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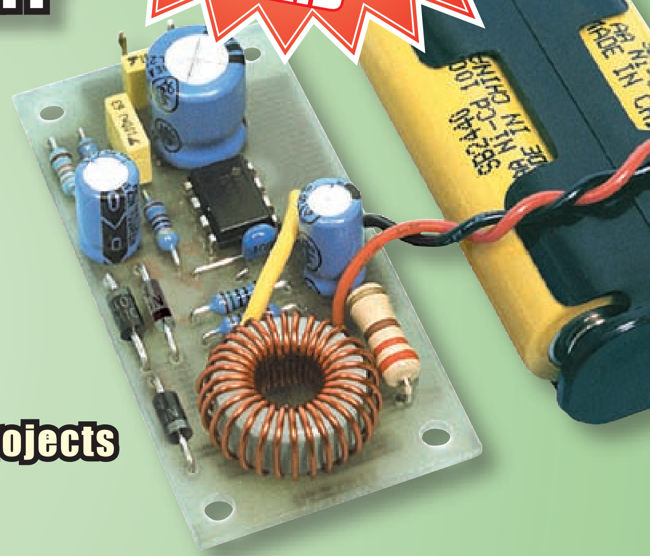

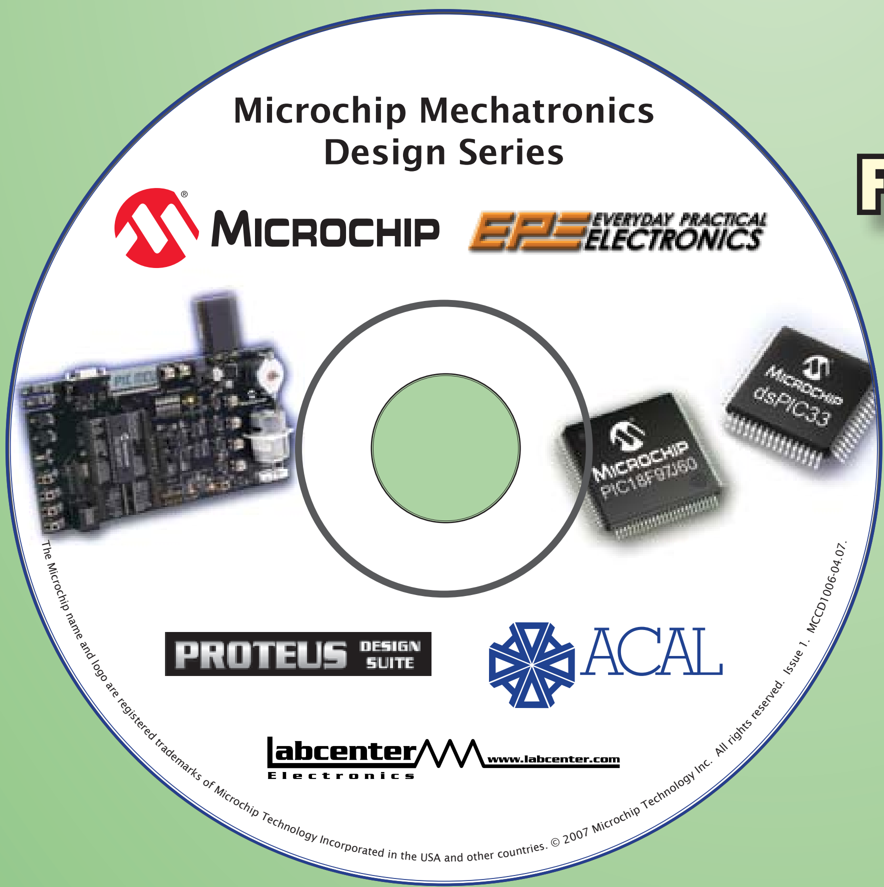

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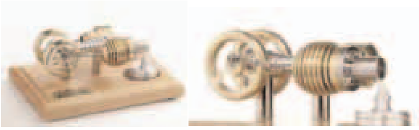
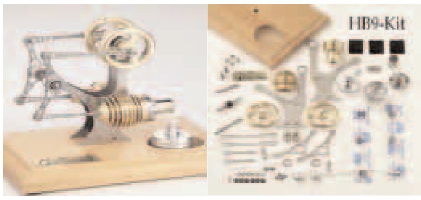
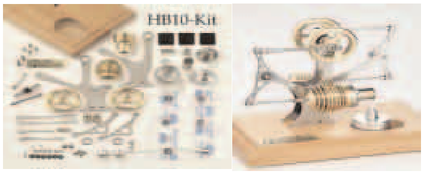


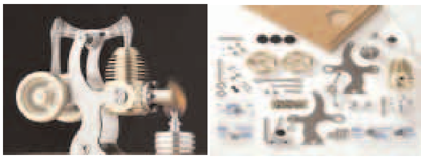
HB7 Stirling Engine
Base measurements: 128 mm x 108 mm x 170 mm, 1 kg Base plate: beech - Working rpm: 2000 rpm/min. (the engine has a aluminium good cooling Cylinder) Bearing application: 10 high-class ball-bearings Material: screw, side parts all stainless steel Cylinder brass, Rest aluminium and stainless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



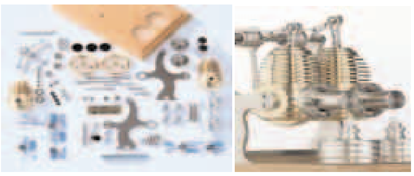
HB9 Stirling engine
Base measurements: 156 mm x 108 mm x 130 mm, 0,6 Kg Base plate: beech Working rpm: approx. 2,000 min Bearing application: 6 high-class ball-bearings Material of the engine: brass, aluminium, stainless steel running time: 30-45 min.
Available as a kit £97.75 or built £101.99
www.mamodspares.co.uk



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

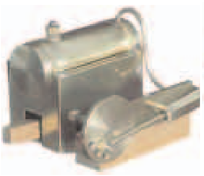


HB11 Stirling Engine
Base measurements: 156 mm x 108 mm x 130 mm, 0,7 Kg Base plate: beech
Working rpm: 2000 - 2500 rpm/min,run Bearing application: 4 high-class ball-bearings Material: screw, side parts total stainless steel Cylinder brass Rest aluminium, stainless steel.
Available as a kit £97.75 or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



