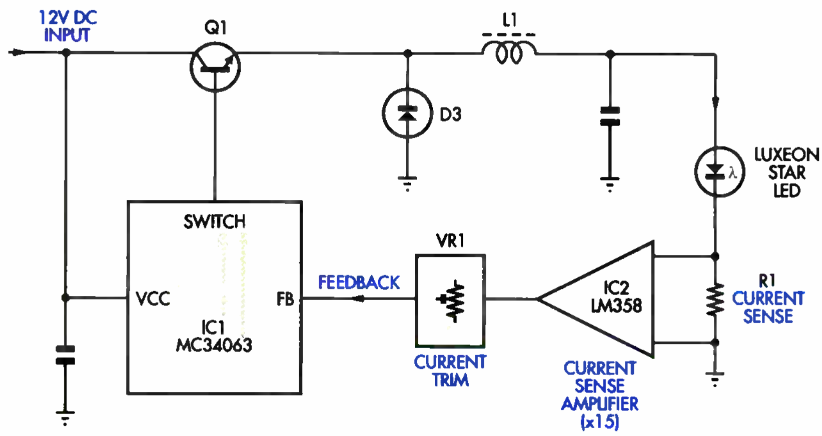



**Fig.2: the basic block diagram of the step-down switching regulator section. A fraction of the input voltage is transferred to the output under control of an MC34063 switching regulator IC. The LED current is regulated by sensing the voltage drop across a small series resistance (R1).**

allowing accurate current adjustment's to be made.

Simply put, the output current is regulated by maintaining the voltage across the sense resistor at about 100mV. In practice, the actual sense voltage depends on the value of R1 and the position of the trimpot VR1.

## Circuit details

The complete circuit diagram appears in Fig.3. Following the circuit from the input voltage side, diode D1 provides reverse-polarity protection. A Schottky type is used here to reduce voltage losses.

Next, a 24V Zener diode (ZD1) clamps input transients to less than the maximum voltage rating of downstream components. A 470µF capacitor then filters the input and provides a low-impedance source for the high-frequency switching circuitry.

As described earlier, transistor Q1 acts as a switch in series with the inductor (L1). A Zetex low $V_{CESAT}$ (collector-emitter saturation voltage) type was chosen for Q1 to improve efficiency and reduce heat dissipation.

The performance of the switching circuit is further enhanced by a turn-off speed-up circuit, which operates as follows:

During an 'on' cycle, transistors internal to the MC34063 switch on, bringing pins 1 and 8 towards ground. This forward-biases the base-emitter junction of Q1 via D4 and L2, switching the transistor on.

When the 'on' cycle ends, pins 1 and 8 go open circuit and the current through L2 ceases abruptly. The magnetic field around L2 collapses, generating a voltage of opposite polarity to the charge voltage. This forward-biases the base-emitter junction of Q2, momentarily switching it on and connecting the base of Q1 to its emitter.

This results in significantly faster turn-off of Q1 than is possible with a resistive pull-up alone. By minimising the transition time between saturation and turn-off, collector power dissipation, and therefore switching losses, are effectively reduced.

When Q1 switches off, diode D3 provides a discharge path for the inductor (L1) to the output filter capacitor and load. Again, a Schottky diode is used for its fast switching and low forward voltage characteristics. Note that we've specified high current (3A) devices in order to withstand a continuous short-circuit condition at the output.

In normal operation, the peak current that flows in the transistor and inductor during each switching cycle is well within the limits of the component ratings. However, with an overloaded or short-circuited output, or with excessively high input voltages, the peak current could increase to destructive levels.

To counteract this problem, IC1 senses peak current via a 0.15Ω 5W resistor in series with the input. When the peak voltage across this resistor nears 330mV, the MC34063 progressively reduces the maximum 'on' time of the switch by shortening the positive ramp of the oscillator.

## Current sensing

A resistor in series with the LED provides a means of sensing output current. The voltage developed across R1 is amplified by one half of a dual op amp (IC2b), which is configured as a differential amplifier. With the resistor values shown, the sense voltage is amplified by a factor of 15 and applied to one end of VR1.

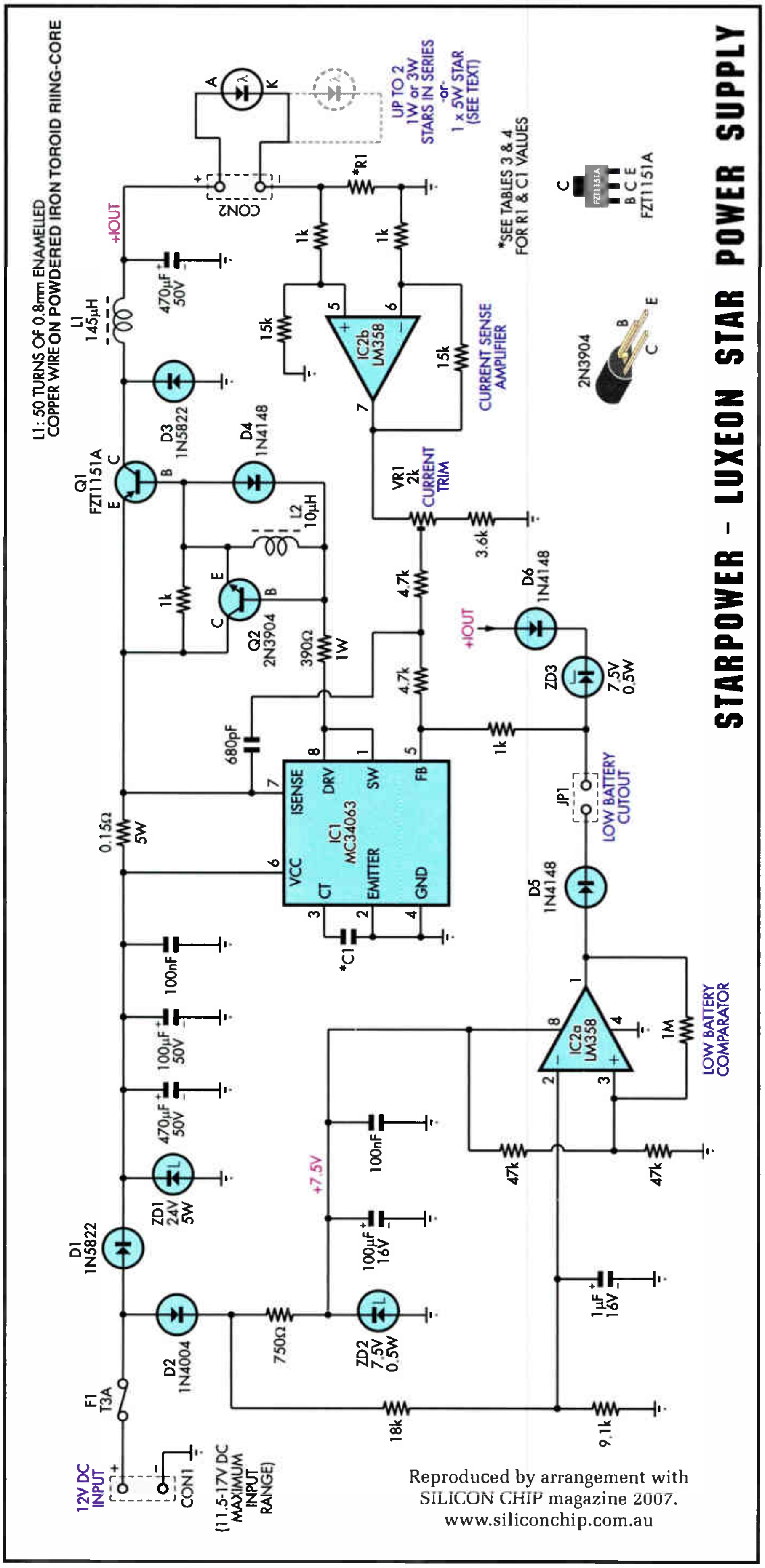



**Fig.3: the complete circuit diagram for the power supply module. A low VCE$_{SAT}$ transistor (Q1) is used for the switching circuit to minimise heat dissipation and improve efficiency. Output current is selectable in three ranges by choosing an appropriate value for R1.**

Effectively, trimpot VR1 provides a means of adjusting the voltage drop across R1. As the wiper is moved towards the top (clockwise), less voltage is required across R1 to satisfy the feedback loop, so the output current decreases. The opposite occurs when the wiper is moved downwards, attenuating the op amp's output and thus increasing the output current.

During construction, R1 is selected from Table 3 to suit the desired LED current. These values were chosen such that close to 100mV will be present across the resistor at the listed LED current level. It's then just a matter of adjusting VR1 to get the precise current level.

To reduce harmonics in the switching circuit, a novel scheme is used to 'feed forward' a small portion of the switching signal into the feedback circuit. This is achieved with a 680pF capacitor between the ISENSE and FB pins of IC1.

## Low battery cutout

IC2a is used as a simple voltage comparator for the low battery cutout circuit. It works as follows.

Zener diode ZD2 provides a clean +7.5V supply for this op amp. This 7.5V rail is also divided in half by two 47kΩ resistors to provide a reference voltage for the comparator on (non-inverting) pin 3. Similarly, the power supply input voltage is divided down by 18kΩ and 9.1kΩ resistors and applied to the negative (inverting) input (pin 2).

When the voltage on pin 2 falls below that on pin 3 (corresponding to less than 11.5V at the supply input), the output swings towards the positive rail, forcing IC1's feedback input above the 1.25V set point. This stops IC1 from switching and reduces the input current drain to quiescent levels (less than 10mA).

A 1MΩ resistor between the op amp output (pin 1) and its positive input ensures fast switching and provides a few hundred millivolts of hysteresis. In addition, a 1µF capacitor at the inverting input (pin 2) filters out any

## Parts List: Star Power – Luxeon LED Power Supply

1 PC board, code 615, available from the *EPE PCB Service*, size 105mm x 60mm
1 powdered-iron toroid ring-core, 28 x 14 x 11mm (L1 – see text)
170cm (approx) 0.8mm enamelled copper wire
1 10µH RF choke (L2)
2 2-way 5mm (or 5.08mm) terminal blocks (CON1, CON2)
1 2-way 2.54mm SIL header (JP1)
1 jumper shunt (JP1)
1 8-pin IC socket
2 M205 PC mount fuse clips
1 M205 3A slow blow fuse
4 M3 x 10mm tapped spacers
4 M3 x 6mm pan head screws
2 small cable ties
1 heatsink for 3W or 5W LEDs (see text)
1 2kΩ miniature horizontal trimpot (VR1)

Heavy-duty (7.5A) cable for power input and LED output wiring. (Cable length between output and LEDs should be no more than (25cm.)

**Semiconductors**
1 MC34063 DC-DC converter (IC1)
1 LM358 dual op amp (IC2)
1 FZT1151A PNP transistor (Q1)
1 2N3904 NPN transistor (Q2)
2 1N5822 3W Schottky diodes (D1, D3)
1 1N4004 diode (D2)
3 1N4148 signal diodes (D4 - D6)
1 24V 5W Zener diode (ZD1)
2 7.5V 0.5W (or 1W) Zener diodes (ZD2, ZD3)
1 or 2 1W or 3W Luxeon Star LEDs; or 1 5W Luxeon Star LED (see text)

**Capacitors**
2 470µF 50V low-ESR PC electrolytic
1 100µF 50V low-ESR PC electrolytic
1 100µF 16V PC electrolytic
1 1µF 16V PC electrolytic
2 100nF 50V monolithic ceramic
1 1.2nF 50V ceramic disc (or polyester) — see text
2 680pF 50V ceramic disc — see text
1 560pF 50V ceramic disc — see text
1 330pF 50V ceramic disc — see text

**Resistors** (0.25W 1%)

| | |
|---|---|
| 1 1MΩ | 2 4.7kΩ |
| 2 47kΩ | 1 3.6kΩ |
| 1 18kΩ | 4 1kΩ |
| 2 15kΩ | 1 750Ω |
| 1 9.1kΩ | 1 390Ω 1W 5% |

2 0.15Ω 5W (or 3W) 5% — see text
1 0.1Ω 5W (or 3W) 5% — see text
1 0.27Ω 5W (or 3W) 5% — see text

**Additional resistors for testing**
1 10Ω 5W 5% (350mA test)
1 4.7Ω 5W 5% (700mA test)
1 3.3Ω 5W 5% (1000mA test)

momentary transients and ensures that the negative input remains below the positive input during power up.

Note that despite this filtering, the LED will flash momentarily at power on and power off. This is because unlike the LM358 op amp, the MC34063 operates right down to 3V.

Finally, a series diode (D6) and 7.5V Zener diode (ZD3) connected between the output and the feedback circuits prevents the output voltage rising much above 9V if the LED is inadvertently disconnected. This helps to reduce the peak current flow that occurs if the output is reconnected with power applied.

## Construction

The assembly is straightforward, with all the parts mounted on a PC board coded 615 and measuring 105 x 60mm. The parts are all installed on the board in the conventional manner, except for switching transistor Q1, a surface-mount (SMT) device, which is installed on the copper side (Fig.6).

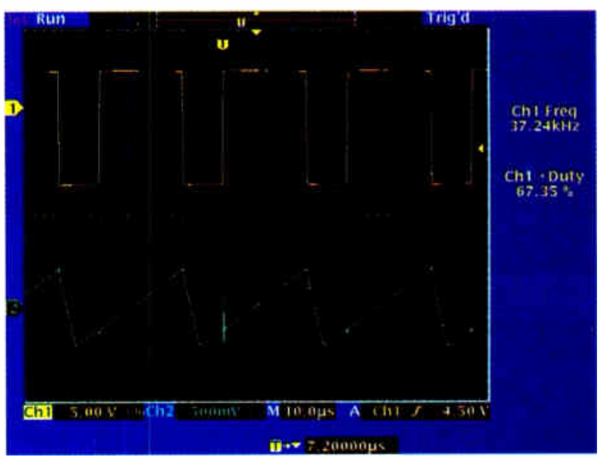



**Fig.4: this scope shot shows the switching waveform present on the cathode of D3 (top trace) versus the MC34063's on-board oscillator on pin 3 (bottom trace). Note that the switching frequency will vary significantly according to LED type and number and will not necessarily equal the oscillator frequency.**

The first job is to mount Q1. Although this is an SMT device, it has relatively large pins with ample spacing that are easy to solder.

To install it, place the copper side of the board up and position Q1 precisely as shown on the overlay diagram (Fig.6) before soldering the leads.

With Q1 in place, turn the board over and install the two wire links using 0.7mm tinned copper wire or similar. One of the links (shown dotted) goes underneath IC2, so it's important that it goes in first!

Next, install all the low-profile components, starting with the 0.25W resistors and diodes. All the diodes, including the Zeners, are polarised devices and are installed with their banded ends oriented as shown.

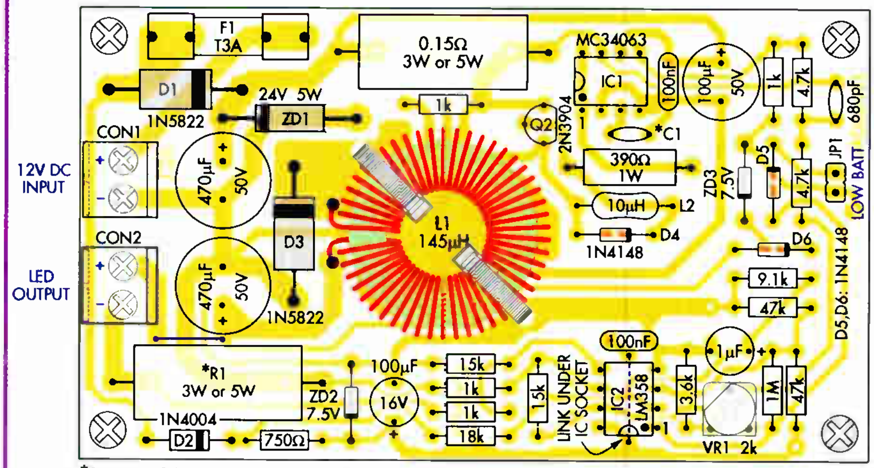
An IC socket can be installed for IC2. However, IC1 should be soldered directly to the board (no socket!) to eliminate the effects of contact resistance. Be sure to align the notched (pin 1) ends as indicated.

All remaining components can now be installed except for the electrolytic capacitors. It's easier to leave these until after the inductor (L1) is in place.

Select appropriate values for C1 and R1 from Tables 3 and 4. It's very important that these match your intended application (type of LED and one or two LEDs in series). The parts list includes all of these parts, so you will have an extra three ceramic capacitors and two 5W (or 3W) resistors left over once assembly is complete.

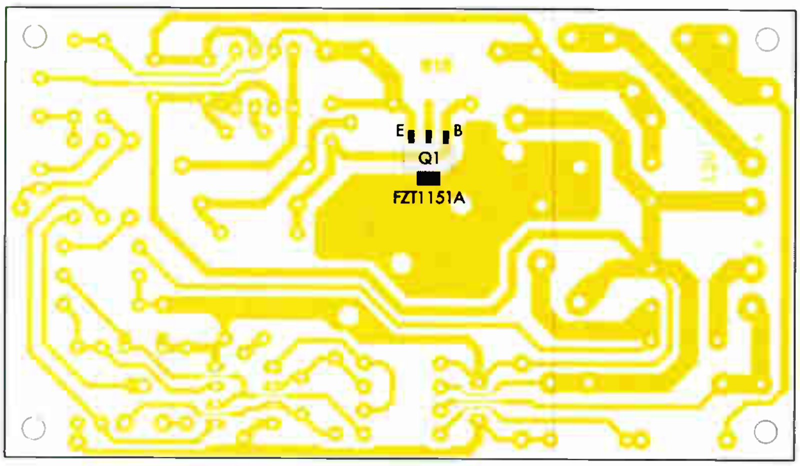
## Winding the inductor

The inductor (L1) must be hand-wound using the specified toroidal core and about 170cm of 0.8mm enamelled copper wire. Play out the wire into a straight length, removing any kinks before you begin.




*SEE TABLES 3 & 4 FOR R1 & C1 VALUES

**Fig.5: follow this layout diagram when installing the parts on the PC board and don't forget the link under IC2.**




BOTTOM (COPPER) SIDE

**Fig.6: the mounting details for transistor Q1. It's soldered on the copper side of the board using a fine-tipped soldering iron.**

It's easier to wind one half at a time, so start by feeding about half of the wire through the centre of the core. Wind on the first half using firm even tension and keep the turns as close as possible without overlapping.

Now repeat this procedure with the second half of the wire. In total, the core will accommodate 50 turns if there are no gaps between adjacent turns on the inside of the core.

Now count the total number of turns. With a bit of luck, you should have 49 or 50 (one less is OK!). Trim and fashion the ends of the wire so that the assembly slips home easily into the holes in the PC board with a few millimetres protruding out the opposite side.

Next, scrape the enamel off the ends of the wire, tin them and reposition the inductor on the PC board. Don't solder the wires just yet though. It's important to first attach the inductor to the board using small cable ties. Position the inductor so that it is well clear of surrounding components before tightening up the ties. That done, solder and trim the wire ends.

Finally, install all the electrolytic capacitors to complete the job. Take particular care with orientation – their positive leads must go in as indicated by the '+' markings on the overlay diagram.

## Setup and testing

Before connecting an LED to the output for the first time, the supply should be checked for correct operation. During the test, we'll also set the output current to an initial value to suit the type of LEDs being used.

The test involves inserting a 5W test resistor in the LED output terminals.

## Table 2: Capacitor Codes

| Value | µF Code | EIA Code | IEC Code |
|---|---|---|---|
| 100nF | 0.1µF | 104 | 100n |
| 1.2nF | 0.0012µF | 122 | 1n2 |
| 680pF | – | 681 | 680p |
| 560pF | – | 561 | 560p |
| 330pF | – | 331 | 330p |

## Table 1: Resistor Colour Codes

| | No. | Value | 4-Band Code (1%) | 5-Band Code (1%) |
|---|---|---|---|---|
| ❑ | 1 | 1MΩ | brown black green brown | brown black black yellow brown |
| ❑ | 2 | 47kΩ | yellow violet orange brown | yellow violet black red brown |
| ❑ | 1 | 18kΩ | brown grey orange brown | brown grey black red brown |
| ❑ | 2 | 15kΩ | brown green orange brown | brown green black red brown |
| ❑ | 1 | 9.1kΩ | white brown red brown | white brown black brown brown |
| ❑ | 2 | 4.7kΩ | yellow violet red brown | yellow violet black brown brown |
| ❑ | 1 | 3.6kΩ | orange blue red brown | orange blue black brown brown |
| ❑ | 4 | 1kΩ | brown black red brown | brown black black brown brown |
| ❑ | 1 | 750Ω | violet green brown brown | violet green black black brown |
| ❑ | 1 | 390Ω 5% | orange white brown gold | not applicable |

The resistor value to use depends on the output current level selected during assembly. For 350mA of current, use a 10Ω test resistor, for 700mA a 4.7Ω value and 1000mA a 3.3Ω value.

Don't cut the resistor leads short. It should be screwed into the LED output terminal block and suspended in mid-air, such that it's not in contact with anything; **it will get very hot!** *With this in mind, the circuit should not be powered up for more than a few minutes with the test resistor in place.*

Remove the jumper shunt on JP1 if you installed it earlier and rotate VR1 fully clockwise. Connect a 12V DC (1A or higher) power source to the input terminals and power up. Monitor the voltage across R1 (not the test resistor) with your multimeter and adjust VR1 to get the desired current level. The correct sense voltage for each current level is listed in Table 3.

For example, if you want 700mA for a 3W LED, you will have installed a 0.15Ω resistor for R1, so adjust VR1 to get a 105mV reading on your meter.

If all checks out, you're almost ready to go. Remove the test resistor and replace it with the Star LED leads. Power up again and check that the voltage across R1 is as previously set. If necessary, readjust VR1 to get the listed reading.

***Note: the light output from these LEDs could damage your eyesight. Do not stare directly into the LED beam at close range!***

If you have a variable DC bench supply, you can also test the low battery cutout circuit by slowly reducing the input voltage. At about 11.5V, the LED should switch off. Remember to install the jumper shunt on JP1 to enable this function.

*Note: in a quiet environment, you may be able to hear a low level 'squeal' coming from the inductor (L1). This is completely normal and is due to the harmonics caused by the gated oscillator architecture of the MC34063 switching regulator IC.*

## Fault-finding

If your meter reads way off the mark and/or adjusting VR1 has no effect, then there is a fault on the board. Switch off immediately and remove the test resistor, then power up again with nothing connected to the output.

With your meter set to read volts, first measure between pins 1 and 8 of IC2. These are the op amp supply pins, so you should get close to 7.5V. If not, look for problems around ZD2 and its associated circuitry.

Next, measure between pins 6 and 4 of IC1. Again, these are the supply pins of the IC, but this time, expect about 0.3V less than the input voltage.

If you have an oscilloscope, you can check that the oscillator in the MC34063 is working by examining the waveform on pin 3. You should see a clean sawtooth waveform like that shown in Fig.4.

Assuming the above measurements are OK, then it's back to basics. Examine the board closely for correct component placement and soldering defects, especially around IC1, IC2 and the 100µF 16V capacitor. It's easy to get solder bridges between the closely spaced tracks in these areas.

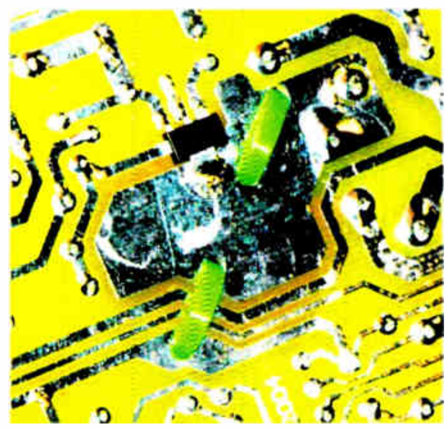
## Mounting and wiring

The completed power supply module can be mounted without an enclosure if a protected location is available. Alternatively, it can be housed in a UB3-sized box for ruggedness.

For marine applications, the entire assembly will need to be conformally coated or installed in a sealed enclosure to keep corrosion at bay.

The power input and LED output wiring must be run using heavy-duty (7.5A) cable. We recommend no more than

**Bend and shape the ends of the winding so that the assembly slips easily into the holes in the PC board. This shot of the underside of L1 shows the general idea, although this core doesn't have the full 50 turns!**



**This larger-than-life size view shows how transistor Q1 is mounted on the underside of the PC board.**

**Table 3: Selecting Resistor R1**

| LED Type | LED Current | R1 | Sense Voltage |
|---|---|---|---|
| 1W Star | 350mA | 0.27Ω | 94.5mV |
| 3W Star | 700mA | 0.15Ω | 105mV |
| 3W Star | 1000mA | 0.1Ω | 100mV |
| 5W Star | 700mA | 0.15Ω | 105mV |

**Table 4: Selecting Capacitor C1**

| LED Type | No. of LEDs in Series | Colour | C1 |
|---|---|---|---|
| 1W Star | 1 | Red, Red-Orange, Amber | 330pF |
| 1W Star | 2 | Red, Red-Orange, Amber | 680pF |
| 1W Star | 1 | White, Green, Cyan, Blue, Royal Blue | 560pF |
| 1W Star | 2 | White, Green, Cyan, Blue, Royal Blue | 1.2nF |
| 3W Star | 1 | All | 560pF |
| 3W Star | 2 | All | 1.2nF |
| 5W Star | 1 | All | 1.2nF |

about 25cm of cable length between the power supply output and the LEDs.

## Keeping your LEDs cool

This project can be used to power any of the 1W, 3W or 5W Luxeon Star range. Out of these, the 1W version is by far the easiest to use because of its relaxed heatsinking requirements.

In fact, when operated in low ambient temperatures, no additional heatsinking is necessary for versions with board mounted optics (Star/O).

However, in most real-world applications, a small heatsink will help to keep the LED junction temperature within spec, as well as prevent heat damage to the acrylic lens. This can often be as simple as a flat metal panel or the lid of a metal case, for example.

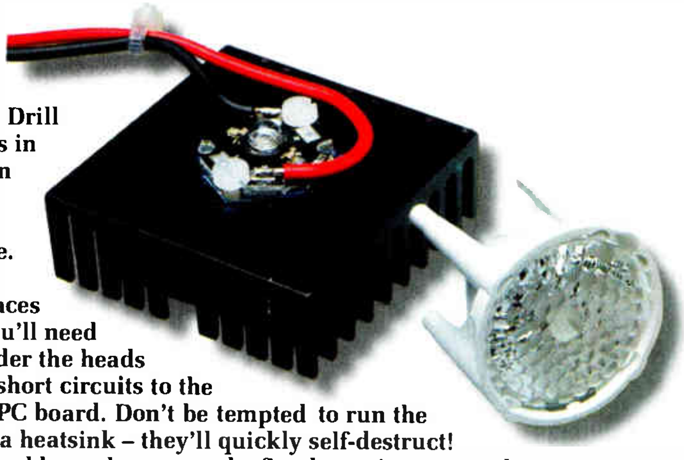
Unlike the 1W types, the 3W and 5W Stars require careful attention to heatsinking, particularly when reliability and long service life are important. Despite this requirement, the excellent 'lumens per pound' rating of the 3W Stars definitely makes them worth a look. So how is the heatsink size determined? Let's find out!

## Heatsink basics

We can calculate the required heatsink thermal resistance once we know the maximum junction temperature, ambient temperature and power dissipated.

As only about 10% of the input power to the LED is emitted as light, it is disregarded in the following calculations. Assuming a nominal LED forward voltage of 3.6V, power dissipation can be found using Ohms law:

$P_D = V/I = 3.6V/1A = 3.6W$



**We mounted our 3W Star on a 48mm square heatsink pinched from an old 486 motherboard. Drill two 3mm mounting holes in line with the slot between the fins and then deburr the holes to obtain a smooth mounting surface. A thin smear of heatsink compound between surfaces will aid heat transfer. You'll need to use nylon washers under the heads of the screws to prevent short circuits to the solder pads on the Star PC board. Don't be tempted to run the 3W or 5W Stars without a heatsink – they'll quickly self-destruct! Wide, narrow and elliptical beam lenses can be fitted to suit most applications.**

Using the absolute maximum LED junction temperature of 135°C and an ambient temperature of 25°C, the junction to ambient thermal resistance is:

$$RTH_{J\text{-}A} = T_J - T_A / P_D$$
$$= 135°C - 25°C / 3.6W$$
$$= 30.5°C/W$$

Next, subtract the junction to board resistance ($RTH_{J\text{-}B}$) listed in the datasheet to find the board to ambient thermal resistance. For most board-mounted Stars, this is 17°C/W:

$$RTH_{B\text{-}A} = RTH_{J\text{-}A} - RTH_{J\text{-}B}$$
$$= 30.5°C/W - 17°C/W$$
$$= 13.5°C/W$$

The result is the maximum allowable heatsink resistance needed to keep the LED junction temperature at or below the maximum rating at 25°C ambient.

The 48 × 48mm finned heatsink shown in the adjacent photo was originally designed for cooling Intel 486 and Motorola 68000 series microprocessors but works equally well here. According to our rough calculations, it has a thermal resistance of about 8°C/W when operated in free air in the vertical position.

So far, we've assumed operation up to the maximum LED junction temperature of 135°C. However, when operated continuously at this maximum, LED light output decreases quite markedly over time. To achieve the 20,000 hours at 50% lumen maintenance figure shown in the datasheets, Lumileds specifies a lower maximum junction temperature of 90°C.

Reworking the figures for this lower temperature, you can see that a heatsink resistance of 1°C/W would be required. This would be difficult to implement in practice, necessitating a bulky heatsink, perhaps even with forced-air cooling.

For maximum life with a realistic heatsink size, the answer is to drive the LEDs at reduced current. For this reason, Lumileds also characterises the 3W Star for operation at 700mA, stating lumen maintenance of 70% after 50,000 hours at the lower temperature figure.

The maximum heatsink resistance needed in this case is 8.8°C/W at 25°C ambient, meaning our chosen heatsink barely makes the grade. If operation in the horizontal position is required or higher ambient temperatures are likely, then a lower resistance heatsink is needed.

The above information is also applicable to the 5W Star, although it's life versus junction temperature figures are radically different to the 3W version. Note also that it's rated for a maximum of 700mA forward current and has a higher forward voltage than the 3W device. Refer to the individual device datasheets for more information.

To learn all about heatsinking, check out the 'Thermal Design using Luxeon Power Light Sources' application brief, available from the Lumileds website at **www.lumileds.com**. *EPE*

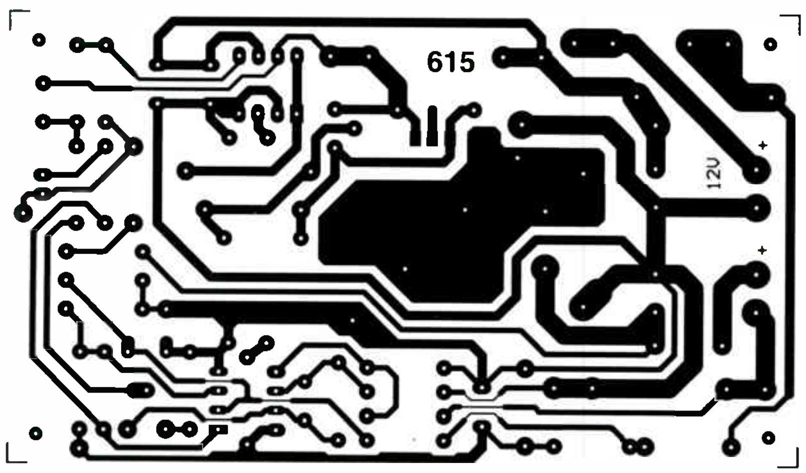



**Fig.7: this is the full-size etching pattern for the PC board.**

# FREE ENTRY COMPETITION


## Win a Microchip PICkit 2 Debug Express Kit!

***Everyday Practical Electronics*** **is offering its readers the chance to win one of three Microchip PICkit 2 Debug Express Kits! The kit supports Microchip's popular PICkit™2 development programmer by allowing in-circuit debugging of selected PIC microcontrollers. This enables engineers to begin development with PIC microcontrollers for a very low initial investment. The kit connects to any personal computer via USB, and its in-circuit debugging features include halt, single step and setting a breakpoint.**

**The Kit includes Microchip's 44-pin PIC16F917 Flash microcontroller demo board, the PICkit 2 programmer, USB cable and software CDs, including Microchip's free MPLAB® IDE, integrated development environment, and a host of other software – enabling new users to easily get started with an embedded control design.**

**For the chance to win a PICkit 2 Debug Express Kit, log onto www.microchip-comp .com/epe-pickit2debug and enter your details in the online entry form.**

# INTERFACE

## Robert Penfold

### ARE YOUR SOFTWARE PROGRAMS VISTA COMPATIBLE?

AT the time of writing this piece, the new Windows Vista operating system had just been launched by Microsoft. From the point of view of writing software for use with PC add-ons, the launch of Windows XP, a little over five years ago, was not particularly helpful.

In fact, it was quite troublesome, and produced problems with many existing programs that had worked well with Windows 98 and ME. New programs written using tried and tested methods often failed to operate with Windows XP. On the plus side, existing programming languages such as Visual BASIC 5 and 6 worked well under this operating system.

#### Losing Touch

The main problem with the new Windows XP was that it did not permit direct control of the addresses in the input/output map. This meant that writing directly to hardware at its output address did not work. Reading direct from an input address was equally ineffective. In order to ensure that conflicts were avoided, the operating system required read and write operations to the ports to be handled via its official and well controlled routes.

This was not actually new, and was a requirement when using Windows NT or 2000. Windows XP was the upgrade path for these operating systems, and for Windows 98 and ME. Upgrading from Windows NT or 2000 was relatively straightforward, but there were big differences between Windows 98/ME and Windows XP.

Programs that handled the ports directly worked well under Windows 98/ME, but at best with Windows XP they failed to control or read from the add-on gadget. Some programs ground to a halt with error messages while others crashed the computer.

Ways around this problem were found, and on the face of it these should work as well with Windows Vista as they did with XP. With some methods this is probably the case, but it would be naïve to expect all programs for PC add-ons that worked perfectly well with Windows XP will perform equally flawlessly under Vista. Apart from this specific issue, there are other potential problems due to general compatibility matters.

#### Runtime Modules

An important point to keep in mind here is that some programming languages do not produce fully-compiled programs, and Visual BASIC 6 is certainly in this category. Some programs written in Visual BASIC 6, and other versions of this programming language, seem remarkably small when they are compiled. The usual reason for this is that the program is relying on one or more runtime modules, which are mostly in the form of dynamic link library (DLL) files, but there are a few other types, such as ActiveX (OCX) files.

Many of these runtime modules are supplied with a modern version of Windows and are included as part of a standard installation. Consequently, there is normally no need to distribute them with Visual BASIC programs.

Unfortunately, only a subset of tried and tested runtime modules are supplied with Windows Vista. This leaves a substantial number of modules that are also tried and tested with Vista, but are not supplied as part of the Vista operating system.

A full list of the modules supplied as part of Vista, plus a list of those that have been tested but are not included, can be found at this web page:

**http://msdn2.microsoft.com/en-us/vbrun/ms788708.aspx**

One notable omission from the runtime modules supplied with Vista is the **mscomm32.ocx** ActiveX component that enables Visual BASIC 6 to access the serial (COM) ports. However, this module is in the list of tried and tested modules not included with Vista, so programs that use this as a means of reading and writing to the serial ports should work properly in this respect when used with Windows Vista. This includes some software featured in past issues of *EPE*.

As far as I am aware, this module was not included with earlier versions of Windows either, so the situation has not really changed. It used to be necessary to distribute this component with any programs that utilised it, and it still is necessary to do so. This component was only supplied with the more upmarket versions of Visual BASIC, which also included a license to distribute it with any software that required its facilities.

#### It Just Works

The web page mentioned previously also includes some general information about the Vista compatibility of Visual BASIC 6 itself and programs written using this programming language. Microsoft is committed to 'it just works' compatibility, which is presumably meant to be taken literally. This apparently applies to the Visual BASIC 6 program itself, as well as any programs written using this language.

#### Third-Party

Of course, there are numerous third-party runtime modules for use with Visual BASIC and other PC programming languages. Understandably, Microsoft takes no responsibility for how well (or otherwise) these operate under Windows Vista. It is up to the producers of these modules to check their compatibility and, where necessary, modify them to suit the new operating system.

Many of the programs featured in the *Interface* series rely on **Inpout32.dll** to enable Visual BASIC 6 programs to perform direct read and write operations with devices in the input/output map. The supporting software for some *EPE* projects also requires the services of this module. It provides programming languages such as Visual BASIC 6 with the Inp and Out commands that were at one time a standard part of most programming languages, but are hardly ever included these days. Unfortunately, **Inpout32.dll** does not seem to work at all with Windows Vista. This is perhaps a bit surprising, since it contacts the hardware via approved routes and works perfectly with Windows XP.

The Visual BASIC 6 programs that I have tried all worked perfectly in the sense that everything appeared to be operating correctly on the screen. Fig.1 shows the result when using a Vista based system to run the power supply program featured in the previous *Interface* article. It all seems to be working properly and there are no error messages, but it has no

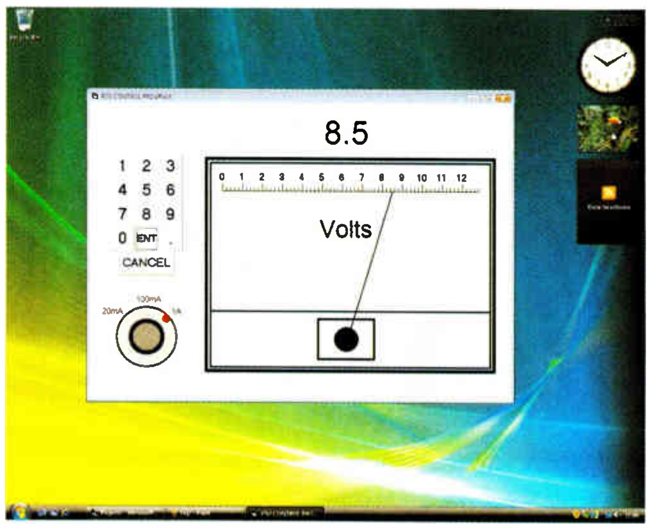



*Fig.1: The power supply program runs perfectly under Windows Vista, apart from the fact that it does not write any data to the printer port.*

effect on the power supply unit driven from the printer port. Everything worked fine when using the same hardware and program with Windows XP as the operating system.

As yet, there is little information on the Internet regarding Windows Vista and **Inpout32.dll**, but it would appear that it does not work with 32-bit or 64-bit versions of Vista. Possibly, in due course, someone will produce a new version of **Inpout32.dll** that is fully Vista compatible. In the meantime though, programs that rely on this component are unusable with systems running Windows Vista.

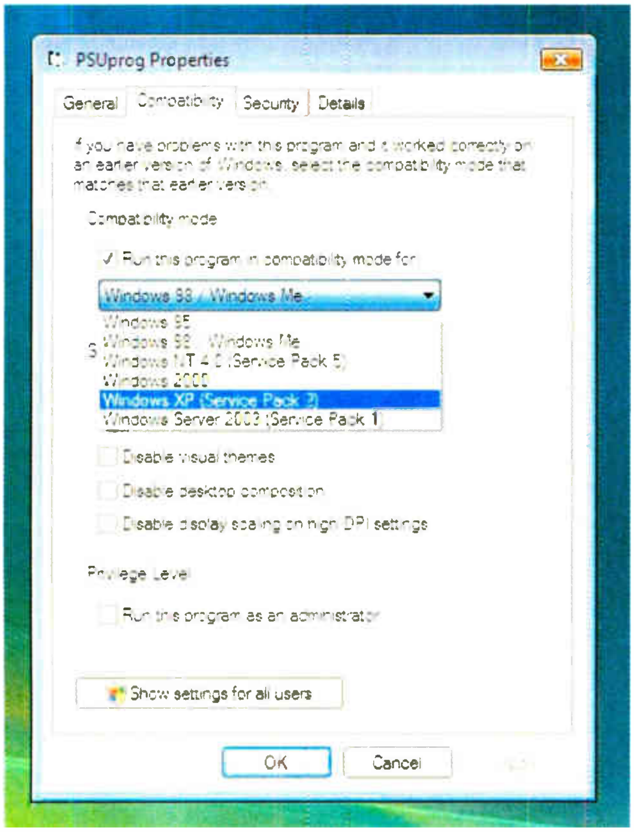



*Fig.2: Windows Vista provides compatibility modes for programs written to operate with previous versions of Windows. In practice, the degree of compatibility provided is sometimes inadequate*

## Setting Compatibility

There is a facility in Windows Vista that enables programs written for earlier versions of Windows to be run in a so-called compatibility mode. The idea is for Vista to run the program in the same way that it would be run in some previous version of Windows. This is essentially the same feature that was introduced in Windows XP, and like its predecessor, it is not always effective.

The compatibility level of a program can be altered by locating the program (EXE) file using Windows Explorer and right-clicking its entry. Then select Properties from the pop-up menu, followed by the Compatibility tab in the new window that appears.

If there is no compatibility tab, run the program, close it, and then try again. The required operating system is then selected from the drop-down menu (Fig.2). Unfortunately, this does not give sufficient compatibility to make **Inpout32.dll** usable with Windows Vista, but it might give better results with other compatibility problems.

The inevitable conclusion from this is that Visual BASIC 6 programs have good compatibility with Windows Vista, but there can be problems with any that are reliant on some form of third-party add-on. It is unlikely that there will be any problems with a Visual BASIC 6 program that uses Microsoft's **mscomm32.ocx** ActiveX control to provide communication with the serial ports. With non-Microsoft it is a different matter, and it could be necessary to obtain an updated module.

Of course, there should be no problems with incompatible programs when using a more recent programming language, such as Visual C# or Visual BASIC 2005 Express. These programming languages were designed to provide compatibility with Windows Vista. Apart from any problems due to bugs that have yet to be corrected, the compiled programs are guaranteed to be fully compatible with Windows Vista. Using the built-in facilities to communicate via the serial port should produce programs that run equally well under Windows XP and Vista.

Once again though, compatibility is not guaranteed if a third-party add-on is used. Using an old add-on with a modern programming language will not remove any incompatibility problems. Using **Inpout32.dll** with modern programming languages tends to be a bit awkward anyway, but even if you do manage to do so, this ploy will certainly not produce programs that are Vista compatible.

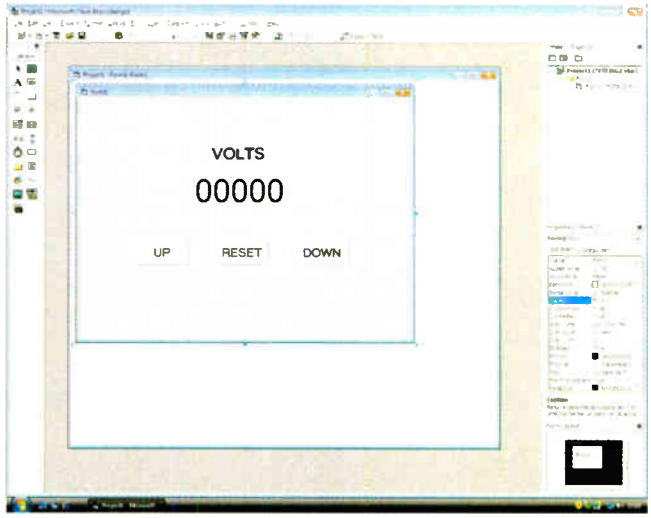



*Fig.3: Visual BASIC 6 can be installed and run under Windows Vista, but only just. This is in line with Microsoft's 'it just works' compatibility for this software*

## VB6 Under Vista

Trying to install Visual BASIC 6 on a PC running Windows Vista produces warning messages, some of which indicate that the operating system 'thinks' that it is actually Visual C++ that is being installed. With persistence it is possible to get Visual BASIC 6 installed, but an error message is produced each time it is launched.

However, once the program is 'up and running' it does seem to run all right when producing simple applications (Fig.3). Apart from any contentious add-ons, it produces compiled programs that seem to run well under Windows XP or Vista. Of course, things might not operate quite as smoothly when producing more advanced pieces of software.

## Progress?

It is noticeable that the more PC hardware and software progresses, the harder it becomes to use a PC with simple add-on projects. In most respects Visual BASIC is well suited to producing programs for user add-ons, but it requires some supporting software in order to access the input/output ports.

Recent versions of Visual BASIC have been aimed at those producing complex applications, which makes them less accommodating when producing simple control software for a PC hardware project. On the hardware side of things, the gradual demise of the ISA bus plus the phasing out of the standard serial and parallel ports has made things even more difficult.

While it is probably a bit early to proclaim simple interfacing to the serial and parallel ports as a thing of the past, it seems unlikely that this method will be a practical proposition for very much longer. In the not too distant future it will probably be a matter of using USB or not bothering at all. Unfortunately, using a USB port is never likely to be as straightforward as directly accessing a port in the input/output map.

# Catalogue for 2007 has arrived!

## Everyday Practical Electronics Feature Kits

Everyday Practical Electronics Magazine has been publishing a series of popular kits by the acclaimed Silicon Chip Magazine Australia. These projects are brilliantly designed 'bullet proof' and already tested down under. All Jaycar kits are supplied with specified board components, quality fibreglass tinned PCBs and have clear English instructions. Watch this space for future featured kits.

### Luxeon Star LED Driver Kit

KC-5389 £9.75 + post & packing

Luxeon high power LEDs are some of the brightest LEDs available in the world. They offer up to 120 lumens per unit, and will last up to 100,000 hours! This kit allows you to power the fantastic 1W, 3W, and 5W Luxeon Star LEDs from 12VDC. Now you can take advantage of these fantastic LEDs in your car, boat, or caravan.

- Kit supplied with PCB, and all electronic components.

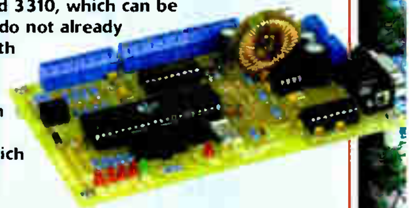
As published in this month's Everyday Practical Electronics Magazine!

### SMS Controller Module Kit

KC-5400 £15.95 + post & packing

Control appliances or receive alert notification from anywhere. By sending plain text messages this kit will allow you to control up to eight devices. It can also monitor four digital inputs. It works with old Nokia handsets such as the 5110, 6110, 3210, and 3310, which can be bought inexpensively if you do not already own one. Kit supplied with PCB, pre-programmed microcontroller and all electronics components with clear English instructions.

- Requires a Nokia data cable which can be readily found in mobile phone accessory stores.



### Three Stage FM Transmitter

KJ-8750 £6.50 + post & packing

This is a Three-Stage radio transmitter that is so stable you could use it as your personal radio station and broadcast all over you house. Great for experiments in audio transmission. It includes a microphone but you can transmit other material as well. Includes a mic, PCB with overlay and all other parts.

- Requires 9V battery (not included)
- Instructions included in kit

### Delta Throttle Timer Kit

KC-5373 £7.95 + post & packing

It will trigger a relay when the throttle is depressed or lifted quickly. There is a long list of uses for this kit, such as automatic transmission switching of economy to power modes, triggering electronic blow-off valves on quick throttle lifts and much more. It is completely adjustable, and uses the output of a standard throttle position sensor. Kit supplied with PCB and all electronic components.

- As published in Everyday Practical Electronics November 2006

Recommended box UB3 HB-6013 £1.05

### Automotive Courtesy Light Delay

KC-5392 £5.95 + post & packing

This kit provides a time delay in your vehicle's interior light, for you to buckle-up your seat belt and get organsied before the light dims and fades out. It has a 'soft' fade-out after a set time has elapsed, and has universal wiring. Kit supplied with PCB with overlay, all electronics components and clear English instructions.

- As published in Everyday Practical Electronics February 2007

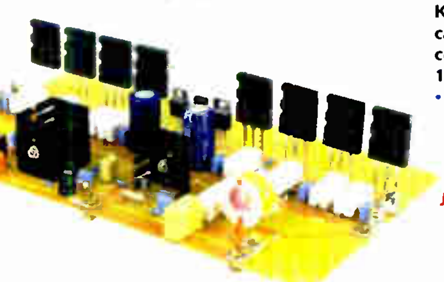
Recommended box UB5 HB-6015 £0.83

### Studio 350 High Power Amplifier Kit

KC-5372 £55.95 + post & packing

It delivers a whopping 350WRMS into 4 ohms, or 200WRMS into 8 ohms. Using eight 250V 200W plastic power transistors, It is super quiet, with a signal to noise ratio of -125dB(A) at full 8 ohm power. Harmonic distortion is just 0.002%, and frequency response is almost flat (less than -1dB) between 15Hz and 60kHz. Kit supplied in short form with PCB and electronic components. Kit requires heatsink and +/- 70V power supply (a suitable supply is described in the instructions).

- As published in Everyday Practical Electronics October & November 2006



### Smart Card Reader and Programmer Kit

KC-5361 £15.95 + post & packing

Program both the microcontroller and EEPROM in the popular gold, silver and emerald wafer cards. Card used needs to conform to ISO-7816 standards, which includes ones sold by Jaycar. Powered by 9-12 VDC wall adaptor or a 9V battery. Instructions outline software requirements that are freely available on the internet. Kit supplied with PCB, wafer card socket and all electronic components. PCB measures: 141 x 101mm.

- As published in Everyday Practical Electronics May 2006

Requires 9-12VDC wall adaptor (Maplin #UG01B £13.99)

Jaycar cannot accept responsibility for the operation of this device, its related software, or its potential to be used in relation to illegal copying of smart cards in cable TV set top boxes.