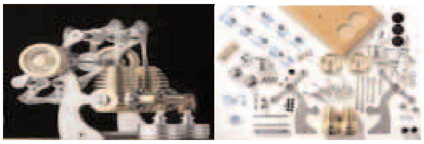
HB12 Stirling Engine
Base measurements: 156 mm x 108 mm x 130 mm, 1 Kg Base plate: beech Working rpm: 2000 - 2500 rpm/min,Bearing application: 6 high-class ball-bearings Material: screw, side parts total stainless steel Cylinder brass Rest aluminium, stainless steel.
Available as a kit £136 or built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

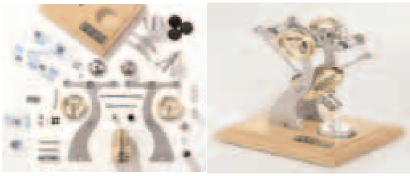


STEAM ENGINE KIT

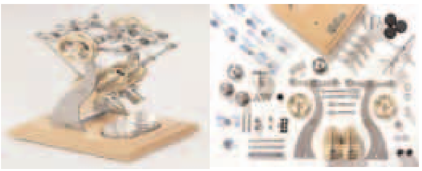
Everything in the kit enables you to build a fully functional model steam engine. The main material is brass and the finished machine demonstrates the principle of oscillation. The boiler, uses solid fuel tablets, and is quite safe. All critical parts (boiler, end caps, safety vent etc.) are ready finished 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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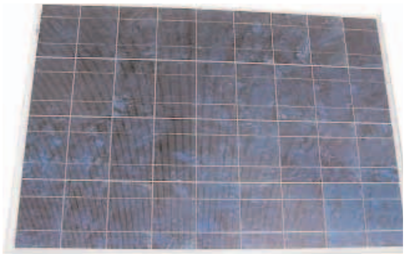
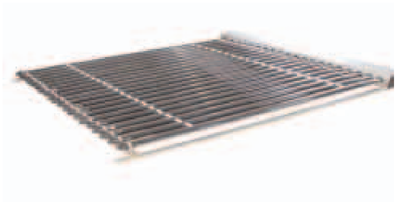
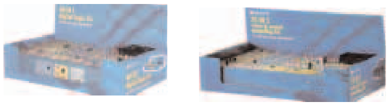


Solar Panels
We stock a range of solar photovoltaic panels. These are polycrystalline panels made from wafers of silicon laminated between an impact-resistant transparent cover and an EVA rear mounting plate. They are constructed with a lightweight anodised aluminium frame which is predrilled for linking 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.slips.co.uk

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PROJECTS . . . THEORY . . .
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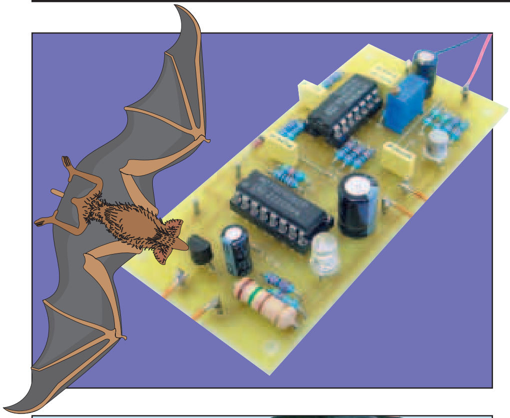

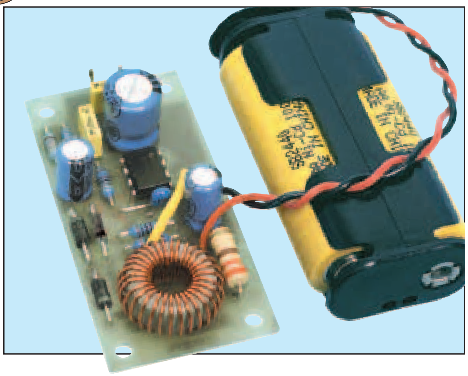

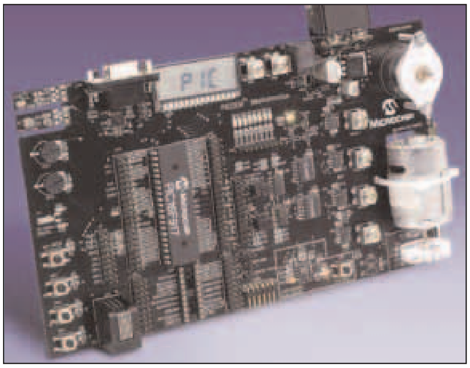

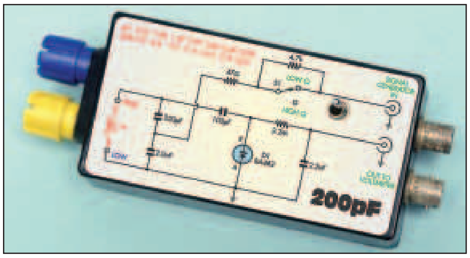

Our July 2007 issue will be published on Thursday, 14 June 2007, see page 72 for details.

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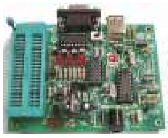
PIC & ATMEL Programmers

We have a wide range of low cost PIC and ATMEL Programmers. Complete range and documentation available from our web site.

Programmer Accessories:
40-pin Wide ZIF socket (ZIF40W) £15.00
18Vdc Power supply (PSU010) £19.95
Leads: Parallel (LDC136) £4.95 / Serial (LDC441) £4.95 / USB (LDC644) £2.95

NEW! USB & Serial Port PIC Programmer

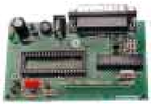


USB/Serial connection. Header cable for ICSP. Free Windows XP software. See website for PICs supported. ZIF Socket and USB lead extra. 18Vdc.
Kit Order Code: 3149KT - **£37.95**
Assembled Order Code: AS3149 - **£49.95**

NEW! USB 'All-Flash' PIC Programmer

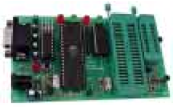
USB PIC programmer for all 'Flash' devices. No external power supply making it truly portable. Supplied with box and Windows XP Software. ZIF Socket and USB lead not incl.
Assembled Order Code: AS3128 - **£44.95**
Assembled with ZIF socket Order Code: AS3128ZIF - **£59.95**