### Audio Video Booster Kit

KC-5350 £31.95 + post & packing

This kit will boost your video and audio signals preserving them for the highest quality transmission to your projector or large screen TV. It boosts composite, S-Video, and stereo audio signals. Kit includes case with silkscreened and punched panels, PCB and all electronic components.

- As published in Everyday Practical Electronics March 2006


Requires 9VAC wall adaptor (Maplin #GU09K £9.99).

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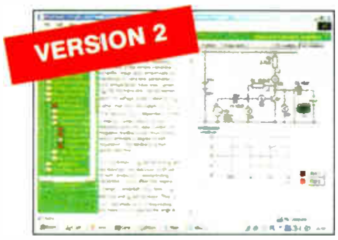
# ELECTRONICS CD-ROMS

## ELECTRONICS PROJECTS

Logic Probe testing

*Electronic Projects* is split into two main sections: **Building Electronic Projects** contains comprehensive information about the components, tools and techniques used in developing projects from initial concept through to final circuit board production. Extensive use is made of video presentations showing soldering and construction techniques. The second section contains a set of ten projects for students to build, ranging from simple sensor circuits through to power amplifiers. A shareware version of Matrix's CADPACK **schematic capture**, **circuit simulation** and **p.c.b. design** software is included.
The projects on the CD-ROM are: Logic Probe; Light, Heat and Moisture Sensor; NE555 Timer; Egg Timer; Dice Machine; Bike Alarm; Stereo Mixer; Power Amplifier; Sound Activated Switch; Reaction Tester. Full parts lists, schematics and p.c.b. layouts are included on the CD-ROM.

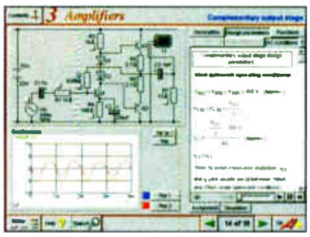
## ELECTRONIC CIRCUITS & COMPONENTS V2.0




Circuit simulation screen

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

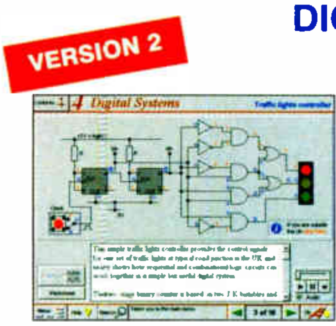
## ANALOGUE ELECTRONICS V2



Complimentary output stage

*Analogue Electronics* is a complete learning resource for this most difficult branch of electronics. The CD-ROM includes a host of virtual laboratories, animations, diagrams, photographs and text as well as a SPICE electronic circuit simulator with over 50 pre-designed circuits.
Sections on the CD-ROM include: **Fundamentals** – Analogue Signals (5 sections),Transistors (4 sections), Waveshaping Circuits (6 sections). **Op.Amps** – 17 sections covering everything from Symbols and Signal Connections to Differentiators. **Amplifiers** – Single Stage Amplifiers (8 sections), Multi-stage Amplifiers (3 sections). **Filters** – Passive Filters (10 sections), Phase Shifting Networks (4 sections), Active Filters (6 sections). **Oscillators** – 6 sections from Positive Feedback to Crystal Oscillators. **Systems** – 12 sections from Audio Pre-Amplifiers to 8-Bit ADC plus a gallery showing representative p.c.b. photos.

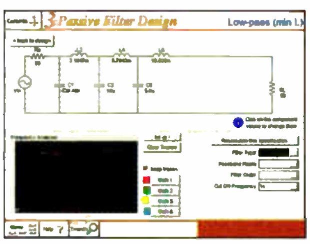
## DIGITAL ELECTRONICS V2.0




Virtual laboratory – Traffic Lights

*Digital Electronics* builds on the knowledge of logic gates covered in *Electronic Circuits & Components* (opposite), and takes users through the subject of digital electronics up to the operation and architecture of microprocessors. The virtual laboratories allow users to operate many circuits on screen.
Covers binary and hexadecimal numbering systems, ASCII, basic logic gates, monostable action and circuits, and bistables – including JK and D-type flip-flops. Multiple gate circuits, equivalent logic functions and specialised logic functions. Introduces sequential logic including clocks and clock circuitry, counters, binary coded decimal and shift registers. A/D and D/A converters, traffic light controllers, memories and microprocessors – architecture, bus systems and their arithmetic logic units. Sections on Boolean Logic and Venn diagrams, displays and chip types have been expanded in Version 2 and new sections include shift registers, digital fault finding, programmable logic controllers, and microcontrollers and microprocessors. The Institutional versions now also include several types of assessment for supervisors, including worksheets, multiple choice tests, fault finding exercises and examination questions.

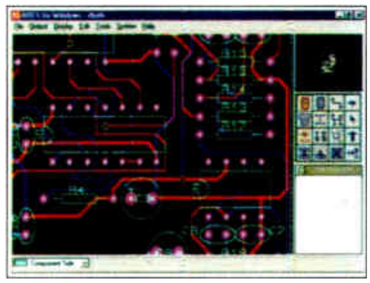
## ANALOGUE FILTERS



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

## ELECTRONICS CAD PACK



PCB Layout

Electronics CADPACK allows users to design complex circuit schematics, to view circuit animations using a unique SPICE-based simulation tool, and to design printed circuit boards. CADPACK is made up of three separate software modules. (These are restricted versions of the full Labcenter software.) **ISIS Lite** which provides full schematic drawing features including full control of drawing appearance, automatic wire routing, and over 6,000 parts. **PROSPICE Lite** (integrated into ISIS Lite) which uses unique animation to show the operation of any circuit with mouse-operated switches, pots. etc. The animation is compiled using a full mixed mode SPICE simulator. **ARES Lite** PCB layout software allows professional quality PCBs to be designed and includes advanced features such as 16-layer boards, SMT components, and an autorouter operating on user generated Net Lists.

## ROBOTICS & MECHATRONICS

Case study of the Milford Instruments Spider

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

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

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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
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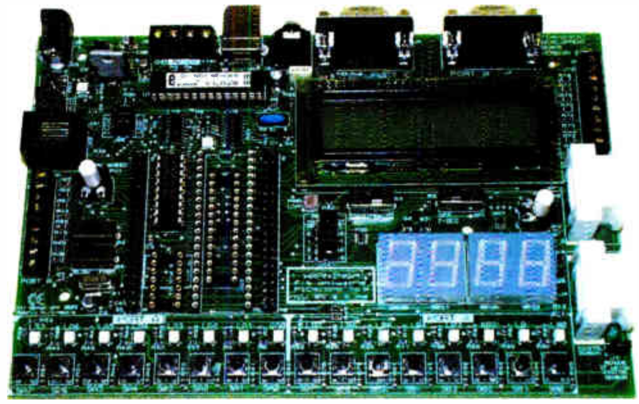


**£158 including VAT and postage**

**supplied with USB cable and programming software**

## SOFTWARE

NEW

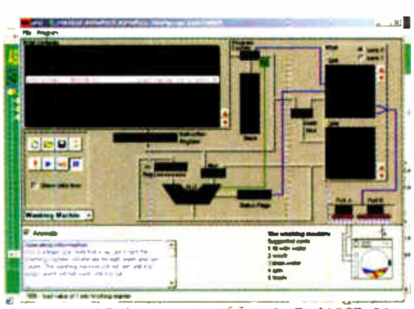
***Suitable for use with the Development Board shown above.***

### 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 microcontroller. This is a simulation tool that allows users to write and execute MPASM assembler code for the PIC16F84 microcontroller on-screen. Using this you can actually see what happens inside the PICmicro MCU as each instruction is executed which enhances understanding.

● Comprehensive instruction through 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 PICmicro VERSION 3

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

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

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

Minimum system requirements for these items: Pentium PC running Windows 98, NT, 2000, ME, XP; CD-ROM drive; 64MB RAM; 10MB hard disk space.

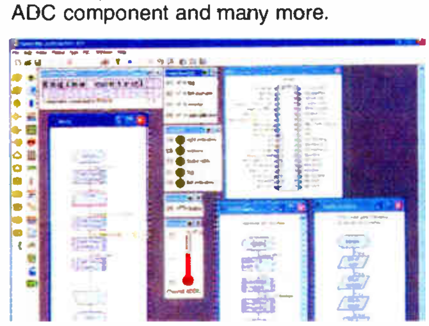
### FLOWCODE FOR PICmicro V3

Flowcode is a very high level language programming system for PICmicro microcontrollers based on flowcharts. Flowcode allows you to design and simulate complex robotics and control systems in a matter of minutes.

Flowcode is a powerful language that uses macros to facilitate the control of complex devices like 7-segment displays, motor controllers and l.c.d. displays. The use of macros allows you to control these electronic devices without getting bogged down in understanding the programming.

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 (ISO5807) ● Full on-screen simulation allows debugging and speeds up the development process ● Facilitates learning via a full suite of demonstration tutorials ● Produces ASM code for a range of 18, 28 and 40-pin devices ● 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 and many more.



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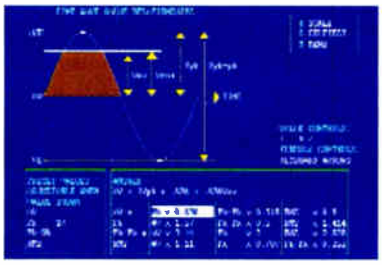

Sine wave relationship values

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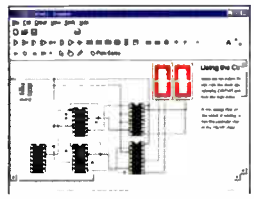
# DIGITAL WORKS 3.0



**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.

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*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.

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- ☐ PICmicro Development Board V3 (hardware)

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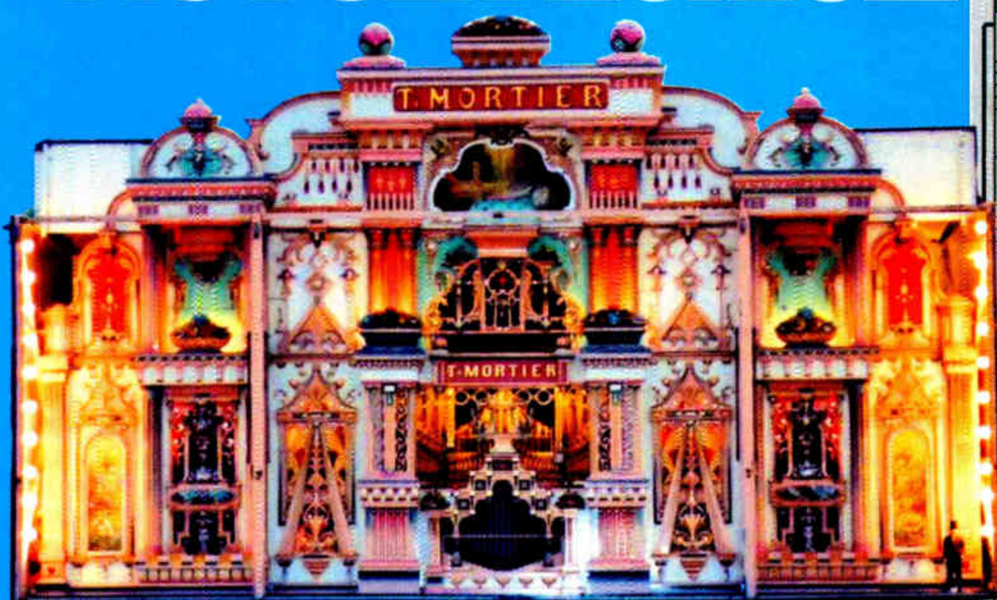
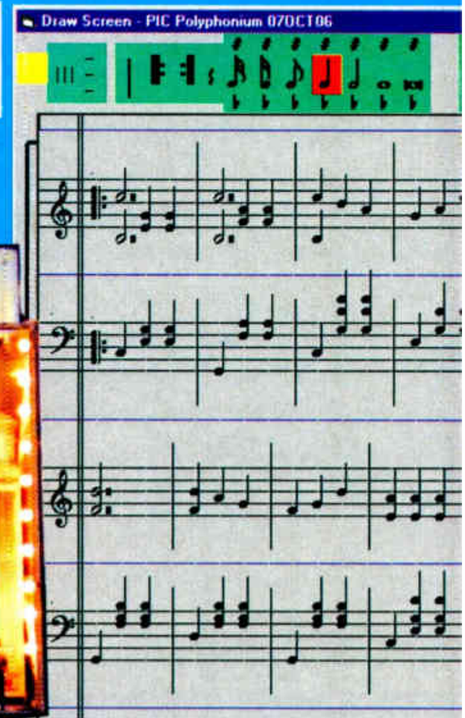



- Polyphonic musical design
- PC-linked with on-screen musical score
- Create your own music
- LED display interface

By JOHN BECKER

## Part 2: LED Display Control Interface

LAST MONTH in Part One we told how when visiting various steam fairs, the author has been fascinated by the grandeur of the sights and sounds of the superb showman's fairground organs there in abundance. We then described a PIC-controlled unit that commemorated them, generating polyphonic music in response to data keyed in as music scores on a PC and sent to the PIC's onboard memory devices.

### Inside-out

This month we describe two means whereby the same data can be output to the outside world to control additional software or hardware, emulating perhaps some of the moving artifacts seen on such grand organs, and which the user can design for themselves. We shall not describe the construction of such hardware, but shall now illustrate how the data can be used to control two different multi-bank arrays of LEDs.

### Giant message display unit

First we describe how the Polyphonium's master control unit can be interfaced to the *EPE Giant LED Message Display* of November 2006, with just the addition of one chip – another PIC microcontroller, used in semi-slave mode. The circuit for this PIC is shown in Fig.4.

The circuit is purely for those who love to experiment. It and its software simply prove the basis for what some may wish to take further in some way. No guidance is given on this point.

This PIC takes the 8-bit data output by IC1 pins RB0-RB7 in Fig.1 – last month. It ignores any note length bytes. Bytes containing notes and their octaves are converted to a serial data stream which is output at 9600 Baud to the first Slave PIC on the *Giant LED Message Display*. As

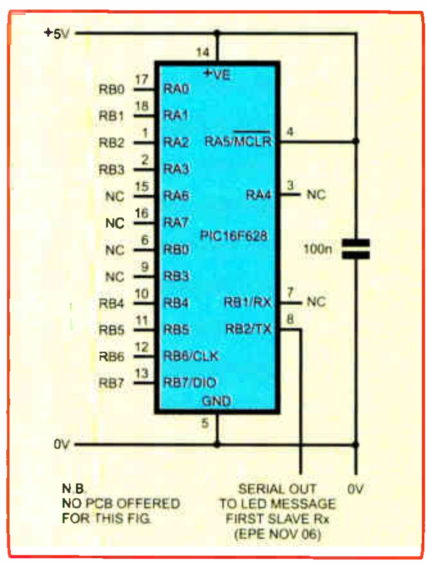
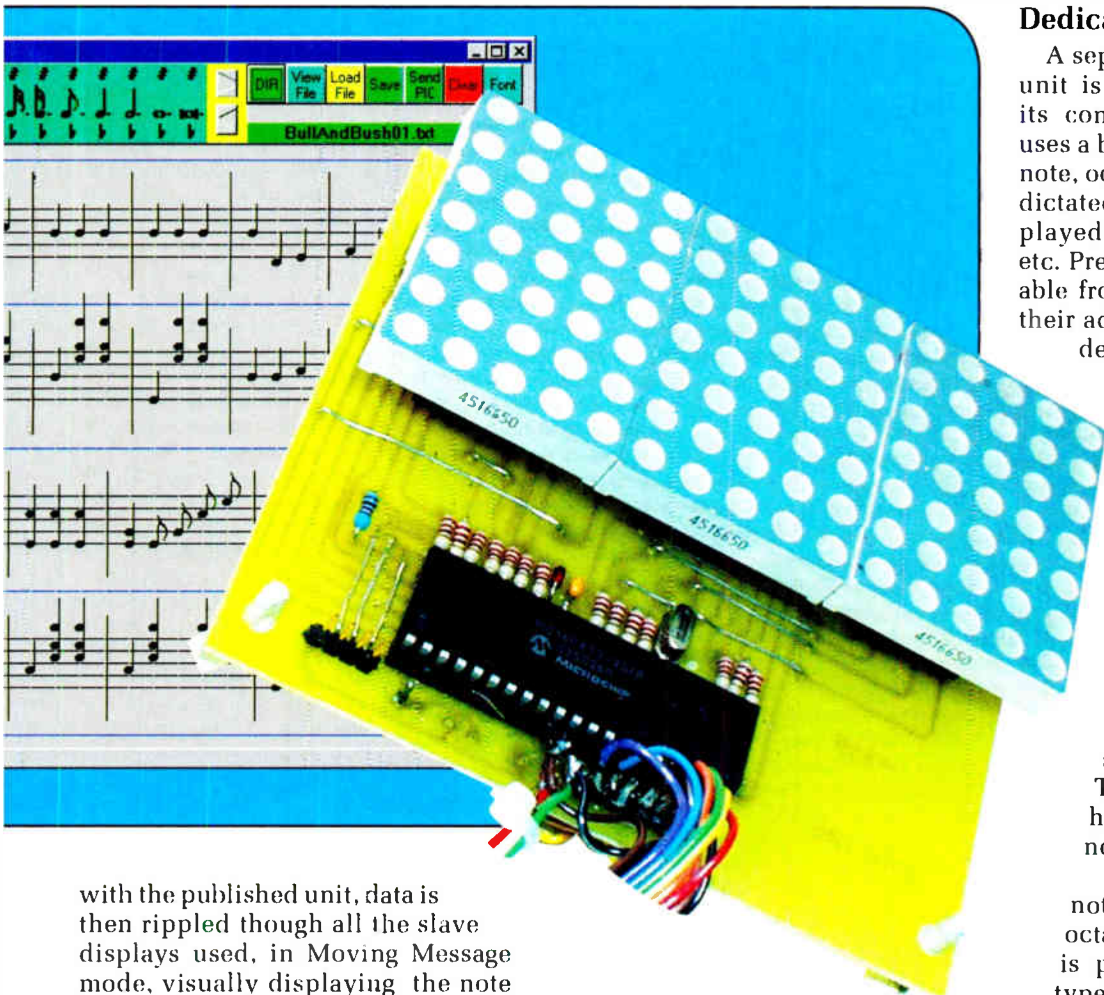



**Fig.4: circuit diagram for a simple RS232 serial interface for the LED Display**




with the published unit, data is then rippled though all the slave displays used, in Moving Message mode, visually displaying the note and octave values.

The bytes coming in from the right, progressively become history along the chain of LEDs as the music and display progresses. Bytes which are a repeat of the previous one are ignored.

The PIC used is a PIC16F628, operating under its own internal clock oscillator running at 4MHz. Selected pins on PORTA and PORTB are used to input the data from IC1 in Fig.1, last month. Serial data is output at pin RB2. It is powered from the Polyphonium controller's 5V supply.

Software for this PIC (**PolyLEDMSGxx.asm**), is available from the *EPE* Downloads site (access via **www.epemag.co.uk**). The PIC is not available preprogrammed. No constructional details are offered for Fig.4, it could be assembled on stripboard.

To use the interface, remove the master control PIC in the unit, and connect the serial output from Fig.4 to the serial line previously served by that PIC, connecting to the first Slave circuit.

## Dedicated LED display

A separate dedicated LED display unit is now described, along with its constructional guidance. This uses a bank of LEDs which show the note, octave and relative on-time, as dictated by the type of note being played: crotchet, minim, quaver, etc. Pre-programmed PICs are available from Magenta Electronics. See their advert in this issue for contact details. The circuit diagram is shown in Fig.5.

Data is input to IC1's port pins RC0 to RC7 from the Polyphonium's control PIC IC2. The data has been split by that device so that it is output as pairs of separate data bytes. The first byte of the pair holds the note (A, B, C etc) in its LSN (least significant nibble, bits 3-0) and its octave in its MSN (most significant nibble, bits 7-4). The second byte of the pair holds the data value for the note's type.

There are twelve possible notes, including sharps, for each octave. A range of seven octaves is possible. There are 14 note types, seven principle ones, plus their dotted versions. In music, the principle types have a 'play duration' that doubles for each type


**Last month's Master Control and Note Generator Unit**

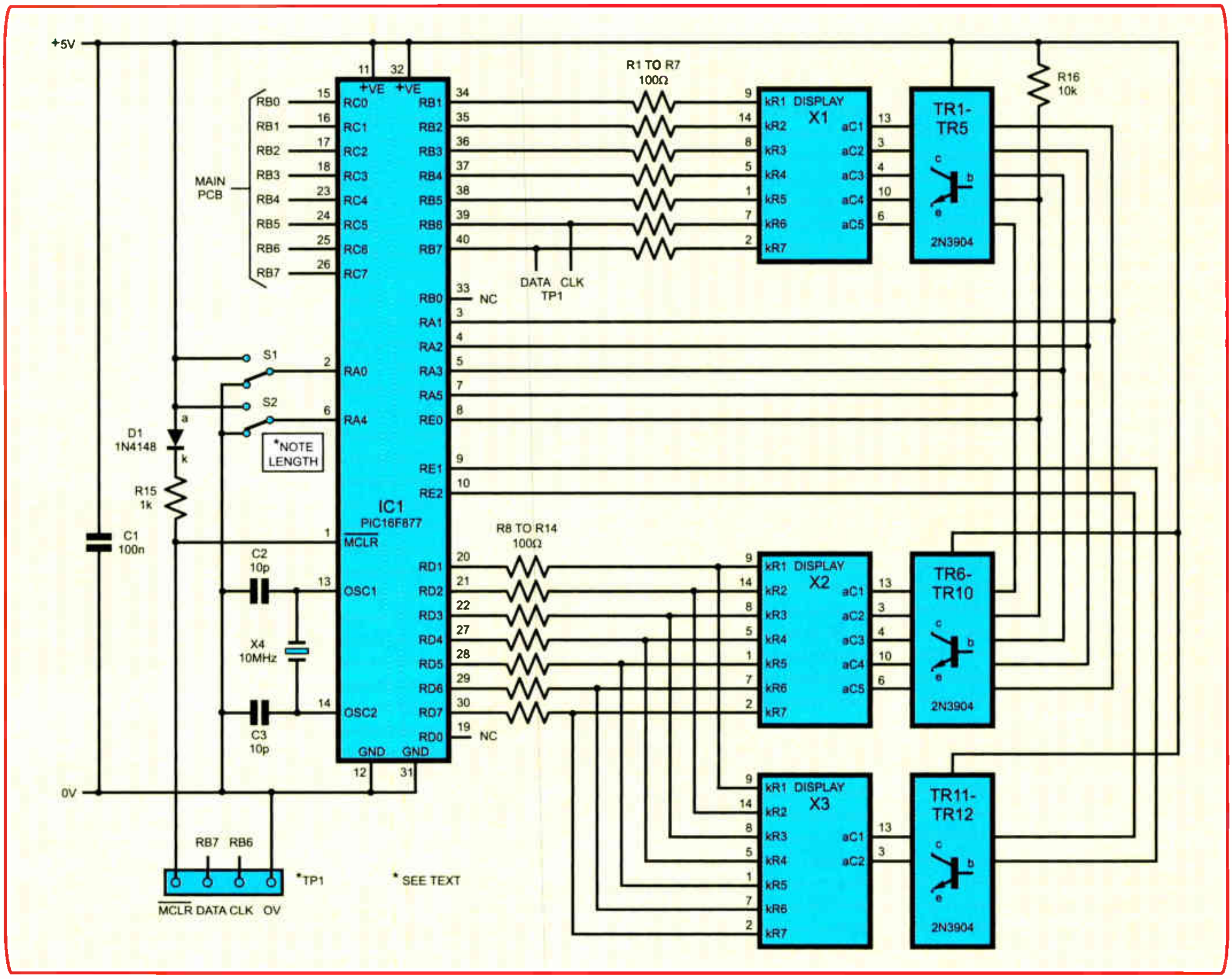



**Fig.5: circuit for the example dedicated LED Display Control Interface for the PIC Polyphonium**

up from the shortest time, for the demisemiquaver. Dotted notes have one and half times the duration of their undotted versions.

Incoming data is formatted by the software so that the individual notes each control a vertical line of seven LEDs, 12 of them, in order of A, A#, B, C, C#, D, D#, E, F, F#, G, G#. Modern music convention is that the flat of a note is the same as the sharp of the note preceding it.

## Multiplexed matrixing

Dot-matrixed LED display modules are used, each consisting of five vertical columns, each seven LEDs high. Three such modules are used, allowing for all 12 notes to be represented, with three columns unused. The LED corresponding to the received note and its octave is turned on for a time relative to the note type. The LED is turned on when the note is received and, using a counter/timer, is automatically turned off at the end of the relative time.

The effect is that of a block of LEDs responding to the music. In a sense it is similar to the familiar sound-to-light displays used to accompany pop music, except that the brightness of the LEDs does not change, merely whether they are on or off.

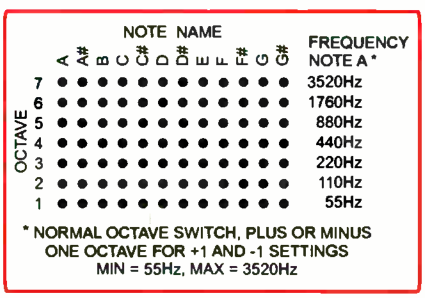



**Fig.6: how the LED modules illustrate the notes being played**

The format of the LED modules is as shown in Fig.6, together with the notes that they represent, plus the octaves (and frequency in relation to note A), lowest at the bottom, highest at the top. Fig.7 and Fig.8 respectively show the arrangement of the LEDS in a module, and the physical order of those pins on it.

The LEDs are multiplexed by means of using PORTB and PORTD to provide the octave data in the LED rows, synchronised with control of which column is turned on by PORTA and PORTE. Columns 1 to 5 and 6 to 10 are jointly controlled by RA1, RA2, RA3, RA5 and RE0, while columns 11 to 12 are controlled by RE1 and RE2. Columns 13 to 15 are not used.

The synchronised control of the displays is too fast for the human eye to notice that columns and rows are being constantly fed by ever-changing data – persistence of vision.

## LED control circuit

The circuit for the LED control is shown in Fig.5 to the right of the control PIC, IC1. The columns are turned on via transistors TR1-TR12, which provide them with +5V when active. The LEDs in any row are turned on when their controlling voltage is at 0V and the corresponding column is at +5V. Resistors R1-R14 limit the current flowing through the LEDs when turned on, limited to the maximum total current that can be sunk by each of the PIC's Ports B and D (typically 200mA, as quoted in the PIC's datasheet).

The values of the resistors should not be decreased in order to attempt to increase the brilliance of the LEDs. The use of high-brightness LED modules is recommended. The multiplexing technique inherently reduces the average brightness seen compared to that which would be expected from LEDs under constant power with the same voltage and ballast resistor values.

Switches S1 and S2 change the overall LED note length periods, in multiples of two, in binary order 2, 4, 8, 16.

As usual, provision has been made for the PIC to be programmed in situ if preferred, via the pins marked as TB1, in the author's standard order. Diode D1 and resistor R16 prevent distress to the +5V power line from the programming voltages, typically +14V and 0V are variously applied to PIC pin 1 ($\overline{\text{MCLR}}$).

## Parts List – PIC Polyphonium

### LED Display Interface

1 PC board, code 612, available from the *EPE PCB Service*, size 116.8 x 96.5mm
1 plastic case, size and type to individual choice
3 2-inch, high brightness, 35-LED matrix modules (X1 to X3)
1 10MHz crystal (X4)
2 s.p.d.t. toggle switches (S1, S2)
6 14-pin DIL sockets – see text
1 40-pin DIL socket (IC1)

**Semiconductors**
1 1N4148 signal diode (D1)
12 2N3904 *npn* transistors (TR1 to TR12)
1 PIC16F877-20 preprogrammed microcontroller – see text (IC1)

**Capacitors**
1 100n ceramic disc (C1)
2 10p ceramic disc (C2, C3)

**Resistors** (0.25W 5%)
14 100Ω (R1 to R14)
1 1k (R15)
1 10k (R16)

Multicoloured ribbon cable and connectors (see text); 1mm terminal solder pins; solder etc.

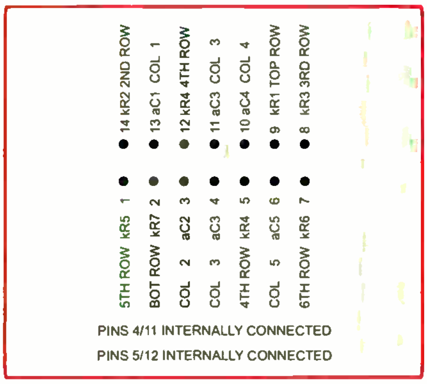



Fig.8: connections and their notations for the LED modules

## Construction

Component positioning and track layout details for the Display printed circuit board (PCB) are shown in Fig.9. This board is available from the *EPE PCB Service*, code 612.

As with Part One, assemble in order of ascending component size, starting off with the on-board link wires, noting that some go under the IC1 position. Use a DIL (dual-in-line) socket for this IC, also solder in two strips of 7-way DIL sockets cut in half lengthwise for the displays, then use another set of identical sockets plugged into the first. It is in these that the displays are ultimately inserted, raising their height to allow

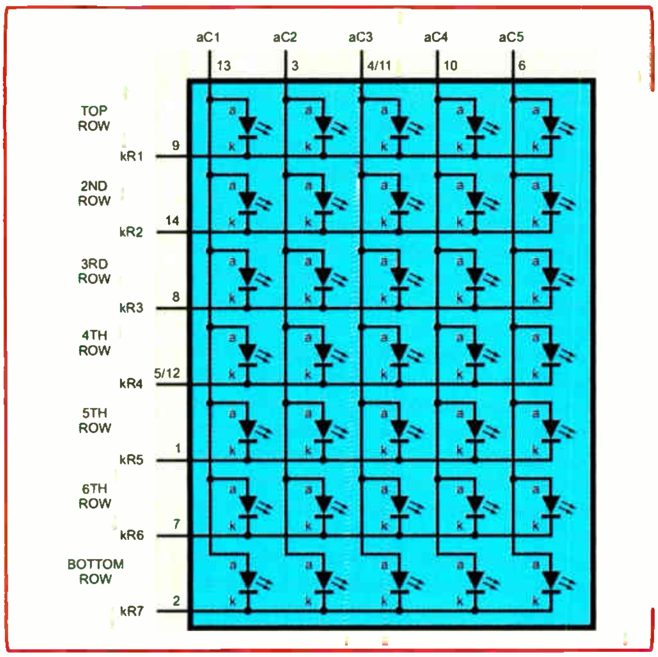
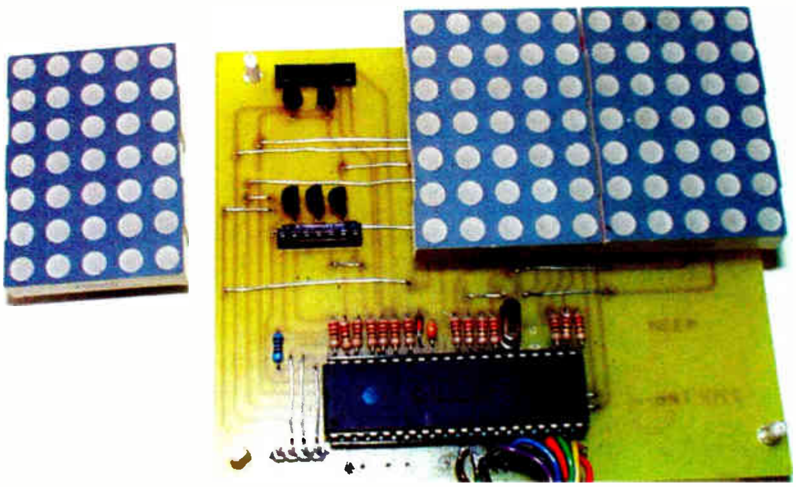



Fig.7: how the LEDs are connected within the modules



One of the LED matrix modules removed from the circuit board to reveal the driver transistors

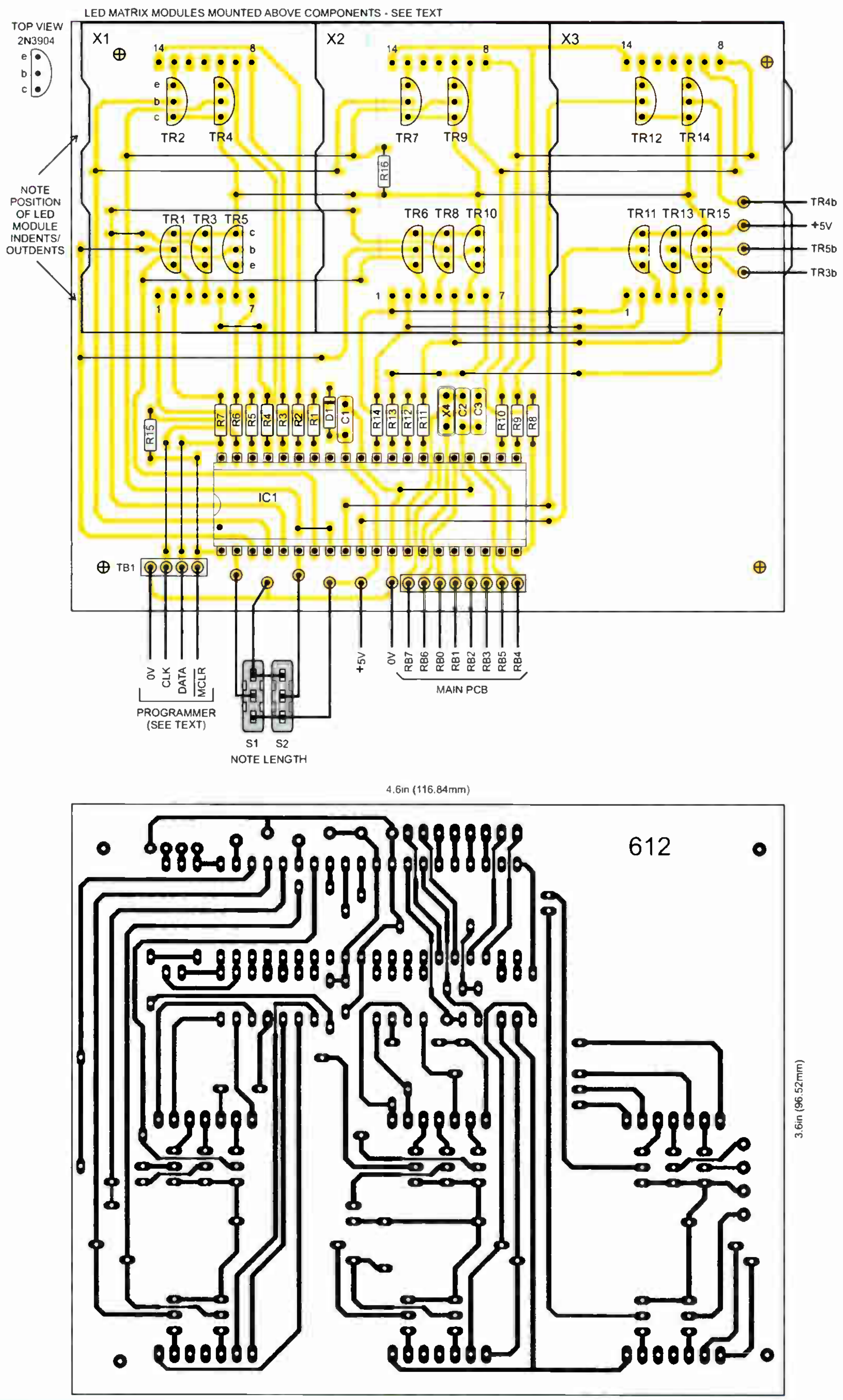


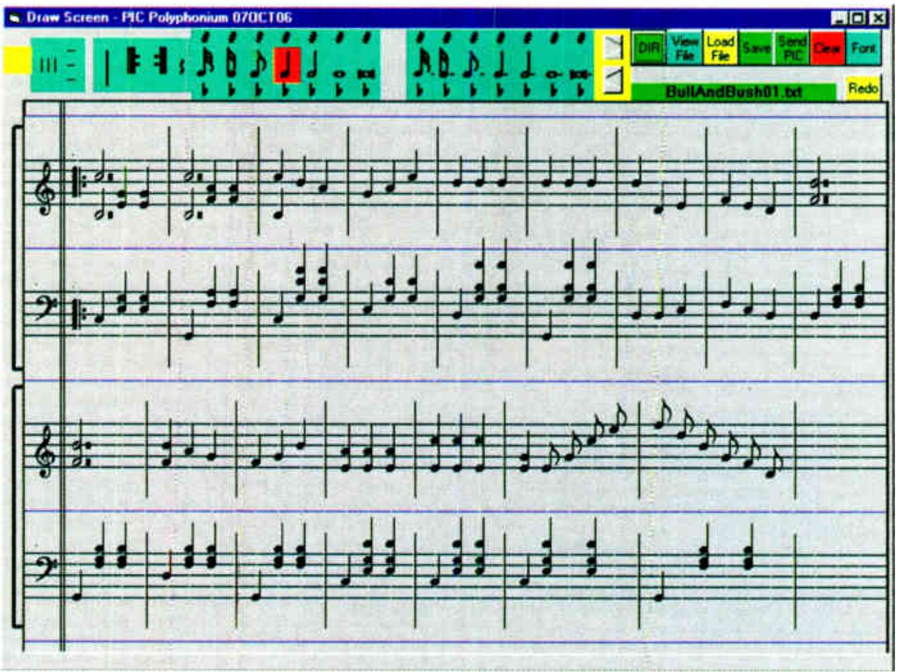

Fig.9: printed circuit board component layout, full-size copper foil master and off-board wiring details for the LED Display Interface

for the transistors which go beneath them. Make sure that the transistor orientation is according to the notations shown. Diode D1's orientation should also be correctly observed.

Thoroughly check the soldering accuracy and component positioning before inserting the pre-programmed PIC and the LED modules. Then apply power supplied by the main board of the Polyphonium, and check that it is still at +5V.

## Case notes

The prototype board was not mounted in a case. Choose one to suit you and it, drilling holes for the switches and data input socket (a 24-pin D-type with the prototype, allowing for the eight data lines plus the power leads, and using alternate pins). A suitable equivalent connector and connections are required at the main control board. The use of ribbon cable is suggested.



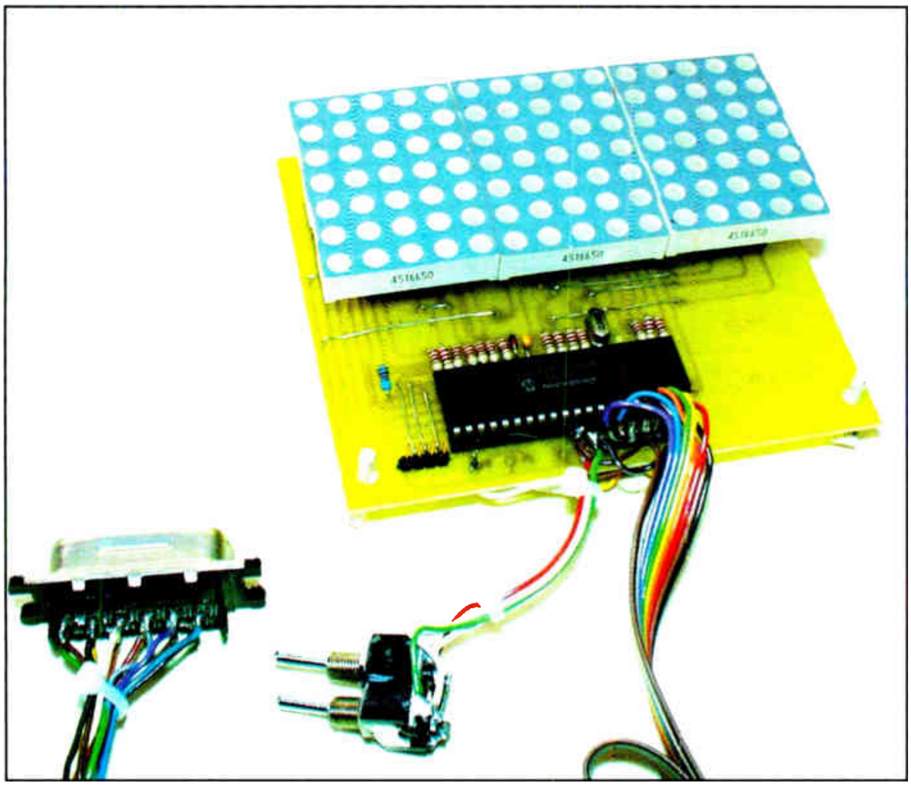

**Screen dump showing an example of a section of a music score keyed in, and the majority of the control buttons**

## Program operation

There are several key routines to the operation of what is essentially a simple program. Only extracts are shown here since several parts within the main sections are basically repeats.

Refer to the full ASM program listng for the detail.

On power up, and following a load of initialisation procedures, the program enters the repeating loop routine at LOOPA (Listing 1).



**Prototype LED Display board showing the two 'note length' switches and the author's data input connector (see text). An equivalent arrangement is required at the Main Control PCB (last month)**

The transistor controlling pins of Ports A and E are cleared, ensuring that all LEDs are initially off.

Then, at LOOPIT, a 16-stage loop, controlled by register LOOPB, is entered which calls another loop, DOLOOPA (Listing 1A). The route here depends on the count value, routing selectively to control the multiplexed columns, as indicated by the example for OUTCOLB1 in Listing 2.

This takes the note value data for the first column controlled by PORTB, held in COLUMNB1, and outputs it to PORTB. It also takes the note value data for the first column controlled by PORTD, held in COLUMND1, and outputs it to PORTD. In both instances, **comf** is used to load W with an inverted value of the bits as the equivalent LED row bits need to be low to allow the LED to conduct when its power supply line is selected.

Note that in other control instances it may not be necessary to invert the bits.

The controlling transistor is then turned on, so passing current into the chosen LED path, in this case by PORTA, bit 4 (other bits of PORTA, and of PORTE, are used for other columns). A return to the calling routine is then made.

## PORT C bit 7

Now bit 7 of the incoming date from PORTC is tested. If it is high, the

## ★★★★★ SOFTWARE LISTINGS ★★★★★

### Listing 1

```
LOOPIT:
      clrf PORTA
      clrf PORTE
      clrf LOOPA
      movlw 16
      movwf LOOPB

LOOPIT3:
      clrf SWITCH             ; get additional note length
                                rate from switches

      btfsc PORTA,0
      bsf SWITCH,0
      btfsc PORTA,4
      bsf SWITCH,1
      call SWITCHVAL
      BANK1
      movwf OPTION_REG        ; set TMR0 accordingly
      BANK0
      call DOLOOPA
      btfsc PORTC,7           ; is bit 7 set (note length
                                value byte)?
      goto NOTELENGTH         ; yes. Immediate
                                response for
                                NOTELENGTH data
      movf PORTC,W            ; get note value
      movwf NOTEVAL
      bcf NOTELENFLAG,0       ; clear note length flag

LOOPIT4:
      decfsz LOOPB,F
      goto LOOPIT3
      movlw 16
      movwf LOOPB
      incf LOOPA,F
      movf LOOPA,W
      xorlw 7
      btfss STATUS,Z
      goto LOOPIT3
      clrf LOOPA
      call DODELAYS
      goto LOOPIT3
```

### Listing 1A

```
DOLOOPA:
      movf LOOPA,W
      andlw 7
      addwf PCL,F
      goto OUTCOLB1
      goto OUTCOLB2
      goto OUTCOLB3
      goto OUTCOLB4
      goto OUTCOLB5
      goto OUTCOLE1
      goto OUTCOLE2
```

### Listing 2

```
OUTCOLB1:
      comf COLUMNB1,W
      movwf PORTB
      comf COLUMND1,W
      movwf PORTD
      movlw 4
      movwf PORTA
      return
```

### Listing 3

```
NOTELENGTH:
      movf NOTELENFLAG,W
      andlw 1
      btfss STATUS,Z          ; has note length flag been set?
      goto LOOPIT4            ; yes, continue LOOPA
      movf PORTC,W            ; no, so update all
      call SETLEN             ; get note length
      movwf LENGTHNOTE
      call OCTAVE             ; get note val & oct data
      movwf RATE
      call CHOSENROUTE
      bsf NOTELENFLAG,0       ; set note length flag
      goto ROUTEIT            ; do update
```

### Listing 3A

```
ROUTEIT:
      movf CHOSEN0,W          ; which note path to use
      addwf PCL,F
      return                  ; 0 no path
      goto VAL1               ; 1 Path 1
      goto VAL2               ; 2 Path 2
```

### Listing 4

```
VAL1:
      movf NOTEVAL,W
      andlw 15                ; note val in LSB
      movwf STORE
      movlw COLUMNB0          ; add note to address
                                of COLUMNB0
      addwf STORE,W
      movwf FSR
      movwf SELECTCOL1
      movf RATE,W             ; octave held in rate
      movwf INDF              ; put into correct column
      movf LENGTHNOTE,W
      movwf DELAY1
      clrf LENGTHNOTE
      bsf CHOSEN1,0           ; flag to show path is chosen
      goto LOOPIT
```

### Listing 5

```
DODELAYS:
      btfss INTCON,2          ; has a timer time-out
                                been detected?
        return                ; no
DEC1:
      decfsz DELAY1,F         ; no, dec DELAY, is it zero?
      goto DEC2               ; no
      bcf CHOSEN1,0           ; clear flag to show path
                                now free
      movf SELECTCOL1,W       ; clear column
      movwf FSR
      clrf INDF

DEC2:   (similar routine)
```

byte represents note length data and a call is made to the routine (NOTELENGTH – Listing 3) which extracts it. If the bit is low, a note data byte is present, so the full value of PORTC is copied into NOTEVAL.

To prevent the NOTELEN routine from being fully actioned in the likely event that the same data remains present on PORTC for several passes of the loop, a flag (NOTELENFLAG, bit 0) is used to indicate if the routine is to be run (bit 0 = 0) or a return immediately made (bit 0 = 1).

If the bit is low, the table routine at SETLEN is called in which the relative timing length of the note is chosen according to its type. This value is set into LENGTHNOTE and a call made to the routine at OCTAVE. Here the octave value for the received note is placed into RATE, and then CHOSENROUTE is called.

The path in which the RATE Value is placed depends on which is not currently in use. Had the PIC allowed for 84 such registers (12 notes x 7 octaves) to be used, a different technique would have been employed. Regrettably, there is insufficient user-memory space to do so, and with the PIC running at only 4MHz, there is insufficient speed to cope with the subsequent timing delays in such a long procedure.

After the return from CHOSENROUTE is made, the NOTELENFLAG flag is set to indicate that this received note length value has been processed. There is then a direct jump to ROUTEIT. The first few lines of this routine are given in Listing 3A. It causes the value now held in CHOSEN0 to route to the available path routine, as held in VAL1 to VAL9. All are similar, and the VAL1 routine is shown in Listing 4.

Here the value of the note itself (A, B, C etc) is extracted and, via the INDF register, the column allocated to that note is selected, and its appropriate octave bit is set. A jump back to LOOPIT is then made, whereupon the loop repeats as before.

Should no path currently be available (all in use) the value is processed by a dummy routine at VAL9. This simply processes matters in the same way as the other eight VALs, but places the results into dummy equivalent registers. So a constant loop timing is maintained. Such a situation can develop if the received note rate is too fast for the note turn off delays to keep paths clear.

If PORTC bit 7 is not set, the incoming value is stored into NOTEVAL and the NOTELENFLAG,0 is cleared so that the next incoming note length byte can then be immediately processed.

LOOPB is then decremented, and if it is not zero, the process repeats. If it is zero, LOOPB is reloaded with a value of 16 and LOOPA is incremented. If LOOPA's value is not equal to seven, the process again repeats.

If LOOPA is equal to seven, then LOOPA is cleared and a call made to the note turn off timing delays at DODELAYS, after which the process is again repeated.

## LED turn-off delays

At DODELAYS, the delays are only processed if the PIC's TMR0 timer has rolled over (btfss INTCON,2), being exited if it has not.

If it has rolled over, nine delay counters are decremented (the ninth being a dummy, as discussed earlier). One such counter is shown in Listing 5.

If a particular counter is not yet zero, the next one is immediately processed. If it is now zero, the chosen path flag is cleared, to indicate that this path is free again. The column to which it relates is then cleared via the INDF register, turning off the active LED column.

The next delay is then similarly actioned, and so on until the end of the ninth delay when the TMR0 overflow is cleared and a return made to the calling routine, which continues as before.

## Flow concept

These routines may appear more complicated than they actually are. The logic behind them is really very simple – receive data from the PC and turn on an appropriate LED for a given length of time, then turn it off again. But there are many conditional requirements which need to be taken into account during the process.

The process is somewhat similar to that used to control the tone generation in last month's main unit. But there are differences. If you are thinking of controlling other equipment by the main unit, you now have two examples of how you might process the basic data.

Whichever method you choose, you must extract the note itself, its octave and its duration. However, if you are thinking about controlling 84 items of external equipment, one for each note, the examples here can only be a guide. 84 paths will need a lot of multiplexing with additional chips, possibly PICs. The author showed one way in which several PICs can be chained in the *Giant LED Message Display* of Nov '06.

## External equipment

In many cases of external equipment, just a single PIC bit can control it, interfaced with a current boosting buffer such as a transistor. Solenoids used to open and close organ pipes, for instance, could be controlled in this way (with suitable back-EMF diodes across the solenoids, of course).

So could the single arm movements of a manikin seemingly conducting the performance, or hitting a triangle at selected points. It would be easy enough to write your own software so that the beats were related to note play rate subdivisions, depending on whether the beat were 3-4 or 2-4 time, for instance.

The hitting of drums could also be controlled by this timing, or they could be triggered by given notes.