'PICALL' ISP PIC Programmer



Will program virtually all 8 to 40 pin *serial-mode* AND *parallel-mode* (PIC15C family) PIC microcontrollers. Free Windows software. Blank chip auto detect for super fast bulk programming. Optional ZIF socket.
Assembled Order Code: AS3117 - **£24.95**
Assembled with ZIF socket Order Code: AS3117ZIF - **£39.95**

ATMEL 89xxxx Programmer

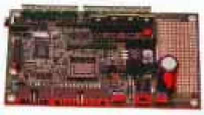


Uses serial port and any standard terminal comms program. 4 LED's display the status. ZIF sockets not included. Supply: 16Vdc.
Kit Order Code: 3123KT - **£24.95**
Assembled Order Code: AS3123 - **£34.95**

Introduction to PIC Programming

Go from complete beginner to burning a PIC and writing code in no time! Includes 49 page step-by-step PDF Tutorial Manual, Programming Hardware (with LED test section), Win 3.11—XP Programming Software (Program, Read, Verify & Erase), and 1rewritable PIC16F84A that you can use with different code (4 detailed examples provided for you to learn from). PC parallel port.
Kit Order Code: 3081KT - **£16.95**
Assembled Order Code: AS3081 - **£24.95**

ABC Maxi AVR Development Board



The ABC Maxi is ideal for developing new designs. Open architecture built around an ATMEL AVR AT90S8535 microcontroller. All circuits are embedded within the package and additional add-on expansion modules are available to assist you with project development.

Features
8 Kb of In-System Programmable Flash (1000 write/erase cycles) • 512 bytes internal SRAM • 512 bytes EEPROM • 8 analogue inputs (range 0-5V) • 4 Opto-isolated Inputs (I/Os are bi-directional with internal pull-up resistors) • Output buffers can sink 20mA current (direct LED drive) • 4 x 12A open drain MOSFET outputs • RS485 network connector • 2-16 LCD Connector • 3.5mm Speaker Phone Jack • Supply: 9-12Vdc

The ABC Maxi STARTER PACK includes one assembled Maxi Board, parallel and serial cables, and Windows software CD-ROM featuring an Assembler, BASIC compiler and in-system programmer.
Order Code ABCMAXISP - **£89.95**
The ABC Maxi boards only can also be purchased separately at £69.95 each.

Controllers & Loggers

Here are just a few of the controller and data acquisition and control units we have. See website for full details. Suitable PSU for all units: Order Code PSU445 £8.95

Rolling Code 4-Channel UHF Remote

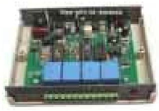
State-of-the-Art. High security. 4 channels. Momentary or latching relay output. Range up to 40m. Up to 15 Tx's can be learnt by one Rx (kit includes one Tx but more available separately). 4 indicator LED 's. Rx: PCB 77x85mm, 12Vdc/6mA (standby). Two *& Ten Channel versions also available.*
Kit Order Code: 3180KT - **£44.95**
Assembled Order Code: AS3180 - **£51.95**

Computer Temperature Data Logger

Serial port 4-channel temperature logger. °C or °F. Continuously logs up to 4 separate sensors located 200m+ from board. Wide range of free software applications for storing/using data. PCB just 38x38mm. Powered by PC. Includes one DS1820 sensor and four header cables.
Kit Order Code: 3145KT - **£18.95**
Assembled Order Code: AS3145 - **£25.95**
Additional DS1820 Sensors - **£3.95 each**

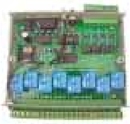
Most items are available in kit form (KT suffix) or pre-assembled and ready for use (AS prefix).

DTMF Telephone Relay Switcher



Call your phone number using a DTMF phone from anywhere in the world and remotely turn on/off any of the 4 relays as desired. User settable Security Password, Anti-Tamper, Rings to Answer, Auto Hang-up and Lockout. Includes plastic case. 130 x 110 x 30mm. Power: 12Vdc.
Kit Order Code: 3140KT - **£46.95**
Assembled Order Code: AS3140 - **£59.95**

Serial Port Isolated I/O Relay Module



Computer controlled 8 channel relay board. 5A mains rated relay outputs and 4 opto-isolated digital inputs (for monitoring switch states, etc). Useful in a variety of control and sensing applications. Programmed via serial port (use our new Windows interface, terminal emulator or batch files). Serial cable can be up to 35m long. Once programmed, unit can operate without PC. Includes plastic case 130x100x30mm. Power: 12Vdc/500mA.
Kit Order Code: 3108KT - **£54.95**
Assembled Order Code: AS3108 - **£64.95**

Infrared RC 12–Channel Relay Board

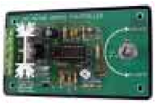
Control 12 onboard relays with included infrared remote control unit. Toggle or momentary. 15m+ range. 112 x 122mm. Supply: 12Vdc/0.5A
Kit Order Code: 3142KT - **£47.95**
Assembled Order Code: AS3142 - **£59.95**

PC / Standalone Unipolar Stepper Motor Driver

Drives any 5, 6 or 8-lead unipolar stepper motor rated up to 6 Amps max. Provides speed and direction control. Operates in stand-alone or PC-controlled mode. Up to six 3179 driver boards can be connected to a single parallel port. Supply: 9Vdc. PCB: 80x50mm.
Kit Order Code: 3179KT - **£11.95**
Assembled Order Code: AS3179 - **£18.95**

Bi-Polar Stepper Motor Driver also available (Order Code 3158 - details on website)

DC Motor Speed Controller (100V/7.5A)



Control the speed of almost any common DC motor rated up to 100V/7.5A. Pulse width modulation output for maximum motor torque at all speeds. Supply: 9-18Vdc. Box supplied. Dimensions (mm): 60Wx100Lx60H.
Kit Order Code: 3067KT - **£13.95**
Assembled Order Code: AS3067 - **£19.95**

Bidirectional DC Motor Driver also available (Order Code 3166 - details on website)

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

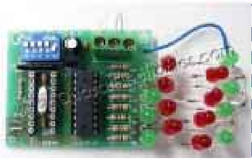
- Units of display: metres per second, feet per second, kilometres per hour and miles per hour
- Resolution: Nearest tenth of a metre
- Range: Zero to 50mph approx.