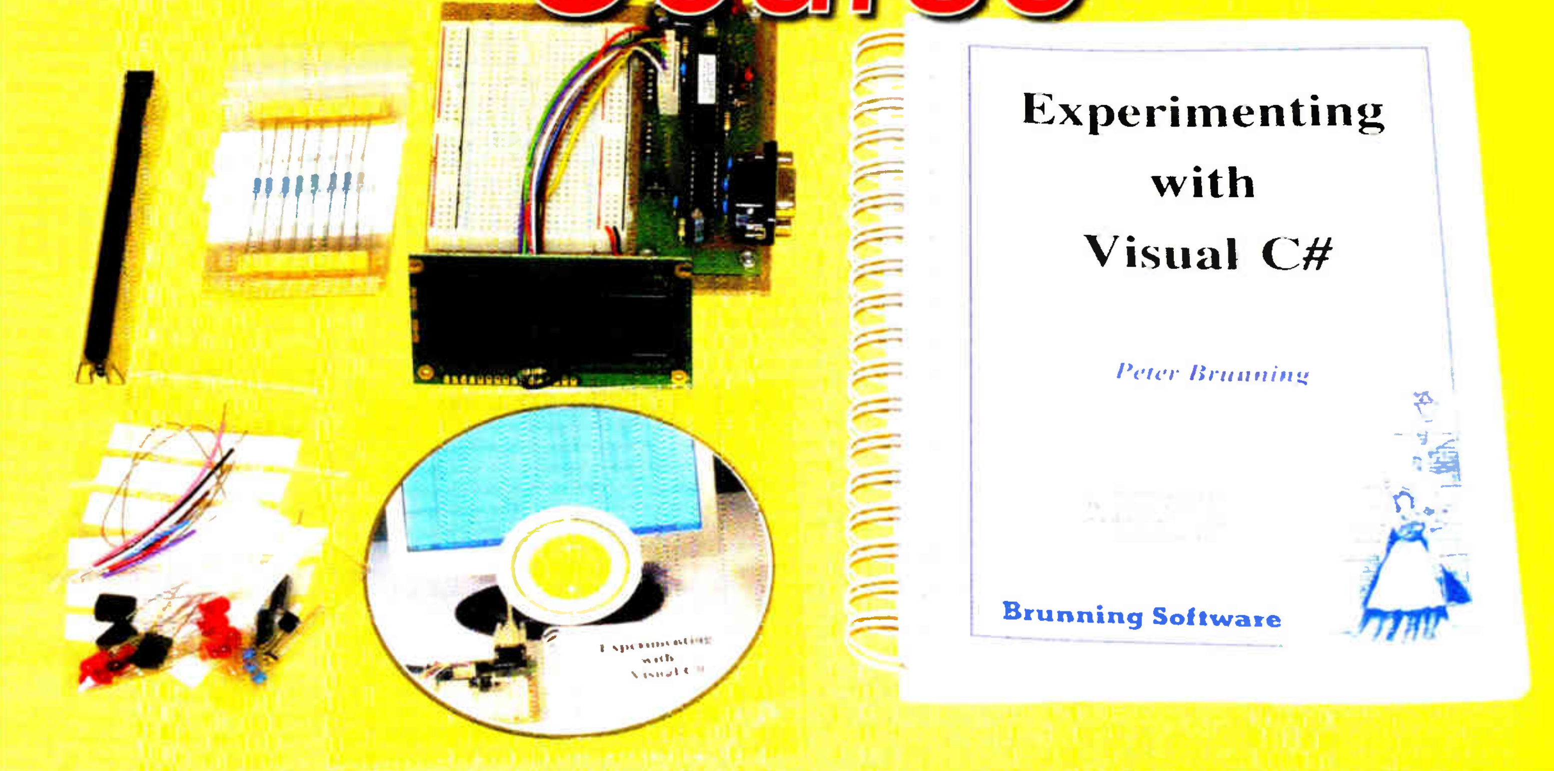
For drum rolls, the author might think of activating the type of electro-mechanics as used to trigger the clappers for alarm bells. Turn on a controlling motor at the start of a note or beat, then turn it off again. The mechanical action of the clapper physically causing the drum roll.

Remember that all the glorious showman's organs were invented before the era of electronics. Basically, very simple means had to be used to control their mechanics by opening and closing an air or steam valve when the punched controlling roll required it. It would no doubt have delighted the author to have invented such items had he been around then.

He is sure that some of you will be inspired to invent your own modern equivalents, using the Polyphonium's controller as your 'rolling punched card'. ***EPE***

# Visual C Training Course

By Robert Penfold




The C programming language became popular in the early days of PCs, when it was noted for its ability to hack into the hardware at a low level as well as operating as a high level language for complex tasks. Modern versions of C have, like most other programming languages, tended to become more and more complex. In the case of C, it was usurped by the more object oriented C++, and visual versions of C++. There is now Visual C# as well, which is intended to give the power of C++, but with improved user friendliness.

Compared to earlier versions, modern high level programming languages are usually less well suited to writing software for add-on computer projects. They are primarily designed for those producing word processors, sophisticated web applications, and so on.

They are in many respects 'over the top' for relatively simple applications such as the software for a piece of computer-based test equipment. Writing this type of program is usually possible, but you have to find and exploit the aspects of the programming language that are of use, while ignoring the other 95 percent or so.

## Express results

The Visual C Training Course from Brunning Software is not a full course in C programming. It is intended to provide an introduction to using Visual C to produce the control software for your own PC add-ons. It provides details of the aspects of C programming that are of use in this context, while leaving out those that are likely to be of little practical value. By 'cutting to the chase' it is possible to get started with your own programs relatively quickly, since there is little time wasted on learning aspects of C programming that will never be needed for this type of programming.

Although the title of the course refers to 'Visual C', the course is actually based on Microsoft's Visual C# Express Edition. This is a cut-down version of Visual C#, but it is perfectly adequate for producing programs for use with PC add-ons. It has the advantage of being available as a free download from the Microsoft website.

At about 30 megabytes for the basic program, it is not essential to have some form of broadband connection in order to download it. However, a full installation, which includes the MSDN Express library, requires a few hundred megabytes to be downloaded and might not be a practical proposition unless some form of broadband access is available. The basic program is sufficient to run the example programs featured in this course.

The Express version of Visual C# lacks the more upmarket features of the full program, but it is otherwise fully operational. There are no restrictions on saving or compiling your programs for example.

Although the Express versions of Microsoft's programming languages were originally to be made available for one year, this time limit has now been removed. Being able to experiment with programs and ultimately write your own without the need to buy an expensive programming language is clearly a big advantage.

## In the kit

The course consists of a book and various pieces of hardware. The book is called *Experimenting with Visual C#*, is ring-bound, and has 272 pages that are approximately 240 by 175mm. It is nicely produced using good quality paper and clear printing with plenty of excellent diagrams.

The main piece of hardware is a serial interface unit that includes a solderless prototyping board (Fig.1). The interface provides eight latching digital outputs and five analogue/digital inputs, and is based on a PIC18F2525 microcontroller. It is a pity that the interface does not provide a full 8-bit digital input port, but this limitation is to some extent mitigated by the ability of the five inputs to operate as analogue types.

Physically, the interface is quite basic, but it is also quite tough and should be capable of standing up to a fair amount of use. A 9-pin PC serial lead is needed to connect the interface to a PC. A suitable lead is not included as standard, but it can be supplied as a low-cost extra, as can a mains power unit.

There is a potential problem in using a serial port to link the interface to the computer, and this is simply that it is increasingly common for new PCs to lack a serial port. The suggested solution to the problem is to buy a USB/serial converter. This method should work well since the interface is accessed via a standard Windows route that does not involve any programming trickery. There should be no problem in using the interface, provided the converter is installed properly as a standard Windows serial port.

The other items of included hardware are the resistors, LEDs, and integrated circuits needed in order to complete the various demonstration circuits featured in the book. There is also a 16 x 2 LCD module that is needed for some of the more advanced demonstration circuits.

Finally, there is a CD-ROM that contains the demonstration programs in the form of simple text files that can be used via the Copy and Paste method. Using these should save a great deal of time and avoid problems with typing errors. There are no program files that can be loaded directly into Visual C#.

No serial lead or power supply unit were provided with the review system. However, I had no difficulty getting the test unit connected and powered-up using a serial lead from a PIC programmer and a suitable mains adaptor selected from a collection of a dozen or so of these units.

With anything of this type I would still recommend paying the small additional cost of the optional lead and power supply. These should guarantee that there will be no hassle or delays involved in getting the system 'up and running'.

If it has powered up correctly the unit flashes an LED and briefly displays a message on the LCD module. It is then a matter of trying a test program to determine whether it is communicating correctly with the computer. The review system operated first time and without any problems (see Fig.2).

## By the book

A system of this type is clearly of little real value unless the documentation provides a good understanding of programming and interfacing techniques. The supplied book does a good job of things, and does not assume that the user has any previous knowledge of programming or electronics. It is assumed that the user knows how to use a PC. A basic knowledge of electronic components and programming would certainly be helpful, but neither are required in order to follow the examples in the book and utilise the system.

The book starts with some basic information about using Visual C#, such as adding components to a form, changing their properties, and running a program. It then gives some information about building a serial interface for use with the provided interfacing examples. Since the book is available separately, it is possible to build your own interface unit and then try out the examples. Doing things this way would require a fair amount of expertise though, and would probably not save a huge amount of money.

Subsequent chapters deal with simple programs that provide an easy introduction to using the interface and also serve as simple checks to ensure that it is working correctly. The review unit was tried with several example programs and always worked first time. Further chapters deal with slightly more advanced circuits and programs. The projects include such things as a simple electronic dice and a more realistic version, a digital IC tester, and a digital-to-analogue converter.

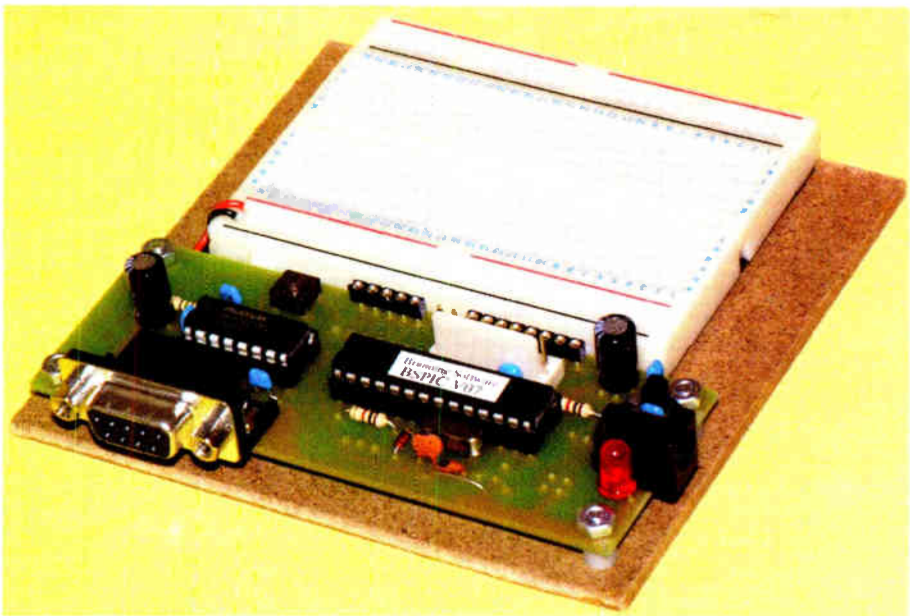


**Fig.1: the AUX200 interface includes a solderless breadboard that is used when building and testing the projects featured in the course. The LED flashes to indicate that the unit has powered up correctly.**

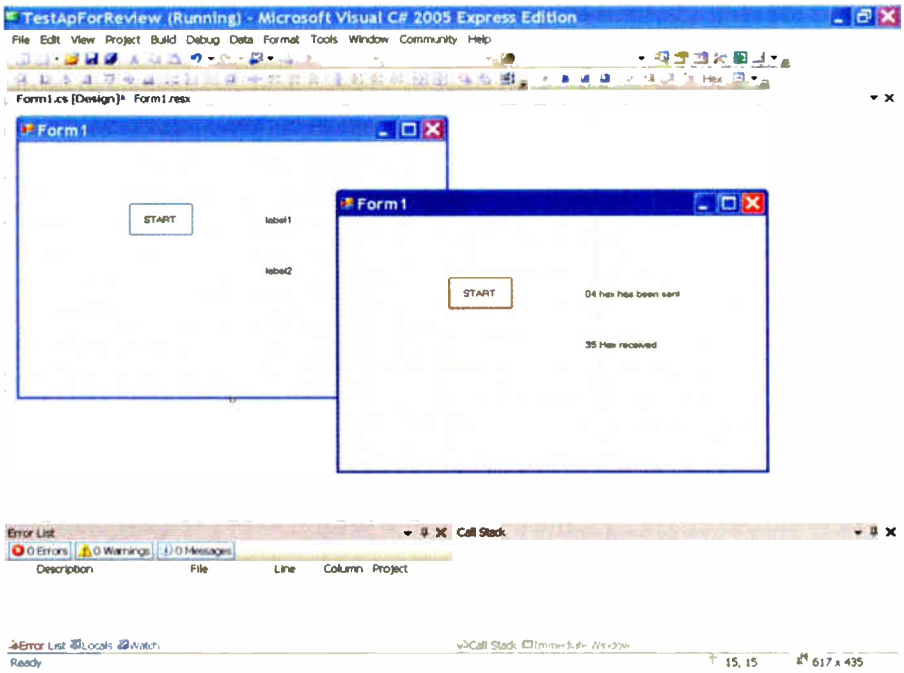



**Fig.2: the simple test program has successfully written data to and read data back from the AU200X interface unit. Visual C# Express is available as a free download from the Microsoft website**

## System Requirements

There is no minimum system requirement as such, but in order to use the course properly it is obviously necessary to have a PC that is up to the task of running Visual C# Express. This is the minimum system recommended by Microsoft:

- Windows 2000 with SP4, or a later version of Windows such as XP or Vista
- A processor running at 600MHz or more (1GHz or more recommended)
- 192 megabytes of RAM (256 megabytes or more recommended)
- 500 megabytes of hard drive space (1.3 gigabytes for a full installation including the MSDN Express library)

These chapters also introduce important aspects of programming, such as variables, loops, and functions. The visual approach to programming greatly reduces the amount of program code that has to be written by the programmer. However, it is still necessary to write some simple routines in order to make a program do something useful. These routines use conventional programming techniques, complete with loops, variables, and so on.

Later chapters show how these conventional programming techniques can be used in practice. These chapters also cover more advanced topics such as temperature measurement, writing data to the LCD display, using graphics, a low frequency oscilloscope, and Fourier analysis.

No soldering is required in order to build the example circuits. They are easily assembled on the interface's solderless breadboard, and all the components needed are included. There are even some pre-cut and prepared connecting leads. Circuit diagrams and practical layout diagrams are included in the book, and building the circuits is therefore quick and straightforward.

## Conclusion

This course certainly provides an easy introduction to using Visual C# with PC add-ons, but I suppose that some might question the choice of any form of C for applications of this type. However, Visual C# is much easier to use than other modern versions of this language.

The *Experimenting with Visual C#* book succeeds in stripping things down to the basics so that real-world programs can be produced quite easily, and without becoming an expert C programmer. You are not swamped with pages of program code that does little more than flash an LED a few times! Although Visual C# might not be everyone's first choice for this type of programming, it represents a practical way of writing software for PC add-ons.

The *Experimenting with Visual C#* book is well written and reasonably easy to follow. The number of example projects is not very large, but those that are featured are covered in detail. For a training course, this is much better than having numerous examples that are given inadequate coverage. As the inner working of the PIC-based interface are described in some detail, it should be possible for users to use the lessons learned from the course to produce their own PC projects.

However, it would be necessary to gain a fair amount of expertise with PIC processors in order to do this. In fact, the use of the PIC method of serial interfacing to the PC means that the user has to learn a certain amount about PIC programming and hardware in order to follow the course properly. Another point to bear in mind is that although the serial approach to PC interfacing has its advantages, especially when used with an 'intelligent' PIC-based project, there are also a few drawbacks. In particular, potential users of this method should bear in mind that some applications are precluded by the relatively slow data transfer rates.

## Cost

The Visual C Training Course should appeal to hobbyists and professionals looking for a simple introduction to basic PC interfacing. I found the course interesting and easy to use, and it can certainly be recommended. It is competitively priced, and the fact that it is based on a free programming language helps to keep costs to a minimum.

The cost of the Brunning Software Visual C Training Course is £88-00 plus £8-00 for postage and insurance. A serial lead costs an extra £3-00, and a mains adaptor is £4-00 plus an additional £2-00 for postage and insurance. Further details are available from:

Brunning Software, 138 The Street, Little Clacton, Clacton-on-sea, Essex, CO16 9LS, UK.
Telephone – 01255 862308
Email – pic@brunningsoftware.co.uk
Web – http://brunningsoftware.co.uk

***EPE***


*Control equipment from anywhere, anytime, using SMS and an old Nokia mobile phone! – By Peter Smith*

# SMS Controller Pt.2

Last month, we described the circuit for the SMS Controller and gave the assembly details. This month, we tell you how to complete the circuit checking and describe how the unit is used.

Having carried out the power supply checks described last month in Part 1, the next step is to check out the serial interface and the microcontroller.

First, disconnect the power and insert IC1 and IC3 into their sockets. If the microcontroller needs to be programmed, then you should do that next. Refer to the Microcontroller Programming panel for more details on this.

Next, install jumper shunts on JP4 to JP7. These should always be in place when the inputs (IN1 - IN4) are not connected, otherwise the micro's port pins will be 'floating' in an indeterminate logic state.

Conversely, remove all jumper shunts from JP1-JP3 if installed earlier and apply power. The 'Comms Error' LED (LED1) should illuminate, while all other LEDs (except the 'Power' LED) should be off. This indicates that the micro cannot communicate with the phone, which of course isn't connected yet. However, it does tell us that the micro is doing what it should.

*Note: the very first time you apply power, all red LEDs may come on for one second and then go out, with just the 'Comms Error' LED remaining on. This sequence indicates that the micro has automatically erased its on-board EEPROM, ready for programming.*

If you get a different result, the problem is most likely due to one or more pins of the micro having missed their sockets and bent underneath the chip.

If bent pins aren't the problem, then check out the oscillator circuit, consisting of crystal X1 and the two 22pF capacitors. If you have access to an oscilloscope, you can observe the operation of the oscillator on pin 18. In addition, check the voltage on the micro's RESET input (pin 9). This pin should measure close to +5V during normal operation, going low only during power up and power down.

The final step involves a quick checkout of the RS232 interface circuit. Measure the voltage between pin 2 of IC4 and ground and pin 6 of IC4 and ground. You should get around +9.5V and -9.3V, respectively. These voltages are generated by the MAX232's internal charge pumps, in conjunction with the four 1µF capacitors.

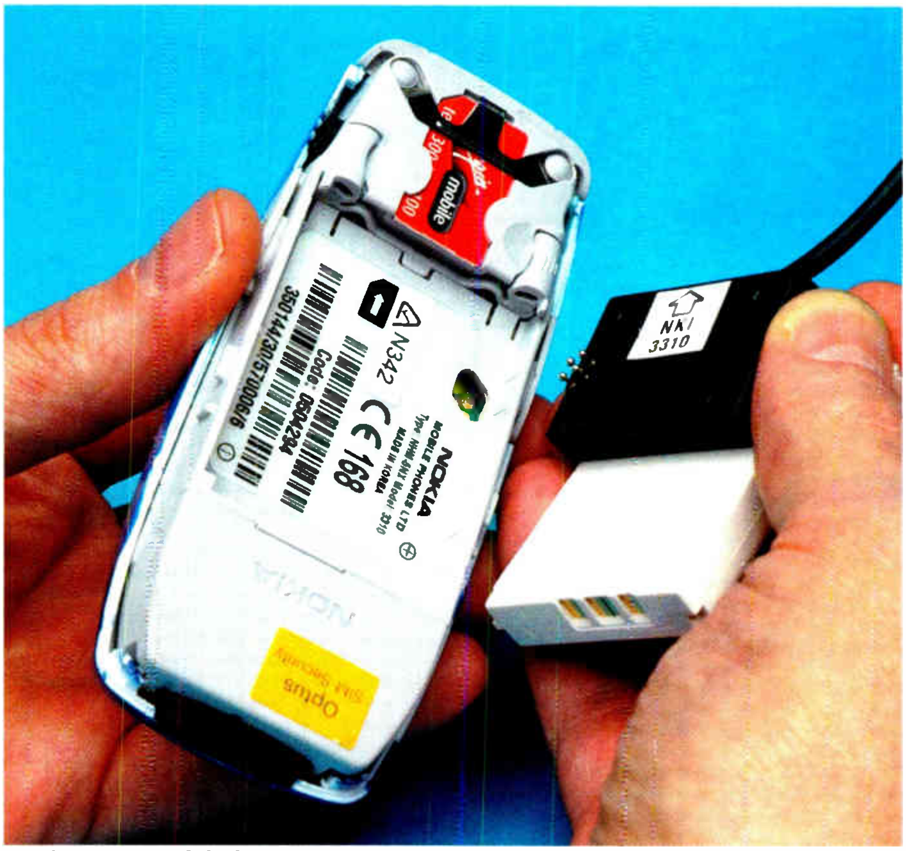
If your board passes all the tests, you can now connect the data cable between your board and phone. Note that's it's a good idea to power off both devices when connecting and disconnecting this cable.

### Suitable case

If desired, the completed module can be housed in a 'UB1' size plastic box or similar, with a slot cut in the side of the box to accommodate the terminal block wiring.

The mobile phone must be positioned at least 50cm from the controller and associated wiring so that RF energy from its antenna doesn't interfere with the circuit operation. **This is very important!** If this separation cannot be attained in your application, then the controller must be housed in a metal case or shielded from the phone with a large metal plate.

Alternatively, both the 5110 and 6110 models support connection of an external antenna, which would allow good separation and improve signal strength in some areas.




**On the 3310 model, the serial interface is accessible through a hole in the rear of the case, underneath the battery. The data cable is terminated with a plastic head assembly that includes a set of spring-loaded contacts as well as tabs to retain the battery that it partly displaces.**

### Operational basics

System operation is quite straightforward – when any of the digital inputs change state, the controller sends a pre-programmed SMS message to the nominated mobile number. Conversely, when you want to turn any of the outputs on or off, you send a message to the controller.

The messages used in both directions are programmed during the setup procedure. This allows the use of messages related to the task at hand. For example, you might want to assign the message 'pump' to turn on the first output and 'nopump' to turn it off. This means that you don't need to remember which output the pump is connected to or which state (high or low) is on or off.

The controller also recognises a number of unique messages, called 'in-built commands', that can be sent from another mobile to program the system during setup, as well as modify system behaviour during normal operation. A summary of all these commands appears in Table 2. Before we look at how to set up the controller, let's look at each command in detail.

### In-built commands

**ACKON** – this command forces the controller to respond to every message that it receives. If a received message is deemed valid, the controller responds with 'OK'. If a message is unknown, the response is 'bad cmd'.

**ACKOFF** – the opposite of **ACKON**. All further acknowledgments are disabled.

**CHARGE{number}** – this command allows you to modify the battery charging parameters, dependent on the model of phone in use.

For the 5110 and 6110, the {number} value defines the battery level at which the on-board charger is switched on. Only values between 0 and 4 are valid. A value of 4 instructs the controller to continually charge the phone and is therefore not recommended. The default level is 1.

For the 3210 and 3110, a timed charge/discharge scheme is used instead, as battery level information is not available to the controller. The {number} value defines the charge time in minutes, with the discharge time being fixed at 8 hours. Only values between 10 and 240 are valid. The default charge time is 40 minutes.

**COUNT** – Use this command to get the total number of messages sent and received by the controller, as well as the firmware version number. The returned message is in the format 'r=nnnnn s=nnnnn v=nn.nn', where 'r' and 's' are the total number of received and sent messages, respectively.

**DIS{string}** – in some situations, you may not want to be informed when a particular input changes state but still want to receive notification on the remaining inputs. An example of this might be when one sector of an alarm system is faulty and has been isolated. Using this command, you can disable notification on either or both states of any input.

For example, suppose a message of 'SECTOR1ALARM' is programmed to be sent when an input goes low and a complementary message of 'SECTOR1IDLE' is programmed to be sent when it returns high. To stop receiving these messages each time the input toggles, you could send the commands

## Microcontroller Programming

You can purchase a ready programmed microcontroller (IC1) from Magenta Electronics – see page 5. Alternatively, you'll need to program the microcontroller yourself.

A 10-way header (CON5) has been included on the PC board for connection to an 'in-system' type programmer.

Once you have a suitable programmer, together with the necessary cables and Windows software to drive it, all you need to complete the job is a copy of the microcontroller program for the SMS Controller. This can be downloaded from our web site – go to the 'Downloads' section.

This contains the file 'SMS.HEX', which needs to be programmed into the micro's program (FLASH) memory. Just follow the instructions provided with the programmer and software to complete the task.

### Fuse bits

We've specified either AT90S8515-8 or ATMega8515-16 microcontrollers for this project. Although it has many improvements over its predecessor, the ATMega8515 is a pin-for-pin replacement for the AT90S8515. In fact, we've tested this project with both of these devices to ensure compatibility.

The only additional requirement when using the ATMega8515 is to ensure that the fuse bits are correctly programmed. The default fuse settings in the AT90S8515 are OK and should not be altered.



'**DIS**SECTOR1ALARM' followed by '**DIS**SECTOR1IDLE'.

**EN{string}** – the opposite of DIS{string}, this command reinstates notification on the input and state designated by {string}.

**LOGIN{pass}** – essentially, this command tells the controller your current mobile phone number. You don't actually need to enter the number, as it's automatically gleaned from the incoming message. All messages are forwarded to the mobile phone that sent the last **LOGIN** command, which remains valid until another **LOGIN** or **LOGOUT** command is received.

If a password had been set, it must immediately follow the **LOGIN** command. An exception to this is in programming mode (JP3 in), where password checking is not performed.

**LOGOUT** – this command disables all outgoing messages. It's wise to send this command to the controller before you switch off your phone. If your phone's battery goes flat, or it's stolen or misplaced, use a friend's phone to first **LOGIN** and then **LOGOUT**. If you don't, a malfunctioning system could see you rack up a phone bill of astronomical proportions – a compelling reason to use only a prepaid plan for the phone connected to the controller (see panel in Part 1)!

**PASS{string}** – sets a new password of 1 to 8 characters long. Passwords longer than 8 characters elicit a 'bad pass' response. The initial password is programmed during the setup procedure. Once set, it can be changed at any time but only from the currently logged-in phone (see **LOGIN** command).

**STAT** – returns the current state of the digital input and open-collector output ports. The displayed format is 'XXXX YYYYYYYY', where 'X' and 'Y' are 'H' for logic high or 'L' for logic

**Table 2: Command Summary**

| Command | Function |
|---|---|
| ACKON | Enable acknowledge messages |
| ACKOFF | Disable acknowledge messages |
| CHARGE{number} | Modify battery charge level (5110 & 6110) or charge time (3210 & 3310) |
| COUNT | Get SMS sent & received counters & firmware version number |
| DIS{string} | Disable state change messages on input defined by {string} |
| EN{string} | Enable state change messages on input defined by {string} |
| LOGIN | Enable message transmissions to your current mobile number |
| LOGOUT | Disable further message transmissions to your mobile |
| PASS{string} | Set new password to {string} (8 characters max.) |
| STAT | Get snapshot of digital inputs & open-collector outputs |
| **The following commands are valid only in programming mode (JP3 in):** | |
| IN{n}{L}{message} | Define the message the controller sends when input {n} goes low |
| IN{n}{H}{message} | Define the message the controller sends when input {n} goes high |
| OUT{n}{L}{message} | Define the message you send to drive output {n} low |
| OUT{n}{H}{message} | Define the message you send to drive output {n} high |
| OUT{n}{P}{message} | Define the message you send to pulse output {n} low |

**Here's a summary of the commands recognised by the controller. The curly braces are used here for clarity and should not be included in your messages. Note: do not use spaces after command words.**


**A complete lineup of the supported models, from left to right: 5110, 6110, 3210 and 3310.**

low. The input port is displayed first, followed by the output port, with the most-significant bits (IN4 and OUT8) displayed first.

For the output port, an 'H' (high) indicates the driver is switched off, whereas an 'L' (low) indicates it is on. Note that external circuits may invert this logic.

A response from the **STAT** command looks like this: 'HHLH HLHHHHHH'. In this case, IN2 is low and IN1, IN3 and IN4 are high. On the output side, OUT7 in on (low) and all other drivers are off (high).

The following commands operate only in programming mode (JP3 in):

**IN{n}{L}{message}** – defines the message that will be sent by the controller when input *{n}* goes low. For example, suppose you've connected a switch to the first input (IN1), as shown in Fig.7(b) – last month. When the switch is closed, the input changes state from a logic high (+5V) to a logic low (0V). To receive the message 'SWITCH CLOSED', the required command would be **IN1LSWITCH CLOSED**.

Of course, you can use any message you like, as long as it's no more than 16 characters long.

**IN{n}{H}{message}** – defines the message that will be sent by the controller when input {n} goes high. Using the previous example, to receive the message 'SWITCH OPEN' when the first input (IN1) changes from a logic low to a logic high, the required command would be: **IN1HSWITCH OPEN**.

**OUT{n}{L}{message}** – defines the message that you send to the controller to drive output {n} low. For example, suppose you've connected a relay to OUT1, as shown in Fig.6(a) – last month. A low on this output grounds one end of the relay coil, switching it on. Assuming you want to use the message 'RELAY ON', the required command would be **OUT1LRELAY ON**.

**OUT{n}{H}{message}** – defines the message that you send to the controller to drive output {n} high. From the previous example, to switch the relay off with the message 'RELAY OFF', the required command would be **OUT1HRELAY OFF**.

**OUT{n}{P}{message}** – defines the message that you send to the controller to pulse output {n}. When the controller receives this message, the specified output will be driven low for one second, after which it returns high. Again from the previous examples, to pulse a relay on OUT1 using the message 'PULSE RELAY', the required command would be **OUT1PPULSE RELAY**. It's important to note that when any output is defined as a 'pulsed' output, you cannot also define it with the **OUT{n}{L}** or **OUT{n}{H}** commands.

## Message syntax

Messages used in the 'IN' and 'OUT' commands can be composed from any characters in the available repertoire but the total length must be limited to 16 characters. Longer messages are automatically truncated. Spaces can be used in the body of messages **but not adjacent to the command or password strings (ie, DO NOT use spaces after command words).**

In addition, all user-defined messages, including the password, are *case sensitive*. This is a trap for the unwary: 'PUMP ON' and 'pump on' are not the same message! Inbuilt commands, on the other hand, are not case sensitive.

Finally, your messages must not start with the in-built command words **ACKON, ACKOFF, CHARGE, COUNT, DIS, EN, LOGIN, LOGOUT, PASS** or **STAT**.

## Example setup

Let's look at a fictitious system setup to see how it all works. The specifications for this system are as follows:

- All commands to the controller must be acknowledged.
- The system is to be password protected. The initial password will be 'REDDWARF'.

## LED Indicators

Five LEDs are provided to indicate system status; four red (LED1 – LED4) and one green (LED5). The red LEDs indicate error conditions, so during normal operation none of them should be on.

**LED1 – Comms Error:** when illuminated, this LED indicates a controller to phone communications problem. Normally, it comes on for 6 seconds after power on and then goes out. If it doesn't go out, check for problems with the controller to phone cable connection. In addition, check that phone security (PIN) has been disabled and that the phone comes up ready for use at power on.

**LED2 – No Service:** indicates that the phone is not registered within the mobile network (check signal strength) or that an outgoing message has been disallowed. The latter is typically due to an empty pre-paid account. Note that although your service provider will block outgoing messages when an account expires, most still allow inbound messages for a certain length of time.

**LED3 – Send Error:** when illuminated, the controller has failed to send one or more messages. This can be caused by a variety of problems, including mobile network overload, momentary signal dropout, an empty pre-paid account, phone malfunction or an intermittent controller to phone connection.

**LED4 – Delete Error:** indicates that the controller cannot delete a message from SIM memory. Cycle the phone power to correct this problem. If the error persists, then there may be a problem with the SIM card or phone.

**LED5 – In Use:** this LED comes on when you login to the system and goes out when you logout.

- A relay is connected to OUT1, as shown in Fig.6(a) – last month. The relay controls a pump motor.
- The relay is to be switched on by sending 'PUMP ON' to the controller.
- The relay is to be switched off by sending 'PUMP OFF' to the controller.
- A switch is connected to IN1, as shown in Fig.7(b) – last month. The switch detects water level in a tank.
- When the switch closes, we want to receive the message 'TANK OVERFLOW'.
- When the switch opens, we want to receive the message 'LEVEL NORMAL'.

We start in programming mode by installing a jumper on JP3 and powering up. After the 'Comms Error' LED goes out (about 6 seconds), we can send our programming commands from a second mobile phone, as follows:

**LOGIN** (the green LED illuminates)
**ACKON**
**PASSREDDWARF**
**OUT1LPUMP ON**
**OUT1HPUMP OFF**
**IN1LTANK OVERFLOW**
**IN1HLEVEL NORMAL**

This completes the programming, so JP3 must now be removed, returning the system to operating mode. We can now control the pump by 'SMSing' the following messages to the controller:

**PUMP ON** (switch the pump on)
**PUMP OFF** (switch the pump off)

If our imaginary tank overflows and the switch closes, we'll receive the message:

**TANK OVERFLOW**

When the level subsides and the switch opens, we will receive the message:

**LEVEL NORMAL**

Now suppose we don't want to receive the 'LEVEL NORMAL' message again. Instead, we only want to be informed when there is an overflow. We can disable the 'LEVEL NORMAL' notification by sending:

**DISLEVEL NORMAL**

To later reinstate notification, we'd send:

**ENLEVEL NORMAL**

To change the password to 'STARGATE' and disable acknowledgments, we could send:

**PASSSTARGATE**
**ACKOFF**

To log out of the system and prevent further messages being sent by the controller:

**LOGOUT** (the green LED goes out)

Finally, note that all future logins will require the current password, as follows:

**LOGINSTARGATE**

Each command is sent as a separate message. After the **ACKON** command, the controller will acknowledge all subsequent commands; you should wait until you receive these before sending the next command. Although you don't need acknowledgments turned on, it's the only way to be certain that the controller has received and processed your commands. This is much more important during normal operation, when you're far from the controller and can't see what's happening.

The password and all user-programmed messages are stored in the micro's EEPROM, so you only need to program the system once. The same goes for the output port state. If a power failure occurs, the last state will be automatically reinstated when power is restored.

You can reprogram the system at any time simply by repeating the steps outlined above. When you redefine a message for any input or output, the old message is automatically overwritten.

If you'd like to start from scratch, then all of the previously programmed messages can be deleted in one operation by erasing the microcontroller's EEPROM. This is achieved by powering off and installing a jumper on JP1. When you power up again, all four red LEDs come on to indicate that erasure is complete.

Note that this operation also wipes the password and all other parameters, including the 'SMS sent' and 'SMS received' counters.

Finally, you can erase just the password by powering off and installing a jumper on JP2. At the next power on, the password will be erased. Be sure to remove JP2 when done, otherwise the **PASS** command will have no effect!

### Security

While it's not strictly necessary to program a password during setup and testing, we recommend that you do so before 'going live'. A password is an effective way of preventing someone else taking control of the module without your knowledge.

Once you've successfully logged in, the SMS controller will only accept messages from your mobile phone number. Messages from all other


**The 3210 interface is also accessible under the rear cover but unlike the 3310, there's no need to remove the battery. Once in place, the connector and cable extend at right angles from the rear of the phone, which may make mounting awkward in some cases.**

numbers are simply ignored. An exception to this is the **LOGIN** command itself, which can be issued from any mobile number at any time, regardless of whether you're already logged in or not. This allows you to regain control of the system using a second phone should your current phone be lost or stolen. *EPE*

**Credits**

Thanks go to the gnokii team, who kindly published details of their work with the Nokia serial bus protocols. You'll find their web site at: **www.gnokii.org**.

Regular Clinic

# Circuit Surgery

Ian Bell

## Active Current Measurement

RECENTLY there has been some discussion on the *EPE Chat Zone* (via **www.epemag.co.uk**) about the measurement of current by amplifying the voltage drop across a small resistor. CZ User ***Chuckieboy*** started the discussion by posting a question about the lack of stability of the reading obtained from such a circuit. Here are some extracts from his post:

*I measure the voltage drop across a 0.1Ω resistor and use an op amp to boost the voltage. The voltage coming out of the op amp seems smooth enough, but my reading is up and down. I feed the op amp with 2 × 1kΩ resistors which go either side of the 0.1Ω resistor. The voltage comes out 0V to 5V with 0V to 400mV across the resistor. I've done some Google searching but got confused as there seem to be so many ways of doing it.*

At the time of writing, there is insufficient information on the details of Chuckieboy's circuit and the nature of the instability to provide a specific diagnosis, but we can look at some of the ways of approaching this problem and hopefully reduce the confusion.

### Key application

A key application of resistive current sensing is the measurement of the supply current being used by a circuit. This may typically be used for power monitoring consumption and providing smart battery management, or to detect fault or misuse conditions causing excessive current, and hence provide a safe shutdown.

The approach is fundamentally very simple – a sensing resistor is inserted in the supply or ground line between the power supply and the circuit. The sense voltage ($V_S$) dropped across the sensing resistor ($R_S$) is used to measure the supply current, I:

$I = V_S/R_S$

Despite this basic simplicity, there are some potential difficulties with the design of the measurement of supply current measurement circuits, and the possibility of detrimental side effects on the system for which the supply current is being measured.

### In consideration

A number of factors may need to be considered when designing supply current measurement circuits. These include heating and power dissipation in the sense resistor, the effect of ground voltage offset or supply voltage drop on the measured circuit, accuracy of the current measurement required, voltage output of power supply (high voltage circuits may need different approaches) and the physical nature of the ground/chassis in the system.

The value of $R_S$ is typically a fraction of an ohm, possibly only a few milliohms for systems consuming several amps. $V_S$ typically has a value of tens of millivolts. The sense resistor dissipates power, P:

$P = I^2R_S$

Making $R_S$ smaller reduces dissipation, but also makes measuring the consequently smaller $V_S$ less accurate. On the other hand, smaller dissipation will reduce self-heating in $R_S$ which may help accuracy.

If the value of $R_S$ is temperature dependent (which it usually will be), the value of $R_S$ will be different for high and low supply currents and the reading will not be so accurate unless this is taken into account. $R_S$ does not have to be a resistor; it could be a piece of wire or a PCB track (trace).

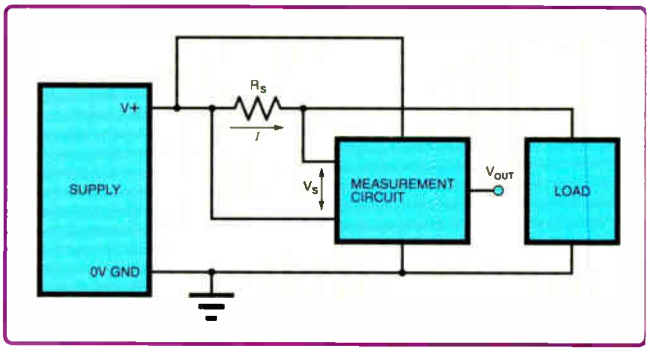



**Fig.1: high-side supply current measurement**

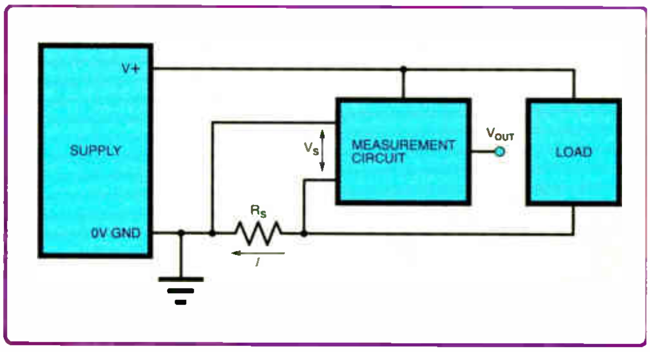



**Fig.2: low-side supply current measurement**

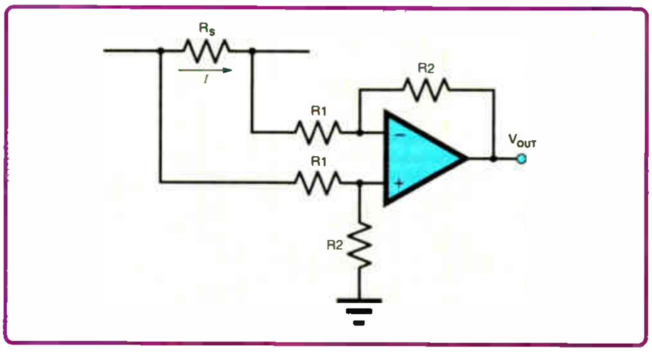



**Fig.3: high-side current measurement using a differential amplifier**

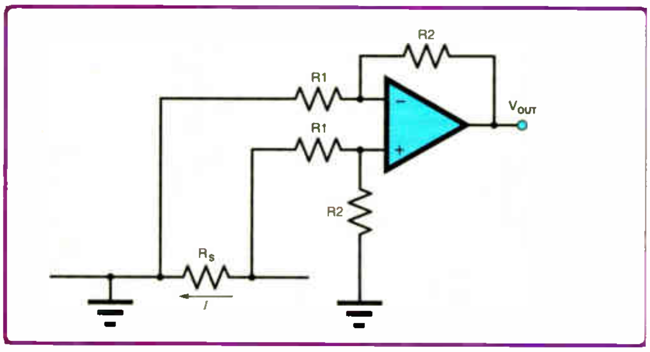



**Fig.4: low-side current measurement using a differential amplifier**

If the current being sensed has a large high-frequency component, the sense resistor must have low inductance. For example, this would be the case with a fast digital circuit which switched a large number of outputs (such as a bus) simultaneously at speed. Wirewound resistors have the highest inductance and low-inductance metal-film resistors are probably the best choice in many cases.

## Implementation approaches

As Chuckieboy indicates, there are a variety of different approaches to circuit implementation. These have different advantages and disadvantages and are suited to different situations. We can build measurement circuits using op amps, but there are also special ICs available for supply current measurement.

One of the key decisions when designing a supply monitor is whether to use high-side or low-side current monitoring. High-side monitoring uses a sense resistor in the supply line, whereas low-side monitoring places it in the ground line. The basic configurations of these two types of supply measurement circuits are shown in Fig.1 and Fig.2.

In general, low-side circuits are easier to design. The sensing circuit sees $V_S$ as a small positive voltage relative to the PSU's ground. This can be easily amplified ready for display on a meter or input to a microcontroller's analogue-to-digital converter (ADC).

However, there is serious problem with low-side monitoring in that the circuit being measured will not have a true ground voltage. Any signal passed between this circuit and other circuitry connected to ground will be subject to an offset voltage equal to $V_S$. This will usually be intolerable in any system processing precision analogue signals.

In situations, such as automotive systems where components are grounded by their mechanical connection to the chassis, use of low side monitoring may be impossible. For these reasons high-side monitoring is often preferred.

A differential amplifier using an op amp may be used for both high-side and low-side measurement. Typical circuits are shown in Fig.3 and Fig.4.

## CMRR Problem

One problem with the differential amplifier circuit used in Figs. 3 and 4 is that its common mode rejection ratio (CMRR) is very poor or, more specifically, is highly dependent on the accuracy of the resistors used. The differential amplifier's output should depend only on the voltage drop across the sense resistor, but the voltage at the sense resistor appears as a common mode input to the amplifier. If the CMMR is poor, this voltage will influence the amplifier's output, distorting the current measurement.

Use of ordinary 5% or 10% resistors in the differential amplifier circuit will lead to very poor common mode rejection. You need 0.01% resistor accuracy to get just 86dB of CMRR with a prefect op amp!

In an experimental situation you could adjust the resistor values to maximise the CMRR, but you would have to take care that values did not drift. A better solution is to use a differential amplifier IC with built-in accurate resistors, such as the MAX4198 and MAX4199 from Maxim. See Fig.5.

These ICs are described as micropower, single-supply, rail-to-rail, precision differential amplifiers. The MAX4198 is factory trimmed to a fixed gain of +1V/V, and the MAX4199 is trimmed to a fixed gain of +10V/V. These gains are set with an error of 0.01%.

With these devices the standard differential amplifier configurations provide common-mode rejection of 90dB for the MAX4198 and 110dB for the MAX4199. For further information consult Maxim's datasheeet at **http://datasheets.maxim-ic.com/en/ds/MAX4198-MAX4199.pdf**.

## CM input range

One important thing you have to watch for when designing supply current monitoring circuits using op amps, is the common mode input range of the op amp. For example, consider Fig.3. The high side sense resistor has one terminal connected to the power supply rail, and by virtue of the small voltage drop essential to prevent this resistor interfering with the measurement, the other side of $R_S$ will be at almost the same voltage. This means that the op amp's common mode input voltage is about equal to the supply voltage.

Not all op amps work happily under such conditions, so this is something you must check when selecting an op amp for this task. The manufacture's datasheet will detail the acceptable common mode input range. Special high side current monitoring ICs are, of course, designed to cope with large common mode input voltages.

One of the op amps Chuckieboy mentioned trying was the LM324. Unfortunately, the common mode input range specified on the LM324's datasheet (from National Semiconductor, available on line at **www.national.com**) only goes to 1.5V below the positive supply.

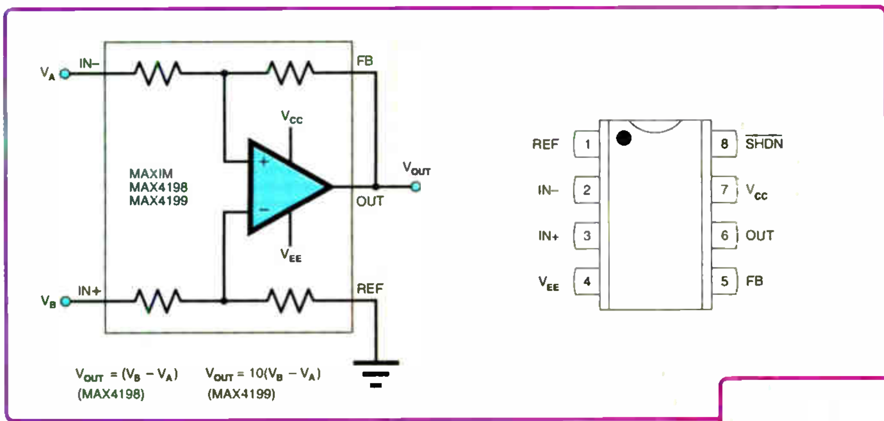



**Fig.5: differential amplifier configuration and chip pinout for the MAX4198 and MAX4199** (from Maxim's datasheet)

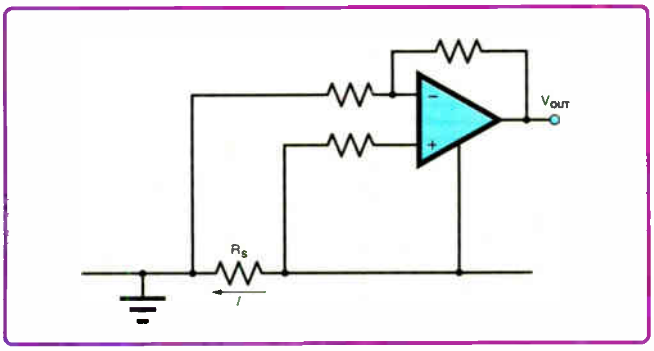



**Fig.6: in this confirguration the op amp must have an input voltage range that extends below its negative supply voltage**

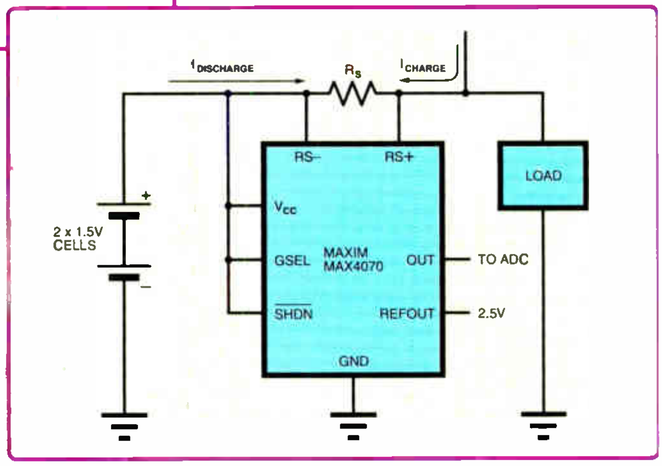



**Fig.7: bidirectional current sensing to monitor battery charge and discharge using the MAX4070** (Maxim datasheet)

A high-side monitor would exceed that requirement and therefore the LM324 is very unlikely to function correctly (although no damage should occur).

He also mentioned the LT1491 from Linear Technology (**www.linear.com**), which is a much better choice as it is a micropower rail-to-rail input and output op amp. This op amp is able to cope with common mode signals equal to its supply voltage.

The situation with common mode input range becomes even more difficult if the op amp's supply pins are the 'wrong' side of the sense resistor. This is illustrated in Fig.6 in which the op amp's common-mode input range must extend below zero by $V_S$. This capability is rarer than rail-to-rail common mode range, but is a further advantage of the MAX4198 which has an input voltage range which extends 100mV beyond the supply rails.