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 preamp 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

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

500-in-1 Electronic Project Lab

Top of the range. Complete self-contained electronics course. Takes you from beginner to 'A' Level standard and beyond! Contains all the hardware and manuals to assemble 500 projects. You get 3 comprehensive course books (total 368 pages) - *Hardware Entry Course*, *Hardware Advanced Course* and a microprocessor based *Software Programming Course*. Each book has individual circuit explanations, schematic and connection diagrams. Suitable for age 12+.
Order Code EPL500 - **£149.95**
Also available - 30-in-1 **£15.95**, 130-in-1 **£37.95** & 300-in-1 **£59.95** (details on website)

Tools & Test Equipment

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

Precision Digital Multitester (4.5 Digit)

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

Order Code: MM463 - Was £44.95 **Now on sale at just £29.95!**

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mikroElektronika

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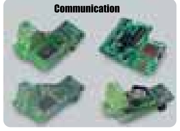
Communication



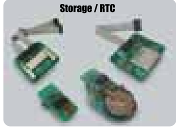
CAN-1 Board - Interface CAN via MCP2551 **$18.00 USD**

CAN-2 Board - Make CAN network with SPI interface **$21.00 USD**

RS485 Board - Connect devices into RS-485 network **$17.00 USD**

Serial Ethernet - Make ethernet network with SPI Interface (ENC28J60) **$28.00 USD**

Storage / RTC



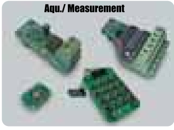
CF Board - Easy way to use Compact flash in your design **$18.00 USD**

MMC/SD Board - Easy way to use MMC and SD cards in your design **$18.00 USD**

EEPROM Board - Serial EEPROM board via I2C interface **$9.00 USD**

RTC Board - PCF8583 RTC with battery backup **$16.00 USD**

Aqu./ Measurement



ADC Board - 12-bit analog-to-digital converter(ADC) with 4 inputs **$22.00 USD**

DAC Board - 12-bit digital-to-analog converter(DAC) with SPI **$18.00 USD**

Keypad 4x4 Board - Add keypad to your application **$9.00 USD**

Accel. Board - Accel. is an electronic device that will measure acceleration forces **$16.00 USD**

PICFlash

with mikroICD support

PICFlash programmer – an ultra fast USB 2.0 programmer for PIC microcontrollers. Continuing its tradition as one of 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. **mikroICD** debugger enables you to execute mikroC / mikroPascal / mikroBasic programs on a host PIC microcontroller and view variable values, Special Function Registers (SFR), memory and EEPROM as the program is running................**$89.00 USD**

- All of our products are shipped in special **protective boxes**.
- On-line secure ordering provides a fast and safe way to buy our products.

EasyPIC4 Development Board

with on-board USB 2.0 programmer and mikroICD

3 in 1 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
mikroC(PIC)	$249.00 USD	mikroC(PIC) (-30%)	$175.00 USD
mikroBasic(AVR)	$149.00 USD	mikroBasic(AVR) (-30%)	$99.00 USD
mikroPascal(AVR)	$149.00 USD	mikroPascal(AVR) (-30%)	$99.00 USD
mikroBasic(dsPIC)	$149.00 USD	mikroBasic(dsPIC) (-30%)	$99.00 USD
mikroPascal(dsPIC)	$249.00 USD	mikroPascal(dsPIC) (-20%)	$199.00 USD
mikroC(dsPIC)	$249.00 USD	mikroC(dsPIC) (-30%)	$175.00 USD

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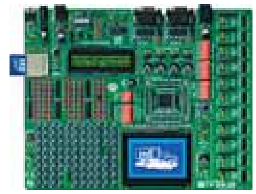
http://www.mikroe.com/en/distributors/

LV24-33 Development Board

The Complete Hardware and Software solution with on-board USB 2.0 programmer and mikroICD

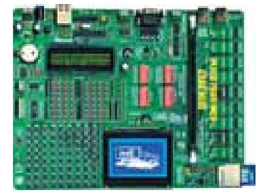


System supports 64, 80 and 100 pin PIC24F/24H/dsPIC33F microcontrollers (it comes with PIC24FJ96GA010 - PIC24 16-bit Microcontroller, 96 KB Flash Memory, 8 KB RAM in 100 Pin Package). Examples in BASIC, PASCAL and C are included with the system. You can choose between USB or External Power supply. LV 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

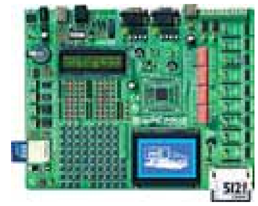


System supports PIC, AVR, 8051, ARM and PSoC microcontrollers with a large number of peripherals. It is enough to switch a card and continue working in the sarne development environment but with a different chip. UNI-DS3 has many features that makes your development easy. You can choose between USB or 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

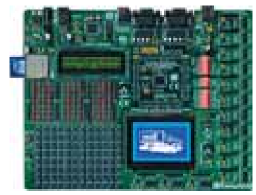


System supports dsPIC microcontrollers in 64 and 80 pin packages. It is delivered with dsPIC30F6014A microcontroller. The dsPICPRO2 development system is a full-featured development board for Microchip dsPIC MCU. dsPICPRO2 board allows microcontroller to be interfaced with external circuits and a broad 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

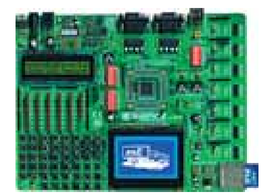
with on-board USB 2.0 programmer

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

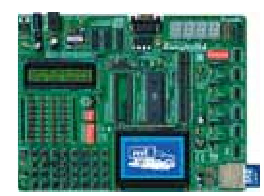


Following in the tradition of its predecessor, the BIGPIC3 as one of the best 80-pin PIC development systems on the market, **BIGPIC4** continues tradition with more new features for same price. System supports the latest 64 and 80-pin PIC microcontrollers (it is delivered with PIC18F8520). Many ready 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**

Please visit our web page for more info http://www.mikroe.com

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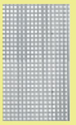
PCB Production - Development

0.1" Copper Stripboard

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



Solderless Breadboard

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

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

PCB Production - Drafting Materials

A4 Artwork Film (per 10 sheets)

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

Etch Resist Pens

"Dalo" Pen	£3.36
"Staedtler" Fine Pen	£0.96

Etch Resist Transfers

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

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

Soldering Irons

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

20W 240V Basic	£3.74
25W 240V Ceramic	£7.14
30W 240V Basic	£4.68

Desolder Pumps

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

Soldering Station

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

Model 167-540 £41.66

Soldering Station

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

Supply: 240V, Iron: 24V 48W

Model 167-570 £55.61

Digital Multimeter

Model: 121-120
Price: £11.47

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

Technical Specifications

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

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PCB Production - Processing Equipment