Special high-side current measurement ICs are also available, for example the range of devices from Maxim, which includes devices such as MAX4071, MAX4172, MAX 4173 and MAX4372. Fig.7 shows an example of a circuit using one of the specialist current measurement ICs, the MAX4070, which is a bidirectional, high-side, current-sense amplifier with reference. Maxim expects this device to be used for monitoring battery charge and discharge currents in notebooks, cellphones, and other portable equipment.

The output voltage of the circuit in Fig.7 is greater than the reference voltage (2.5V) if the battery is charging and less than the reference if the battery is discharging. The difference between the output and reference is proportional to the current flowing in the sense resistor $R_S$ (charge or discharge) and may be connected to an ADC input of a microcontroller or similar device. For further information consult the datasheet at **http://datasheets.maxim-ic.com/en/ds/MAX4069-MAX4072.pdf.**

# Ingenuity Unlimited



Our regular round-up of readers' own circuits. We pay between £10 and £50 for all material published, depending on length and technical merit. We're looking for novel applications and circuit designs, not simply mechanical, electrical or software ideas. Ideas *must be the reader's own work* and **must not have been published or submitted for publication elsewhere.** The circuits shown have NOT been proven by us. *Ingenuity Unlimited* is open to ALL abilities, but items for consideration in this column should be typed or word-processed, with a brief circuit description (between 100 and 500 words maximum) and 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., 408 Wimborne Road East, Ferndown, Dorset BH22 9ND. (We **do not** accept submissions for IU via email.) Your ideas could earn you some cash **and a prize!**

## Wind Speed Monitor – *How Discretely Bloweth the Wind?*

INSPIRED by John Becker's ingenious original design for measuring wind speed using ultrasonic transducers (*EPE* Jan '03), but lacking his PIC programming skills, the author wondered if a similar method could be used but without a PIC. The design described here works quite well, although it does have some significant performance shortcomings compared to John's elegant PIC-based version and it uses many more ICs.

### Fundamentals

The equations associated with the discrete version are as follows, where:

$d$ = the distance between two pairs of ultrasonic receivers and transmitters, A and B
$v_w$ = velocity of wind, blowing from B towards A
$v_s$ = velocity of sound in air
$t_r$ = response time of receivers (assumed to be the same for both)

The total apparent time for a pulse to travel from A to B against the wind is:

$$t_1 = d/(v_s - v_w) + t_r \qquad (1)$$

The total apparent time for the pulse to travel from B to A with the wind is:

$$t_2 = d/(v_s + v_w) + t_r \qquad (2)$$

An up/down counter, driven by a clock frequency of f Hz, is enabled to count up during $t_1$ and down during $t_2$:

count up $= f \times t_1$
count down $= f \times t_2$

If C is the remaining count, then:

$C = f \times (t_1 - t_2)$ (C is positive as $t_1 > t_2$)

Substituting for $t_1$ and $t_2$ from (1) and (2) gives:

$$C = f \times \left(\frac{d}{v_s - v_w} + t_r - \frac{d}{v_s + v_w} - t_r\right)$$

$$= f \times \left(\frac{d(v_s + v_w) - d(v_s - v_w)}{(v_s + v_w)(v_s - v_w)}\right)$$

$$= f \times \left(\frac{2 \times d \times v_w}{(v_s^2 - v_w^2)}\right)$$

But $v_s^2$ is much greater than $v_w^2$
so C is approx equal to $f \times 2d \times v_w/v_s^2$ (3)

As f, d and $v_s$ are constant, the number held in the counter will be directly proportional to the wind speed.

### Calc-Free

To remove the need for any calculations, make:

$f \times 2d/v_s^2 = 1$ (4)
then $C = v_w$

Hence the number remaining in the counter will be the actual wind speed in whatever units have been chosen for d, f and $v_s$. In practice, any convenient clock frequency can be chosen, say 500kHz, and d is then calculated.

### Practical Example

For the display in MPH:

$v_s$ = 741 miles/hour

$f = 500\text{kHz} = 500 \times 10^3$
count $= f \times 60 \times 60$ cycles per hour $= 1.8 \times 10^9$

$d = v_s^2/2f$ from (4)

$= 741^2/(2 \times 1.8 \times 10^9)$ miles

$= 1.53 \times 10^{-4}$ miles

$= 1.53 \times 10^{-4} \times 3 \times 1760$ feet

$= 0.81$ feet

$= 9.68$ inches (246mm)

### The Circuit

The sequence of operation is controlled by the outputs of a decimal divider, IC7, driven by a 10Hz clock, IC14d (Fig.4). During the period of count 0 to 1, OR gate IC6b closes analogue switch IC2a and connects the first receiver, RX1 and TR1, through IC1a and IC1b (Fig.2), to the reset of one half of D-type flip-flop, IC3 (Fig.3). Resistor R4 and capacitor C3, on pin 5 of IC6b (Fig.2) ensure that its output remains high during the IC's transition from 0 to 1.

At the same time, referring to Fig.1, transmitter TX1 is selected by switch IC2c and the synchronous up/down counter formed by IC10 and IC11 (Fig.5) is set to count up. At the start of count 1 from IC7 (Fig.4) in Fig.1, pin 3 of IC6a triggers a 1ms monostable, IC4, which enables the

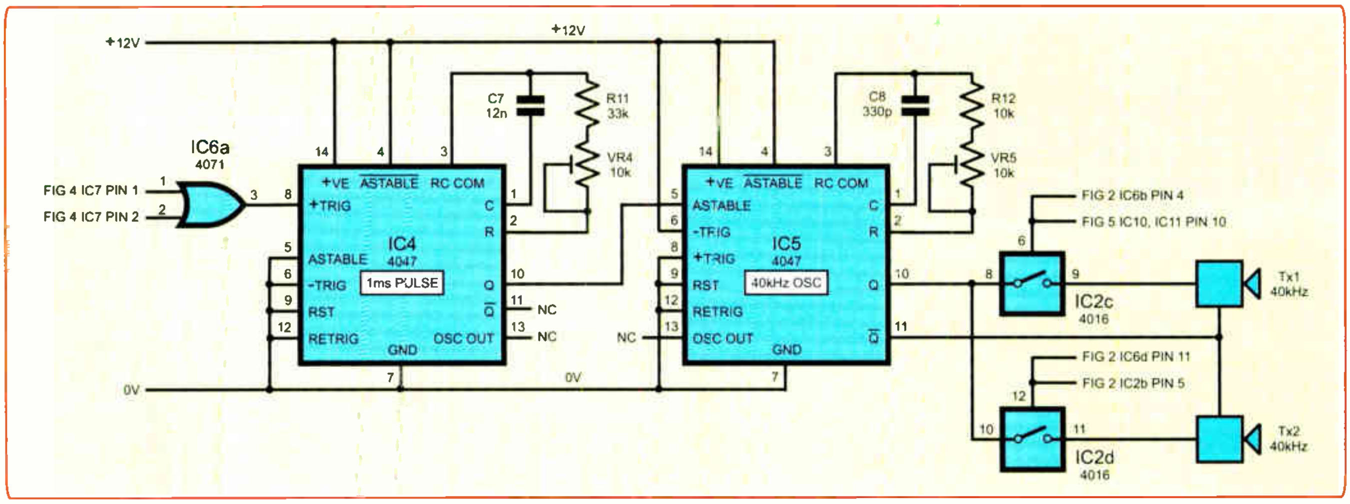



*Fig.1 Transmitter driver circuits*

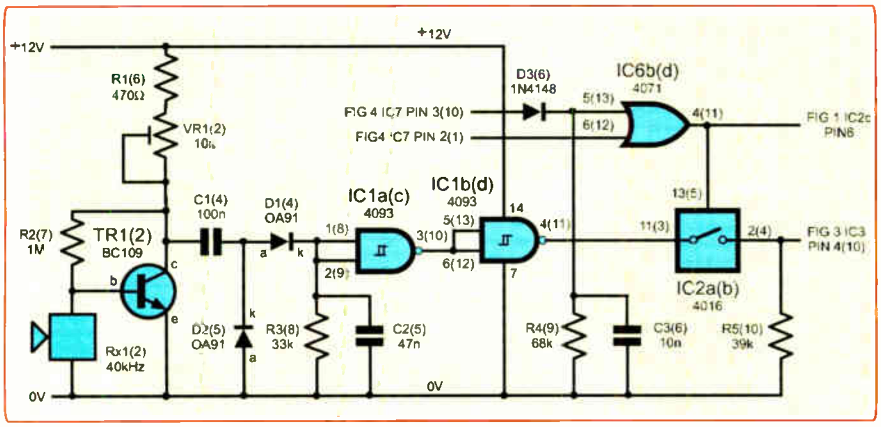
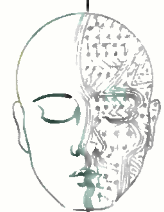



*Fig.2. Receiver Circuit*

# INGENUITY UNLIMITED

## BE INTERACTIVE

IU is your forum where you can offer other readers the benefit of your Ingenuity. Share those ideas, earn some cash and possibly a prize.



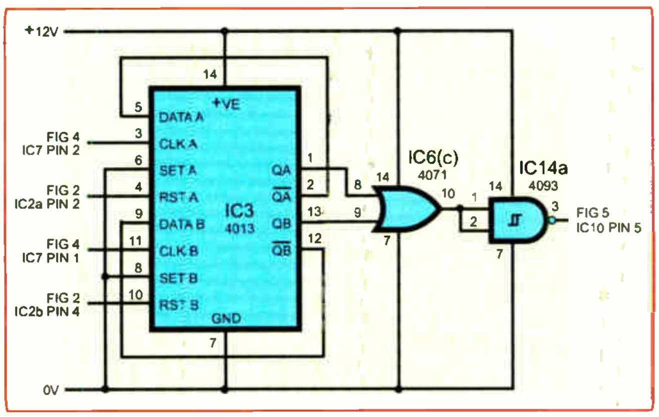



*Fig.3. Dual D-type flip-flop stage*

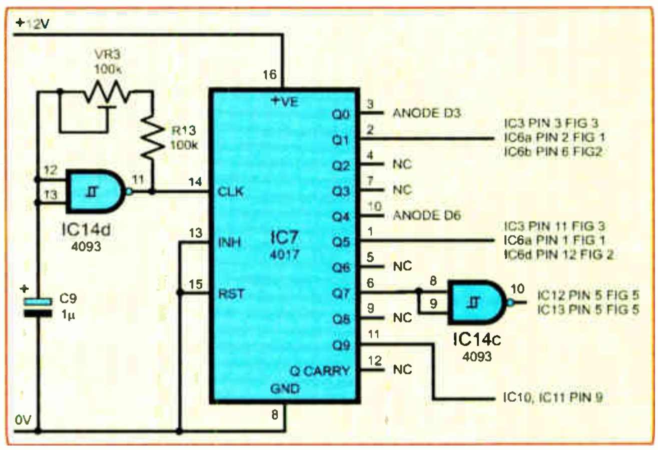



*Fig.4. Sequence controller*

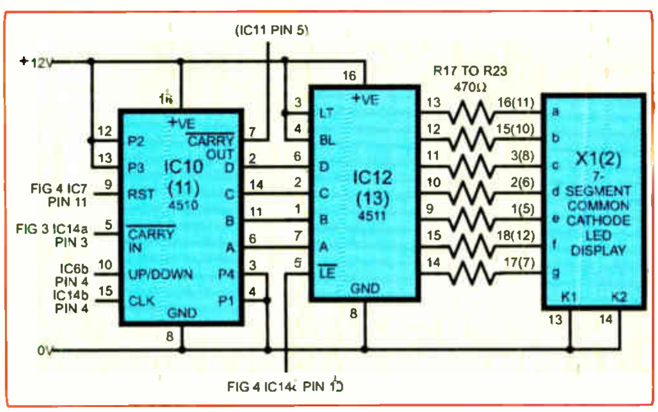



*Fig.5. Up/Down counter and display driver*

40kHz oscillator IC5 which drives TX1, sending a pulse to receiver RX1 (Fig.2). Count 1 also clocks one half of flip-flop IC3 (Fig.3). TR1 in Fig.2 goes high and starts the up/down counter (Fig.5) via IC6c and IC14a (Fig.3).

While the pulse is travelling against the wind from TX1 to RX1, the counter is counting up. The counter is driven by a stable clock provided by the 10MHz oscillator module, IC8 (Fig.6). IC9 divides its output by 20 to give 500kHz. As IC8 and IC9 use a 5V stabilised supply (IC16), and the rest of the circuit employs 12V, an LF351 op amp, IC15, is used to restore the logic level to 12V. As the slew rate of the LF351 is inadequate for 500kHz, IC14b squares up the output for the counter. (This is a bit unconventional, but the author had a spares box of op amps!)

When the pulse arrives at RX1 (Fig.2), it is amplified by TR1 and demodulated by germanium diodes D1 and D2. The receiver has a finite response time and as the demodulated pulse rises, it triggers IC1a and is inverted by IC1b, which resets flip-flop IC3 (Fig.3). (The response time is added to the true transit time of the pulse and would appear to cause an error. However, as shown previously, the response times of the two receivers cancel out, provided they are both the same.)

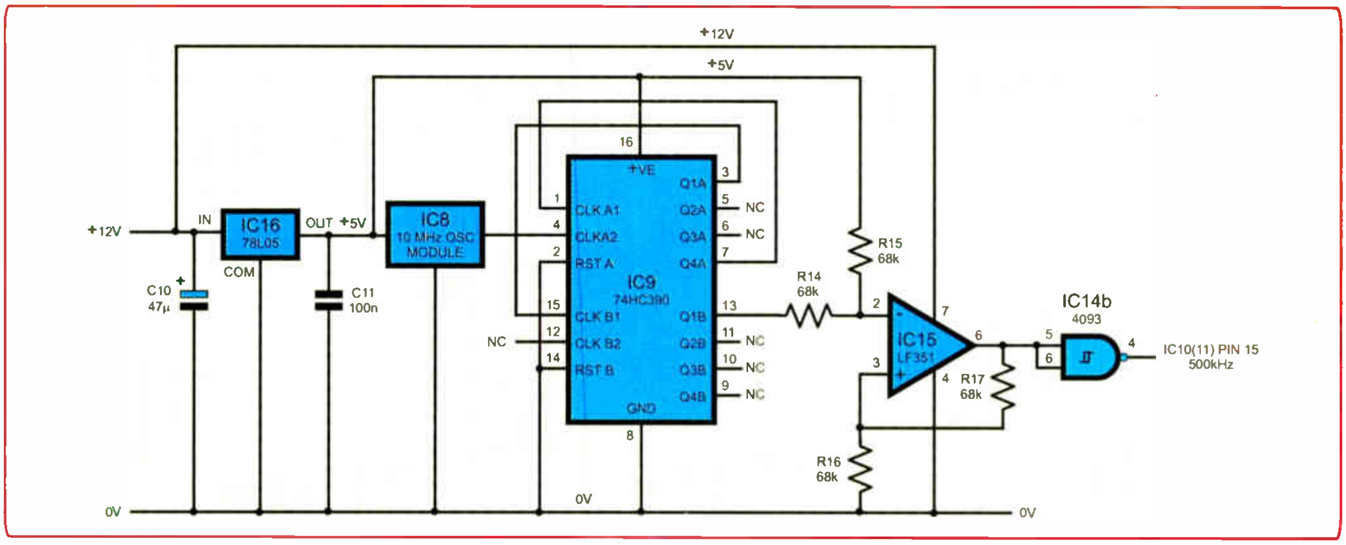



*Fig.6. The 500kHz clock and restore logic level section*

In Fig.3, as flip-flop IC3 resets, its QA output goes low and the counter is stopped, via IC6c and IC14a. There is then a short delay until count 4. During the period of counts 4 and 5, the output of IC6d goes high and the other receiver, RX2, is selected through the switch IC2b, and the second transmitter, TX2, through IC2d.

The counter (Fig.5) was previously set to count down by IC6b (Fig.2) at the end of count 1. At the start of count 5, IC6a (Fig.1) triggers IC4, enabling IC5 which drives TX2. The counter then counts down until the pulse is received by RX2, which resets the flip-flop and stops the counter. The outputs of the counters are sent to the two 7-segment LED display drivers IC12 and IC13 (Fig.5).

At count 7 the drivers send the stored number to the LED displays (Fig.5), which show the wind speed. Only two displays are needed as the remaining count is unlikely to exceed 99 (MPH!). At count 9, the counter is reset and the cycle repeats.

## Setting Up

Referring to Fig.1, adjust preset potentiometer VR5 to give a frequency of 40kHz from IC5 and maximum output from the receivers at the collectors of TR1 and TR2 (Fig.2). Set the pulse length from IC4 (Fig.1) to about 1ms with VR4. The sequence controller IC7 (Fig.4) is set by VR3 to run at 10Hz. The display should read zero with no wind. If it does not, adjust VR1 together with VR2 so that each receiver has the same response time.

**Stephen Stopford, London**

*(John Becker reckons that programming PICs is easier than what Stephen must have gone through to achieve his design!)*

# READOUT

Email: john.becker@wimborne.co.uk

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

All letters quoted here have previously been replied to directly.

## WIN AN ATLAS LCR ANALYSER WORTH £79

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## ★ LETTER OF THE MONTH ★

### Congrats and Suggestions

Dear EPE,

I just want to say 'Thank you!' for Mike Hibbett's wonderful *C or PICs* series in *EPE* recently. The series has prompted me (a middle-aged molecular biologist without formal electronics and programming training, who's been reading *EPE* and other mags for many years, but hardly finds the time to build and program anything outside his head) to buy a PIC programmer and a few PIC18Fs, and learn to program them in C as a summer project (I'm in New Zealand).

Being a novice to C, I wouldn't have succeeded without Mike's articles, despite having some programming experience (Perl, VB). It's always those first few steps to get over the initial hurdle – we call it 'activation energy'. Biological enzymes and chemical catalysts work by lowering that hurdle, and these articles have been exactly that – a great catalyst!

Given the large code space and low price of the 18F PICs, and C18/MPLAB, I find it hard to justify learning to program them in assembler. So I would like to encourage you to continue writing about the topic – personally, I feel a few more examples incorporating standard tasks would be most helpful.

How about re-coding some of the assembler examples Microchip provides for their demo boards? Using those, your readers won't have to build hardware as it is (more) economical to buy the demo boards – (those wanting to can do so as both circuit and PCB layout are on the Microchip website); you could just refer to the circuitry 'as per Microchip' without sacrificing page space; and the *EPE* community will gain a nice collection of code 'snippets' covering most routine jobs.

Furthermore, I think we need more help using the USB facility on these chips, as Microchip's documentation is not very comprehensive, and a little too abstract even for 'initiated' novices. Mike's latest articles cover sending data via USB to a PIC very well. How about describing how to send data from a PIC via USB to a PC. Again, writing code for some of the circuits previously published in *EPE* would be useful and *EPE* won't have to re-publish the circuits.

For example, using one of the Dallas sensors to measure temperature, using a PIC to keep it constant and log the data while offline from the PC, sending stored data to the PC and checking for new settings when connected would be fantastic.

The bootloader itself is also worth more coverage, as I have seen statements that Microchip's C code won't fit in lower registers of the 2550 when compiled with the student edition of the compiler (once the optimisations are disabled). And describing how to connect to the PIC on the USB port using one or more of the visual languages (C#, VB, Delphi, all of which are now available free to hobbyists) would be a very welcome one-off article.

Finally, the Microchip website has a reference to add Ethernet connectivity to PICs – that would be cool to learn with C, as would be hooking PICs up to some of the now very cheap USB devices – Bluetooth, WiFi, etc.

Regarding a constructional project involving hardware, maybe a relationship with Microchip could be of interest – something like an extended demo board that is used to test all the functions accessed via the C code described in the future series. Microchip should welcome this, as it will expose more users to their chips, and you will help train their future customers, which can only be good for them.

**Klaus Lehnert, Auckland, New Zealand, via email**

*We do have a tie-up with Microchip and will be running some articles from them in the future – there will also be a free Microchip CDROM with the June issue.*

*Mike Hibbett replied to Klaus:*

*Thank you for your comments, the feedback is always welcome!*

*Regarding 'code snippets', I think it's an excellent idea – I'll try to set up something, like a library of useful functions for the PIC. It's unlikely that I would re-write existing assembly code though, since this can just be linked into a C project if needed. I'll probably be covering how to link in assembly language routines in a later article.*

*Your point about the USB project is well noted; as much as we hobbyists love RS232 it is a 'dying' interface and we are all going to have to embrace USB or Ethernet at some point. I will probably cover more on USB in the months to come.*

*I see you have noticed that Microchip have moved into proving Ethernet solutions – I noticed too! I have some samples of their Ethernet to SPI interface IC, and I have already planned to include an article on it in* Pic'N'Mix *at some point this year. It's a great little IC, one I have been waiting some time for, and I'm looking forward to playing with it.*

*Thank you very much for the comments. I am a great fan of the C language, and was very pleased when EPE agreed to let me share my enthusiasm with readers by writing the articles. Programming is great fun and I hope you continue to enjoy it.*

**Mike Hibbett, via email**

### Wind Power

*Following on from the Editorial in the Feb '07 issue, there have been a number of letters on the subject of alternative power sources. It has also come up on the* EPE *Chat Zone recently (access via* **www.epemag.co.uk**). *Here are a few of the letters we've received by email.*

**Mike Mee:**

I believe that *EPE* can provide some very useful construction articles on alternative power generation, but not in the way suggested. As you point out, Bull Group offer wind turbines, as do B&Q, so why attempt mechanical construction in an electronics magazine?

The way forward has to be with the electronics required to provide 240V AC from any of the generation methods, i.e. wind, photovoltaic or water wheel.

There are two possible routes here, depending on whether power is to be stored or not. If storage batteries are required the first item is a charger of some sophistication that can take in virtually any DC voltage up to about 150V and *correctly* charge the battery connected to it.

Commercial units seem to be able to be set for batteries up to 60V in 12V increments, some are even able to auto-sense and select the required voltage. Currents in the region of 30A to 60A.

Inverters – with the battery as above, the inverter can be set for a certain input voltage, which might make for a slightly easier design. Inverters designed for direct input, no batteries, must take whatever is thrown at them, i.e. 75V to 150V, even 250V to 500V in some cases, and provide 240V AC with a true sinusoidal waveform suitable for grid connection.

The next interesting bit is that the inverter should be able to synchronise with the National Grid and auto connect itself when it has something to give, and to give all it can in preference to the mains supply. Power of 3kW+ would be useful, so that many people could at least run the immersion heater in summer and shut off the gas boiler for six months, or supplement the AC mains requirements for the full year. There are many options here, and one heck of a challenge!

While the Grid supply people don't seem to mind me connecting home made projects requiring power via a transformer to the mains, I think they may be a bit more fussy about power producing systems being paralled to them as the consequences of 'out of phase' connection are interesting to put it mildly! I have some experience of this as a marine engineer paralleling generator sets – **don't get it wrong!**

Modern electronics is up to it, you just need the designers. What about it?

**www.windsave.com** – this site, I think is the supplier to B&Q and provides about 1kW to a 13A socket i.e. erect windmill and plug into the household ring main.

**www.unlimited-power.co.uk** – this site is worth looking at for the data sheets of chargers, inverters, photovoltaic cells and wind turbines, and general information and inspiration.

**David Houghton:**

The Feb '07 Editorial was a welcome confirmation of the conclusion I had nearly reached on domestic wind turbines. I have been researching alternative energy for some time and it is very difficult to be realistic as opposed to being self-deceived into believing there is a bargain of free energy just waiting to be collected. I for one would welcome guidance on other DIY alternative options. The comparison of light outputs from various sources in the same issue was useful too.

Solar cells produce little current at low voltage. Solar collectors might be worthwhile from the energy angle but they look unsightly on the roof and if one's plumbing is working fine it seems a pity to disturb it.

Would collecting rain water give better rewards than alternatives for those with water meters? An additional higher roof tank might be employed so that its head of water is used in preference to the mains. That tank could be topped up by water from butts pumped by electricity from solar cells solely when it's available. No need to store the electricity in batteries, just store a head of water. Precautions would need to be taken, for example to avoid damage to ceilings due to the extra weight in the roof.

How about having a small area solar collector with large area parabolic mirrors reflecting the sun onto it? Has a community group geothermal energy source been investigated to overcome the objection of it being too big a project for one household?

These are just a few of the options and objections that *EPE* could investigate for readers with the initial emphasis on pointing our efforts to potentially fruitful alternative projects. I won't carry out my plan to replace some of our kitchen concealed fluorescents with LEDs now that I've learned they are less efficient!

How about it *EPE*, can you do the research and tell us the best options with detailed projects to follow?

**Peter Woffinden:**

After reading in Feb'07 about wind turbines, I think you should publish something, even if it's only a small whirlygig type that produces up to 12V at around 100mA. I have been playing around for about a year and built one out of a car alternator with neomydium magnets in the rotor. The blades are made from 8-inch diameter pipe that I hope to use to charge the battery on an electric fence unit/bird scarer. I haven't sorted the controller to stop it overcharging the battery yet.