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

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2 x 8W Tubes, 6 min timer
229 x 159mm working area
Model 332-002 £98.75
4 x 15W Tubes, 7½ min timer
330 x 260mm working area
Model 332-004 £209.48

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Low cost plastic tray £2.30
Process tanks feature electrically operated pumps and/or heaters with thermostat control, suitable for boards upto 320 x 260mm.
Universal Tank with heater
Model 333-007 £169.58
Bubble etch Tank with heater & bubble pump.
Model 333-004 £208.48

Any of these items, carriage £5.50

PCB Production - Tools

Drill Bits

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

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

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

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

Drilling Machines

Expo Reliant 12V drill, 3.8mm capacity, 8400rpm £12.78
Expo Zircon 12V drill, 3.8mm capacity, 11900rpm £14.20

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

SPECIAL PRICE £31.02

Servisol Products

Aerosols

200ml	Switch Cleaner	£2.30
200ml	Freezer	£4.39
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400ml	Cleaner / lubricant	£2.79
75ml	Vide Head Cleaner	£1.94
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250ml	Cold Clean	£3.14
200ml	Label remover	£3.52
400ml	Isopropyl alcohol	£3.42

Tubes

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

Bench Power Supplies

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

Model: 461-550	0-30V0-3A	£70.88
Model: 461-552	0-50V 0-3A	£81.00
Model: 461-554	0-30V 0-10A	£135.00

Panel Meters

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

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

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

Magnifying Desk Lamp

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

Model: 028-205 £28.80

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Sound & Lighting
equipment for the Entertainment Industry

PCB Production - Laminates

Copper clad - paper

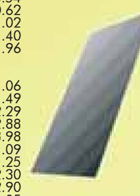
Single sided low cost paper composite board

100 x 160mm Board	£0.54
100 x 220mm Board	£0.62
160 x 233mm Board	£1.02
220 x 233mm Board	£1.40
8" x 12" Board	£1.96

Copper clad - glass fibre

Single & Double 1.6mm 305g/m²

100 x 160mm Single	£1.06
100 x 220mm Single	£1.49
160 x 233mm Single	£2.29
220 x 233mm Single	£2.88
8" x 12" Single	£3.98
100 x 160mm Double	£1.09
100 x 220mm Double	£1.25
160 x 233mm Double	£2.30
220 x 233mm Double	£2.90
8" x 12" Double	£4.05



Photoresist Coated

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

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

PCB Production - Chemicals

100ml	Aerosol Photoresist spray, covers 2m²	£4.62
50g	Powder developer, makes 1lt	£1.09
500g	Powder developer, makes 10lt	£7.08
250g	Ferric Chloride Pellets, makes 500ml	£1.68
500g	Ferric Chloride Pellets, makes 1lt	£3.04
2.5kg	Ferric Chloride Pellets, makes 5lt	£9.84
1.1kg	Clear Fine etch crystals, makes 5lt	£17.58
90g	Tin Plating Powder, makes 1lt	£11.58
200ml	Aerosol Flux spray	£3.41
110ml	Aerosol PCB Laquer spray	£3.54

Tools - Cutters & Strippers

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

Side Cutters

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

Wire Strippers

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

Tools - Ratchet Crimping Pliers

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

Red / Blue / Yellow	£15.80
BNC /TNC RF series	£15.08
RJ11/12 Data Series	£22.32
RJ45 Data Series	£20.43
RJ11/12 & 45 Series	£11.83

CK® Tools Crimp Pliers

Green/Red/Blue	£24.38
Red/Blue/Yellow	£22.88
0.24-2.5mm² crimps	£26.01
0.5-6.0mm² crimps	£26.01
Non insulated crimps	£24.38

Cable - Ribbon

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

Size	per 305mm	per Reel
10 Way	£0.10	£5.80
14 Way	£0.14	£7.50
16 Way	£0.16	£8.58
20 Way	£0.20	£10.72
26 Way	£0.26	£13.94
34 Way	£0.34	£18.22
40 Way	£0.40	£21.44
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Lightbulb Lunacy

The recent announcement by the EU that we may all be forced to use CFL (compact fluorescent lamp) light bulbs by 2009, follows a similar ruling in Australia a few months ago. The new ruling has been heavily condemned in Australia as being basically unworkable and, no doubt, it will also be in Europe. How such legislation can be suggested without any proper research beats me. Are our politicians so blinded by the global warming protagonists that they will do anything to jump on the bandwagon, no matter how unworkable the legislation?

If this ruling is enforced – something I doubt will occur – then the initial cost, both in financial terms and to the environment, will be massive. CFLs will not work in enclosed fittings as the heat generated burns them out. No suitable CFLs are available for a wide range of light fittings including all low voltage spotlights. Because CFLs take some time to warm up they tend to be left on longer and the mercury vapour, phosphors and the electronics used in them give increased disposal problems.

Most CFLs will not work with dimmers and have a poor power factor so, whilst they might give a reduced electricity bill, they are not so effective at reducing the actual power that needs to be generated.

We have yet to see any research that investigates and compares the 'carbon footprint' of incandescent bulbs and CFLs. An independent body needs to look at all the factors, including raw materials, manufacture, packaging, transport, (CFLs are significantly heavier), power factor, recycling etc.

We hope to investigate the pros and cons in a feature article in a few months time. Meanwhile, we wait to see if those behind this proposed legislation will be forced to think again, or if they will try to inflict this massive expense on us all. CFLs are excellent in certain situations and we encourage their use where appropriate.

We fully support any sensible form of energy saving in an effort to preserve what natural resources are left in the world, but we need to encourage it – not take a heavy handed attitude. There is little doubt that LED lighting will prove to be the way forward in the future, backed up by CFLs and other types (including incandescent bulbs) in suitable situations, but to try to force everyone into using CFLs everywhere will never work. This simply seems to be the EU jumping on the carbon emissions global warming bandwagon – one which many scientists dispute.

No doubt the companies making CFLs and light fittings will be rubbing their hands together at the massive profit this could make for them. Hopefully, a balanced view will be forthcoming over the next two years.

Mike Kenward

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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

Sony's Progress

Barry Fox reports that Sony has been through some difficult times but is coming back strongly.

SONY has been through tough times recently 'most notably losing the portable market to Apple and the iPod', but is now 'flourishing' according to Fujio Nishida, the new President of Sony Europe. "But I do not want Sony to be famous for being famous. I want Sony to be the leading digital entertainment brand in Europe. I know that sounds suspiciously close to arrogance but I believe we have the technological firepower to make it happen."

Nishida was speaking at Sony's *Media Experience* event on the Greek island of Rhodes recently, with 430 journalists and 200 Sony staff flown in by chartered planes from 28 European and ex-Eastern bloc countries. Soft spoken, with good English and persuasive enthusiasm, Nishida reminds you of a young Akio Morita, the charismatic founder of the company who died in 1999 and left the company with a succession of leaders who did little to inspire confidence.

Europe now accounts for 29% of Sony's global sales, making Europe Sony's number one market – largely due to the success of the Bravia LCD TVs, with sales up from 1 million in 2005 to 2.5 million in 2006.

The new Arsenal Emirates soccer stadium in London has been kitted out with 450 HDTV LCD screens and there are now plans to use WiFi to send pictures round the stadium to fans.

Lost face

At the end of last year Sony lost face, and the Christmas market to Nintendo's Wii, by having to delay the European launch of PlayStation 3. The games console, which also plays Blu-ray movie discs, finally went on sale in March, with just under a million players shipped to shops in PAL countries. So anyone who has wanted to buy has been able to find one. Nick Sharples of Sony Computer Entertainment admits this has prompted snipes that PS3 sales are not going well: "We are damned if we do and damned if we don't."

PS3 games are not region coded, but the players are coded because Blu-ray movie discs carve the world into three zones, A, B and C. So far most movies have been coded for playback in all regions, though. The first 500,000 PS3 owners can register for a free copy of *Casino Royale* on Blu-ray. Another 10,000 copies were sold retail in the UK alone during the first week.

In Japan, Blu-ray is winning the blue laser format war hands down. Over the last three months 95% of the HDTV recorders sold for recording HDTV broadcasts have been Blu-ray and only 5% HD-DVD.

Unlike Panasonic, Sony is not yet selling an HDTV camcorder which uses solid-state memory instead of tape or disc. Says Sony spokeswoman Yoshiko Matsuda: "The price of memory is still too high and the capacity too low."

AVCHD MPEG-4 system

Like Panasonic, however, Sony is using the new AVCHD MPEG-4 recording system to capture HDTV. The UX3 (€1000) and UX7 (€1300) use blank 8cm DVDs. Sony is also exploiting the new xvYCC (extended video YCC) colour system recently standardized by the IEC, and catered for by the new Ver 1.3 HDMI digital connection standard. With xvYCC-capable screens like the latest Bravias, the new IEC system, which Sony calls x.v.Colour, displays 1.8 times the currently available range of video colours.

The latest Bravia TV sets can also accept a 24p input signal, as delivered by top end Blu-ray players, such as the BDP-SE1, which Sony will launch this summer for close to £1000. With 24p the movie is shown as shot, with 24 full, progressively scanned pictures a second, instead of 25fps in Europe or 30fps in the USA. So there is no 4% hike in speed and audio pitch, no 4% cut in running time, and none of the panning judder seen when 3:2 pulldown is used to show 24fps movies at 30fps.

Because the PS3 is subsidised by the profits which Sony expects from games sales, it is by far the cheapest Blu-ray player – at around £425. But the PS3 lacks 24p playback. Sony also showed a prototype TV for the UK, with built in MPEG-4 (AVC H264) decoder. So it can be used to view HDTV Freeview transmissions, if the UK government allocates frequencies for digital terrestrial HD broadcasting. The set was demonstrated in Greece with signals recorded from the Crystal Palace transmitter in London, which the BBC is using for its HD DTTV broadcasts.

Thomas Scarborough Books Online

We are delighted to tell you that Thomas Scarborough has published a series of books, available via the web. Thomas has long been a contributor to *EPE*, designing full contructional projects and sharing his circuit ideas through *Ingenuity Unlimited*. He has published his ideas through many other electronics mags as well, and is arguably the most widely-published electronics writer/designer of the 21st Century. He is renowned for his 'alternative methods' of solving electronic requirements simply.

To begin with, he has placed five of a series of electronics booklets on the web at **http://stores.lulu.com/store.php?fAcctID=980032**, devoting the whole backcover of the books to *EPE*.

The first in the series of books is *free* as a download, as an advertisement for the rest. All the booklets are available as downloads ($1.00 each) or as printed copies ($6.95 ea.) – with Book 1, again, being *gratis*.

All the booklets contain five designs, none using more than six components.

Rather than itemise the subjects here, browse the above website. We are sure they will entertain, fascinate and captivate electronics constructors everywhere.

INTERFACING ROBOTS

Research linking robots, ants and humans has gained funding at Newport's University. Underwater robotics and industrial automation are two of the areas which will benefit from research starting up in the Robotic Intelligence Lab at the University of Wales.

The research project, 'Defying the Rules: How Self-Regulatory Social Systems Work', will study how behavioural rules and environmental factors enable self-regulating interactive behaviour to emerge, and examine a wide range of social systems – human, animal and robotic – in order to develop theories and models of emergent self-regulation.

"In particular, I will be researching multi-robot control methods for applications where communication is limited but reliability is all-important – in areas such as underwater robotics," explained the Lab's Director and Senior Lecturer, Dr Torbjorn Dahl. "Understanding how self-regulation emerges can also improve the way governments handle community regeneration and can also improve existing technologies for automated manufacturing."

The funding has been awarded by the Engineering and Physical Sciences Research Council (EPSRC) which will give the project over half a million pounds over the next three years.

Browse **www.newport.ac.uk**.

Pico Upgrades IU Awards

Pico Technology have long sponsored our *Ingenuity Unlimited* pages, making annual awards of PicoScopes to the most ingenious readers. They have generously upgraded their awards. Thank you Pico!

For the best *IU* submission during the year they offer their latest 4-channel oscilloscope, the PicoScope 3206, worth £799. To the annual runner-up they will offer the handheld PicoScope 2105, worth £199.