*Well readers, are there any among you who have the necessary expertise to take up the challenges for* EPE*? Drop us an email or letter.*

## Network Servers and PICs

Dear EPE,

I've been subscribing to *EPE Online* for a few years now. Recently there's been a net server developed, the PICAXE Net Server, which is fine but could one of your authors start the development of a Net Server using one of the 18F series of PICs, particularly with one of the newer 18F PICs of the species, 4550, 4620 or better. I'm sure there would be masses of interest, especially as it would enable security control from anywhere on the planet plus many other uses of remote control too numerous to mention.

The code could also be written in C which would further boost popularity. I know that now there's interest in developing code for Microchip PICs in C++, I use the FED C compiler, FED advertise with you and I know that Robin Abbott is at this moment developing his version of the FED C++ compiler, we're waiting with eager anticipation. As they say, the future's bright.

**Glynne Hewlett, via email**

*I sent Glynne's comments on to Mike Hibbett, who replied to him:*

*Small network servers (a microcontroller with a TCP/IP 'internet stack') have been around for a few years now. One of the first really useful designs was the PicoWeb, for which the design is still available at* ***www.picoweb.net****.*

*One of the main obstructions to building such a unit, however, has been the difficulty in purchasing a suitable ethernet interface IC. These ICs tend to be very fine pitch too. Things are improving however; Microchip are soon to release PIC microcontrollers with an internal ethernet interface, and in an easy to use package. You may rest assured that when these parts become readily available, your wishes will be addressed!*

**Mike Hibbett, via email**

## Project Index

Dear EPE,

I thought you might like to know that I have a database containing details of all constructional projects published in *EPE* since 1992 (when I first bought the magazine). The database is available either as an MS Access file or with a stand-alone application included to view and search for projects by description or year.

I update the details at the end of each year from the published index, so the database currently has projects to the end of 2006. Both versions can be downloaded from **www.electronics2000.co.uk**. I originally made the database for my own use, never being able to find old projects I wanted to refer to, and find it invaluable from time to time.

Incidentally, I'm sure you used to publish indexes on your website but I can't find them anymore. If you did it would save a lot of typing next year! Keep up the good work with the magazine.

**Simon Carter MEng MIET, via email**

*Thanks Simon. In fact there is a Project Index for 1998 to 2006 on our UK website, via* ***www.epemag.co.uk****. Click on 'Project Index' on the top left corner of the home page.*

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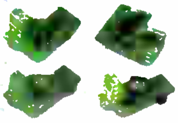

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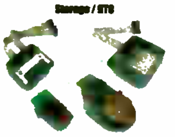

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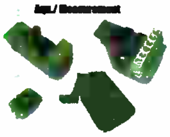

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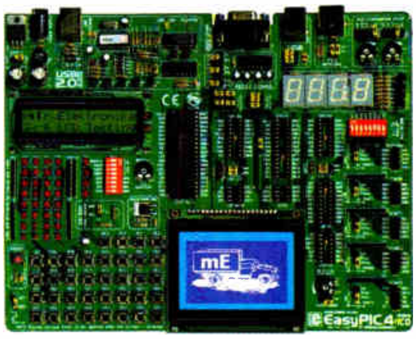

3in1 DEVELOPMENT SYSTEM — HARDWARE ICD ON-BOARD, USB 2.0 ON-BOARD PROGRAMMER, HIGH PERFORMANCE DEVELOPMENT BOARD

**EasyPIC4 development board:** Following in the tradition of the EasyPIC3 as one of the best PIC development systems on the market, the EasyPIC4 has more new features for the same price. The system supports 8, 14, 18, 20, 28 and 40 pin PIC microcontrollers (it comes with a PIC16F877A).

**mikroICD** is a highly effective tool for Real-Time debugging on a hardware level. The ICD debugger enables you to execute a mikroC/mikroPascal/mikroBasic program on a host PIC microcontroller and view variable values, Special Function Registers (SFR), memory and EEPROM as the program is running.

**On-board USB 2.0 PICFlash programmer** – an ultra fast USB 2.0 programmer for fast MCU programming. Continuing its tradition as the fastest PIC programmer on the market, the new PICFlash with mikroICD now supports more PIC MCUs giving the developer a wider choice of PIC MCU for further prototype development.

Package contains: EasyPIC4 development system, USB cable, Serial cable, User's manual, MikroICD manual, CD with software, drivers and examples in C, BASIC and Pascal language.
Note: LCD, DS1820 temp. sensor and GLCD are optional.

**EasyPIC4 Development System** ................................ **$119.00 USD**
**Optional:**
**2x16 LCD and DS1820 temperature sensor** ............ **$15.00 USD**
**Graphic LCD 128x64 dots** ........................................ **$17.00 USD**

## mikroElektronika Compilers
Pascal, Basic and C Compilers for various microcontrollers

Supporting an impressive range of microcontrollers, an easy-to-use IDE, hundreds of ready-to-use functions and many integrated tools makes MikroElektronika compilers one of the best choices on the market today. Besides mikroICD, mikroElektronika compilers offer a statistical module, simulator, bitmap generator for graphic displays, 7-segment display conversion tool, ASCII table, HTML code export, communications tools for SD/MMC, UDP (Ethernet) and USB, EEPROM editor, programming mode management, etc.

Each compiler has many routines and examples such as EEPROM, FLASH and MMC, SD and CF card reading/writing, writing to character and graphic LCDs, manipulation of push-buttons, 4x4 keyboard and PS/2 keyboard input, generation of signals and sounds, character string manipulation, mathematical calculations, I2C, SPI, RS232, CAN, USB, RS485 and OneWire communications, Manchester coding management, logical and numerical conversion, PWM signals, interrupts, etc. The CD-ROM contains many ready-written and tested programs for use with our development boards.

| Regular price: | | Price with discount: | |
|---|---|---|---|
| mikroBasic(PIC) | $149.00 USD | mikroBasic(PIC) (-30%) | $99.00 USD |
| mikroPascal(PIC) | $149.00 USD | mikroPascal(PIC) (-30%) | $99.00 USD |
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http://www.mikroe.com/en/distributors/

## LV24-33 Development Board
The Complete Hardware and Software solution with on-board USB 2.0 programmer and mikroICD

System supports 64, 80 and 100 pin PIC24F/24H/dsPIC33F microcontrollers (it comes with PIC24FJ96GA010 - PIC24 16-bit Microcontroller, 96 KB Flash Memory, 8 KB RAM in 100 Pin Package). Examples in BASIC, PASCAL and C are included with the system. You can choose between USB or External Power supply. LV 24-33 has many features that makes your development easy. Explore new PIC24F/24H/dsPIC33F PIC MCU's with LV 24-33 and experience all advantages of this microcontrollers.

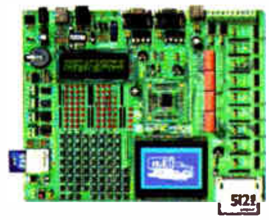
**LV24-33 Development System** ............................................. **$149.00 USD**

## Uni-DS 3 Development Board
with on-board USB 2.0 programmer

System supports PIC, AVR, 8051, ARM and PSoC microcontrollers with a large number of peripherals. It is enough to switch a card and continue working in the same development environment but with a different chip. UNI-DS3 has many features that makes your development easy. You can choose between USB or External Power supply. Each MCU card has own USB 2.0 programmer on it !

**Uni-DS 3 Development System** [with one MCU card]........... **$199.00 USD**

## dsPICPRO2 Development Board
with on-board USB 2.0 programmer



System supports dsPIC microcontrollers in 64 and 80 pin packages. It is delivered with dsPIC30F6014A microcontroller. The dsPICPRO2 development system is a full-featured development board for Microchip dsPIC MCU. dsPICPRO2 board allows microcontroller to be interfaced with external circuits and a broad range of peripheral devices. This development board has an on-board USB 2.0 programmer and integrated connectors for SD/CF memory cards, 2 x RS232 port, RS485, CAN, DAC etc..

**dsPICPRO2 Development System** ........................................ **$239.00 USD**

## EasyARM Development Board
with on-board USB 2.0 programmer

EasyARM board comes with Philips LPC2214 microcontroller. Each jumper, element and pin is clearly marked on the board. It is possible to test most of the industrial needs on the system: temperature controllers, counters, timers etc. EasyARM has many feature to make your development easy. One of them is on-board USB 2.0 programmer with automatic switch between 'run' and 'programming' mode. Examples in **C** language are provided with the board.

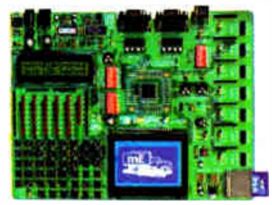
**EasyARM Development System** ........................................... **$149.00 USD**

## Easy8051A Development Board
with on-board USB 2.0 programmer

System is compatible with 14, 16, 20 and 40 pin microcontrollers (it comes with AT89S8252). USB 2.0 programmer is built in and programming can be done without removing the microcontroller. Many industrial applications can be tested on the system : temperature controllers, counters.. **Easy8051A** development system is a full-featured development board for 8051 microcontrollers. It was designed to allow students or engineers to easily exercise and explore the capabilities of the 8051 microcontrollers.

**Easy8051A Development System** ......................................... **$114.00 USD**

## BIGPIC4 Development Board
with on-board USB 2.0 programmer and mikroICD



Following in the tradition of its predecessor, the BIGPIC3 as one of the best 80-pin PIC development systems on the market, **BIGPIC4** continues tradition with more new features for same price. System supports the latest 64 and 80-pin PIC microcontrollers (it is delivered with PIC18F8520). Many ready made examples guarantee successful use of the system. Ultra fast on-board programmer and **mikroICD** (In-circuit Debugger) enables very efficient debugging and faster prototype developing. Examples in C, **BASIC** and **Pascal** language are provided with the board.

**BIGPIC4 Development System** .............................................. **$132.00 USD**

## EasyAVR4 Development Board
with on-board USB 2.0 programmer

System supports 8, 20, 28 and 40 pin microcontrollers (it comes with ATMEGA16). Each jumper, element and pin is clearly marked on the board. It is possible to test most of the industrial needs on the system: temperature controllers, counters, timers etc. **EasyAVR4** is an easy to use Atmel AVR development system. On-board USB 2.0 programmer makes your development easy. Examples in **BASIC** and **Pascal** language are provided with the board.

**EasyAVR4 Development System** ............................................. **$114.00 USD**

## EasyPSoC3 Development Board
with on-board USB 2.0 programmer

System supports 8, 20, 28 and 48 pin microcontrollers (it comes with CY8C27843). Each jumper, element and pin is clearly marked on the board. EasyPSoC3 is an easy to use PSoC development system. On-board USB 2.0 programmer provides fast and easy in system programming. EasyPSoC3 has many features that makes your development easy. You can choose between USB or External Power supply. EasyPSoC3 also supports Character LCD as well as Graphic LCD.

**EasyPSoC3 Development System** ......................................... **$169.00 USD**

## EasydsPIC3 Development Board
with on-board USB 2.0 programmer

System supports 18, 28 and 40 pin microcontrollers (it comes with dsPIC30F4013 general purpose microcontroller with internal 12 bit ADC) EasydsPIC3 has many features that make your development easy. Many ready made examples in C, BASIC and PASCAL language guarantee successful use of the system. On-board USB 2.0 programmer allows for faster prototype development.

**EasydsPIC3 Development System** ......................................... **$119.00 USD**

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# Net Work

## Alan Winstanley

### A failing memory

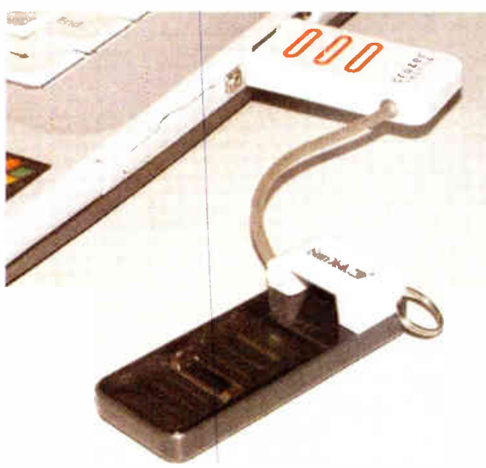
A staple ingredient of many users' Internet diets is eBay, the online emporium that sells new and used merchandise in every classification imaginable. Most transactions are completed successfully and there are millions of satisfied buyers and sellers.

Sometimes, though, a deal seems too good to be true. The photo shows a new 2GB USB memory branded as Kingston, one of the top names in memory components. A buyer sourced this via eBay for a price that is much less than branded sellers; the eBay seller played the common trick of charging excess for postage, which doubled the cost to about £16 ($32), totalling a few pounds cheaper than other web sites. The only problem is that it turned out to be a counterfeit. It is a remarkable copy of a reputable product, with extremely convincing packaging, accessories, barcodes and multilingual instructions. Even a seasoned buyer would be fooled.

The story unfolded when the product failed in use, and close-up photographs were emailed to Kingston, who soon confirmed that the item was not genuine. Memory chips are graded after manufacture and the rejects are not reliable enough for the number of read/write cycles that a USB thumb drive will experience. So the drive suddenly packed up on the job, without giving its owner any written notice beforehand.


*This Kingston USB memory drive was purchased via eBay – a convincing counterfeit.*

*(below) Sandisk Cruzer Profile memory contains an effective fingerprint scanner*



Where does this leave the buyer? It seems they have bought a hard-luck story. The item was 'pulled' from eBay within the hour after Kingston notified eBay of the forgeries. Kingston, however, was not interested in compensating those who had reported the illicit copies to them, and consequently they missed a low-cost opportunity to reciprocate with some goodwill, e.g. by replacing the item for a genuine product.

Individuals have to follow the complaints procedures of eBay and PayPal and some users can be forgiven for giving up. For some buyers, the feeling of being ripped off would be a very corrosive one and, incensed at losing £15 on a transaction, they would spend their valuable time trying to claw back their money, complaining to Trading Standards, eBay, PayPal, magazines and more beside, while others will just shrug and write it off to experience.

Looking at the seller's credentials, alarm bells should really have sounded before the eBay deal was struck: the seller's other items (having a feedback score of several thousand) related to herbal remedies, aromatherapeutic goods and, erm, physique enhancement products. So ask yourself the question, where would such a seller get a box of 48 cheap 2GB Kingston DataTraveler memory drives from? One could be generous and assume that he bought them in good faith, but from whom? Unfortunately eBay is one method used to fence stolen or counterfeit goods, though eBay clearly acted very swiftly when a verified report of counterfeit sales was submitted.

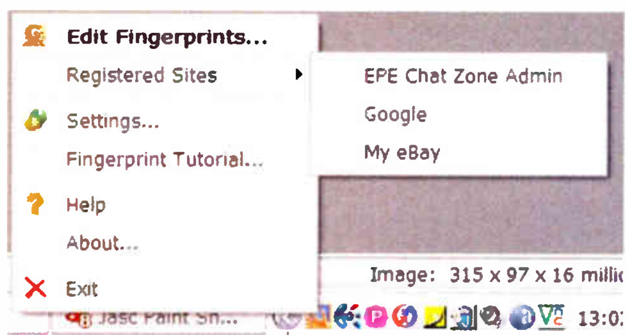
### Biometric memory gets a thumbs-up

Continuing on the subject of USB memory drives and data security, the author has been using an interesting biometric device made by Sandisk. The Sandisk Cruzer Profile is a 512k or 1GB drive that contains a fingerprint scanner. It uncouples to form a USB plug with a 7cm flexible wire connected to a combined memory drive and fingerprint scanner that works surprisingly well. It requires a USB port and will not work on an unpowered hub.

One of the great benefits of the Cruzer Profile is its ability to capture network or website logins that are accessible only by swiping a registered fingerprint. You could log into your eBay account, PayPal or even the *EPE* Chat Zone forum, simply by tapping the Cruzer icon in the system tray, point to the website you wish to log into, and then swipe a finger across the scanner. The system is pleasingly accurate and once a print has been scanned – usually successful first time – the owner of the dexterous digit is automatically logged in to the appropriate web page. A border around the web page briefly flashes to register the secure login.

And if your favourite forefinger is smothered in a Band-Aid, no problem: the Sandisk Cruzer profile software will register (or 'enrol') all ten prints, if preferred. The device is completely portable as the software and logins are contained within the fingerprint-protected USB drive. Simply plug it into a port, and then open up by scanning a print. It is an ideal accessory for a laptop, but you may need a USB extension lead (see eBay) to run the device on your desk. You can buy the Sandisk Cruzer Profile from Misco (**www.misco.co.uk**) or via **Amazon.co.uk** from about £16.00.

You can E-mail me at:
**alan@epemag.demon.co.uk**




*Simply select your website, scan your fingerprint and the device will open the webpage and log you in automatically*

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**Mike James**

The practical solutions to real problems shown in this cookbook provide the basis to make PIC and 8051 devices really work. Capabilities of the variants are examined, and ways to enhance these are shown. A survey of common interface devices, and a description of programming models, lead on to a section on development techniques. The cookbook offers an introduction that will allow any user, novice or experienced, to make the most of microcontrollers.

*240 pages* **Order code NE26** **£23.50**

**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.**

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If you want to know what to do next when confronted with Microsoft's Windows XP screen, then this book is for you. It applies to both the Professional and Home editions.

The book was written with the non-expert, busy person in mind. It explains what hardware requirements you need in order to run Windows XP successfully, and gives an overview of the Windows XP environment.

The book explains: How to manipulate Windows, and how to use the Control Panel to add or change your printer, and control your display; How to control information using WordPad, Notepad and Paint, and how to use the Clipboard facility to transfer information between Windows applications; How to be in control of your filing system using Windows Explorer and My Computer; How to control printers, fonts, characters, multimedia and images, and how to add hardware and software to your system; How to configure your system to communicate with the outside world, and use Outlook Express for all your email requirements; How to use the Windows Media Player 8 to play your CDs, burn CDs with your favourite tracks, use the Radio Tuner, transfer your videos to your PC, and how to use the Sound Recorder and Movie Maker; How to use the System Tools to restore your system to a previously working state, using Microsoft's Website to update your Windows set-up, how to clean up, defragment and scan your hard disk, and how to backup and restore your data; How to successfully transfer text from those old but cherished MS-DOS programs.

*268 pages* **Order code BP514** **£7.99**

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**Robert Penfold**

Shows the reader how to build a variety of increasingly sophisticated computer controlled robots using the brilliant Lego Mindstorms Robotic Invention System (RIS). Initially covers fundamental building techniques and mechanics needed to construct strong and efficient robots using the various "click-together" components supplied in the basic RIS kit. Explains in simple terms how the "brain" of the robot may be programmed on screen using a PC and "zapped" to the robot over an infra-red link. Also, shows how a more sophisticated Windows programming language such as Visual BASIC may be used to control the robots.

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**Covers the Vision Command System**

Shows the reader how to extend the capabilities of the brilliant Lego Mindstorms Robotic Invention System (RIS) by using Lego's own accessories and some simple home constructed units. You will be able to build robots that can provide you with 'waiter service' when you clap your hands, perform tricks, 'see' and avoid objects by using 'bats radar', or accurately follow a line marked on the floor. Learn to use additional types of sensors including rotation, light, temperature, sound and ultrasonic and also explore the possibilities provided by using an additional (third) motor. For the less experienced, RCX code programs accompany most of the featured robots. However, the more adventurous reader is also shown how to write programs using Microsoft's VisualBASIC running with the ActiveX control (Spirit.OCX) that is provided with the RIS kit.

Detailed building instructions are provided for the featured robots, including numerous step-by-step photographs. The designs include rover vehicles, a virtual pet, a robot arm, an 'intelligent' sweet dispenser and a colour conscious robot that will try to grab objects of a specific colour.

*298 pages* **Order code BP902** **£14.99**

**THE PIC MICROCONTROLLER**
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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** **£18.50**

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**John Crisp**

If you are, or soon will be, involved in the use of microprocessors and microcontrollers, this practical introduction is essential reading. This book provides a thoroughly readable introduction to microprocessors and microcontrollers. Assuming no previous knowledge of the subject, nor a technical or mathematical background. It is suitable for students, technicians, engineers and hobbyists, and covers the full range of modern micros.

After a thorough introduction to the subject, ideas are developed progressively in a well-structured format. All technical terms are carefully introduced and subjects which have proved difficult, for example 2's complement, are clearly explained. John Crisp covers the complete range of microprocessors from the popular 4-bit and 8-bit designs to today's super-fast 32-bit and 64-bit versions that power PCs and engine management systems etc.

*222 pages* **Order code NE31** **£22.00**

**EASY PC CASE MODDING**
**R.A Penfold**

Why not turn that anonymous grey tower, that is the heart of your computer system, into a source of visual wonderment and fascination. To start, you need to change the case or some case panels for ones that are transparent. This will then allow the inside of your computer and it's working parts to be clearly visible.

There are now numerous accessories that are relatively inexpensive and freely available, for those wishing to customise their PC with added colour and light. Cables and fans can be made to glow, interior lights can be added, and it can all be seen to good effect through the transparent case. Exterior lighting and many other attractive accessories may also be fitted.

This, in essence, is case modding or PC Customising as it is sometimes called and this book provides all the practical details you need for using the main types of case modding components including:- Electro luminescent (EL) 'go-faster' stripes: Internal lighting units: Fancy EL panels: Data cables with built-in lighting: Data cables that glow with the aid of 'black' light from an ultraviolet (UV) tube: Digital display panels: LED case and heatsink fans: Coloured power supply covers.

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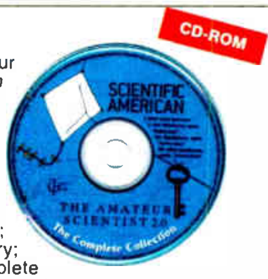


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In the main little or no previous knowledge or experience is assumed. Using these simple component and circuit testing techniques the reader should be able to confidently tackle servicing of most electronic projects.
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**Robin Pain**

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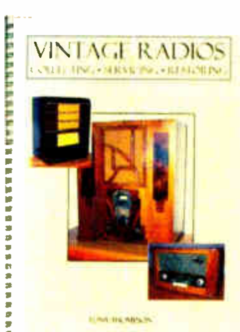


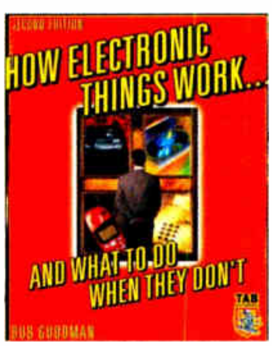


Simple circuit examples are used to illustrate principles and concepts fundamental to the process of fault finding. This is not a book of theory, it is a book of practical tips, hints and rules of thumb, all of which will equip the reader to tackle any job. You may be an engineer or technician in search of information and guidance, a college student, a hobbyist building a project from a magazine, or simply a keen self-taught amateur who is interested in electronic fault finding but finds books on the subject too mathematical or specialised.
The fundamental principles of analogue and digital fault finding are described (although, of course, there is no such thing as a "digital fault" – all faults are by nature analogue). This book is written entirely for a fault finder using only the basic fault-finding equipment: a digital multimeter and an oscilloscope. The treatment is non-mathematical (apart from Ohm's law) and all jargon is strictly avoided.
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**Steve Money**

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The principles of operation of the various types of test instrument are explained in simple terms with a minimum of mathematical analysis. The book covers analogue and digital meters, bridges, oscilloscopes, signal generators, counters, timers and frequency measurement. The practical uses of these instruments are also examined.
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Topics such as Boolean algebra and Karnaugh mapping are explainend, demonstrated and used extensively, and more attention is paid to the subject of synchronous counters than to the simple but less important ripple counters.
No background other than a basic knowledge of electronics is assumed, and the more theoretical topics are explained from the beginning, as also are many working practices. The book concludes with an explanation of microprocessor techniques as applied to digital logic.
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**Owen Bishop**

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Cutting edge topics such as microcontrollers, neural networks and fuzzy control are all here, making this an ideal refresher course for those working in Industry. Basic principles, control algorithms and hardwired control systems are also fully covered so the resulting book is a comprehensive text and well suited to college courses or background reading for university students.
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This is a very human account, from the dawn of radio to the attainment of a Royal Charter in the late 1920s. It tells of the struggles and frustrations of engineers in developing innovative equipment and of the great John Reith who battled with everyone to bring the BBC from a staff of four up to a Corporation of several hundred.

Brian Hennessy's book also describes the devlopment of broadcasting equipment, the search for premises and looming bankruptcy before ending with the emergence of a firmly established Chartered Corporation – the BBC.

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*436 pages* **Order code EBB** **£26.00**

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**B. B. Babani**

A complete book for the home constructor on "how to make" RF, IF, audio and power coils, chokes and transformers. Practically every possible type is discussed and calculations necessary are given and explained in detail. Although this book is now twenty years old, with the exception of toroids and pulse transformers little has changed in coil design since it was written.

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**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.

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The universal nature of the SMS Controller means that it can be used in a huge variety of applications. As a result, external interface circuits will sometimes be required. Here are three handy add-ons: (1) a test jig; (2) a PIR sensor interface; and (3) a low-battery alarm.

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*For Editorial address and phone numbers see page 7*



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