PicoScope oscilloscopes simply connect to the USB port of any standard Windows-based PC, making full use of the PC's processing capabilties, large screens and familiar graphical user interfaces. They are supplied with PicoScope software (oscilloscope, spectrum analyser and meter). Also suplied is PicoLog data aquisition software that transforms your PC into a high-speed datalogger.

For more information on PicoScopes and a variety of data aquisition products, browse: **www.picotech.com**.

Bletchley Park 2007 Events

The 2007 programme of events at Bletchley Park, Milton Keynes, includes six Battle of Britain Memorial flypasts and a range of activities for young and old, including an Alice in Wonderland event, Churchill Weekend, Forties Family Festival, Classic Car and Motorbike Picnic and Enigma Reunion. Visitors can also explore the many permanent exhibitions and private collections.

The flypasts will coincide with a number of special weekends at the Park. Subject to weather conditions, they are scheduled for 28 May, 9 and 23 June, 8 and 22 July and 22 September.

Bletchley Park, home to the codebreakers of the Second World War and the birthplace of the modern computer, is a museum and heritage site. Its fascinating history and wide range of exhibits and private collections provide something of interest for all ages and make it a great day out for all the family. A newly launched £10 adult and £22.50 family annual season ticket allows free and unlimited visits to the Park for up to 12 months following the first visit, while children under 12 years' old are free.

Other major events in 2007 (dates to be confirmed) will be the inauguration of Hut 8. This is where Alan Turing and his fellow codebreakers cracked the Nazi Enigma cipher and where Turing famously padlocked his mug to a radiator. Also planned is the launch of a fully-operational rebuild of Colossus, the world's first semi-programmable electronic computer, which was used by codebreakers to read encrypted German messages.

Please check before travelling as some exhibits are not always open. For visitor information, contact 01908 640404, email info@bletchleypark.org.uk, or go to **www.bletchleypark.org.uk**

Bletchley Park is open during 2007 every day except 21 April, Christmas Day, Boxing Day and New Years Day:

- 1 November to 31 March: weekdays, weekends and Bank Holidays 10.30am - 4.00pm.
- 1 April to 31 October: weekdays 9.30am - 5.00pm, weekends and Bank Holidays 10.30am - 5.00pm.

MERG Journal

The Model Electronic Railway Group (MERG) has sent its latest Journal. In its 46-page A4 format, it gives details of the Group's activities and highlights some of the track layouts used by its members. There are also discussions of electronic circuits such as 555 timers and examples of using PIC code to control train or track functions. Technical bulletins on various control block options are included as additional supplements, along with a list of membership updates.

It looks a superbly informative document for those who are heavily involved in railway modelling, and if you are, then you should belong to the Group, which now consists of over 800 members. They attribute this quantity to the huge interest in DCC and the large reservoir of resources that they are able to offer to the modellers.

For more information contact Nicholas Griffin, Publicity Manager, Spread Eagles, Melbury Abbas, Dorset SP7 0DU. Group website: ***www.merg.info****.*

NEW FLASH DEVICES

Microchip has announced eight new members of the cost-effective PIC24F 16-bit microcontroller family, with up to 64 Kbytes of Flash program memory and up to 8 Kbytes of RAM, in smaller, lower cost, 28- and 44-pin packages, including a tiny 6x6mm 28-pin QFN package option.

'Peripheral Pin Select' pin-mapping allows designers to use the available pins exactly as they like. For many applications, this can allow the use of a smaller, more cost-effective microcontroller. The wide range of on-board peripherals includes two independent channels each of I^2C, UART and SPI communications.

The new family is supported by the MPLAB IDE – including the enhanced Visual Device Initializer, which graphically assists the Peripheral Pin Select feature, generating the required initialisation code. The MPLAB C30 C compiler provides industry-leading code densities, along with free maths and peripheral libraries. For emulation and debugging with the new family, Microchip offers the MPLAB REAL ICE and the cost-effective MPLAB ICD 2.

In addition, a new version of the Explorer 16 development board is available, fitted with a 44-pin PIC24FJ64GA004. For those who already own the Explorer 16 board, a new Plug-in Module (PIM) has been created to enable development with the new family. A number of PICtail Plus daughter cards are also available for use with the Explorer 16 board that enable designers to add Ethernet connectivity, an SD/MMC card, speech playback or an IrDA(r) interface.

Microchip has also developed a web seminar about this new 16-bit family, which can be viewed now at **www.microchip.com/training**.

Looking Deeper into Space

A new technology developed by University of Birmingham scientists is enabling astronomers to observe in more detail some of the most distant and spectacular phenomena in the universe without needing to build bigger telescopes.

Professor Mike Lancaster and his team at the University's Department of Electronic, Electrical and Computer Engineering are using superconductors to build filters for radio telescopes that make them more sensitive to distant objects such as rapidly rotating pulsars and remote, evolving galaxies.

In collaboration with astronomers at the Jodrell Bank telescope and other major observatories in the US and Australia, Professor Lancaster has been developing relatively inexpensive, 'plug and play' devices that allow the incredibly weak signals from cosmic bodies trillions of miles from Earth to pass unhindered, but screen out any unwanted interference from terrestrial sources such as mobile phones and television transmitters.

Mike Lancaster explains, "Our filters are able to distinguish between the signals coming from a remote star and those from a local mobile phone by homing in on the precise frequencies we require. It's like a narrow radio turnstile shutting out intruders."

TECHNO-TALK MARK NELSON

Sea Change In Electronics

The marine environment is the setting for a number of remarkable developments in electronics, so grab your sickness pills and lifebelt – while Mark Nelson takes you on an inspection cruise of some highly improbable but genuine things to come

Sea change is one of those annoying expressions that are so criminally overused nowadays and I used the phrase for this article's title only because it seemed apt. To be honest, until I started researching this article I had no idea what a sea change was.

In case you too are in the dark, I discovered that it comes from Shakespeare's *The Tempest*, written in 1610, in which the bard has the character Ariel sing:

Full fathom five thy father lies;
Of his bones are coral made;
Those are pearls that were his eyes:
Nothing of him that doth fade
But doth suffer a sea-change
Into something rich and strange.
Sea-nymphs hourly ring his knell.

The original meaning was 'a change brought about by the sea' but as with many of Shakespeare's quotable quotes, the obscure literal sense has been replaced by a more common popular meaning.

Strange but True

There you go, and never let it be said that these articles are lacking in culture! We'll return now to scientific topics, including oceanic sensors for monitoring climate change, gas sensors and batteries made from materials dredged from the seabed, plus the mysterious case of ozone that's nothing of the sort.

Measuring climate change in deep sea waters may sound a strange way of going about things but it has nothing to do with April 1st and makes sense once explained. The National Oceanography Centre, based at Southampton University, uses an electronic 'laboratory on a chip' to measure the number of tiny phytoplankton plants in seawater.

Quoted on news website MDSL Net, researcher Dr Matt Mowlem said: "We will measure chemistry and biology in the ocean for climate change and pollution research. This involves testing and making bio-sensors by borrowing microelectronic techniques to make micro-fluidic and micro-optical systems."

Abnormal Numbers

The numbers of phytoplankton (algae) in the sea vary seasonally, according to temperature and light intensity. Increasing temperatures and light intensity stimulate their growth, leading to an increase in population density, and abnormal numbers could point to global warming. The University of Southampton's School of Electronics has embarked on a project to develop chips that can count the number of phytoplankton in water samples. The micro fluidic devices will be connected to various electronics and through optical fibres to LEDs for spectral analysis.

"We will flow sea water through them to measure and characterise plankton," said Dr Mowlem, explaining that the devices will be installed in a new generation of battery-powered buoys that are dropped into the ocean and repeatedly dive to 2,000m; measuring temperature, pressure and salinity as they rise to the surface. Data is transmitted to satellites during periods on the surface.

He concluded, "[Currently] there are 3,000 deployed at any one time and they have already improved weather forecasting."

Diatomic Detection

Diatoms, as everyone knows – don't they!, are a kind of algae that leave behind a skeleton of silica when they die. They are very small, no more than 20 to 200 microns in diameter or length normally. Industrially they have many uses, including paint and toothpaste, and are found in fresh and marine waters, the soil and in fact almost anywhere moist.

Now there are two electronic applications as well, thanks to a chance meeting between a ceramics expert and a marine biologist on a bus in Germany. Professor Ken Sandhage of Georgia Institute of Technology told Trade journal *Electronics Weekly*, "We got talking and the biologist showed me some pictures of diatoms. These are a type of algae that leave a silica skeleton. It turns out every one of 100,000 species is genetically-tuned to make identical nano-featured structures."

Sandhage's team has succeeded in converting the silica skeleton into silicon chemically, then adding platinum wires to make a sensor for nitric oxide. "It is a very sensitive detector," he says, "and when you increase the concentration from 1ppm, to 2ppm, to 3ppm it detects the changes as a change of resistivity in a few seconds." According to the report, the university also sees applications for marine diatoms in batteries, because of the high surface area to volume ratio, and the modified skeletons also emit a small amount of light.

Oh for Ozone

It was the US movie actress Mae West who once said: "Too much of a good thing can be wonderful", but she obviously didn't have ozone in mind. Ozone, you will recall, is a highly active form of oxygen, with three atoms instead of two. It occurs naturally and is produced artificially by a high voltage electrical discharge. Discovered in 1826 and used medically since the 1870s, it still has a wide following and you can find plenty of praise for ozone therapy on alternative health websites.

Indeed, it was once so highly esteemed that the Central Line of the London Underground railway was once equipped with its own ozone plant. In 1912 a company called Ozonair won a contract to purify the atmosphere on what was then called the Central London Railway. The firm is still going by the way but the underground ozone apparatus disappeared a long time ago.

In small concentrations ozone is healthy, killing germs and mould spores. Too much of a good thing is in this case not 'perfectly marvellous', however, which is why we are told to avoid placing laser printers next to our desks, because these can give off high concentrations of ozone. Ozone also occurs when sunlight reacts with volatile organic compounds that exist in hydrocarbon vehicle emissions.

Even at relatively low concentrations, ozone can trigger irritation of the eyes, respiratory tract, nose, throat, and trachea. Signs of irritation include heavy coughing and tightness in the chest area. If the gas reaches a higher concentration, it may hamper lung function seriously. Fortunately, the molecule's unstable nature means its half-life is six to eight hours, meaning its concentration halves in that period.

Breathe Deeply?

Healthy ozone was always said to be the characteristic smell of the seaside. As children we were told it was ozone and that we should breathe deeply to gain the benefit of this highly active oxygen.

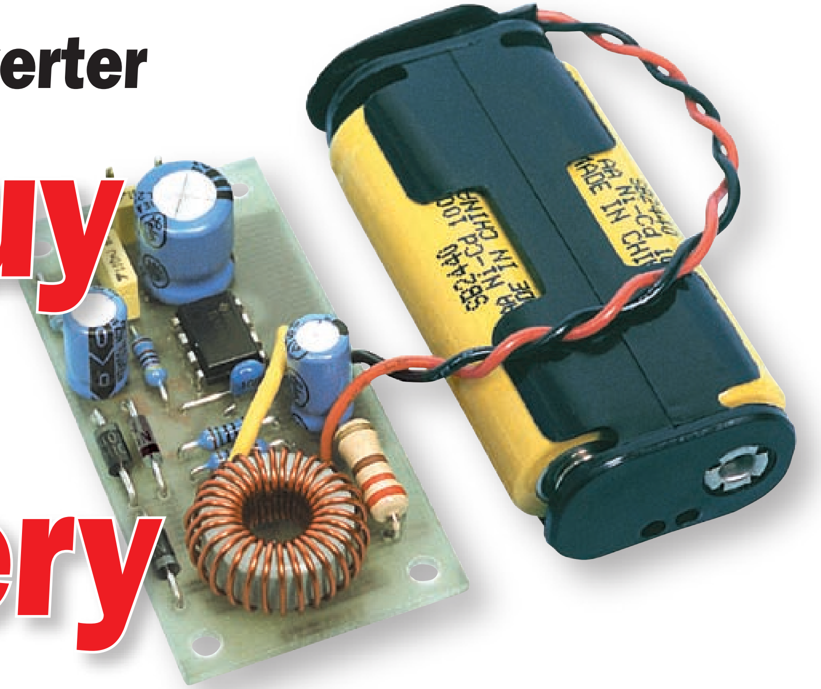
It seems we were mistaken. The 'ozone' is in fact dimethyl sulphide (DMS), which is released by microbes that live near plankton and marine plants, including seaweeds and some salt-marsh plants. It is also produced by cooking certain vegetables, notably corn and cabbage, and seafoods.

The discovery that DMS is the true scent of the sea is the conclusion of Prof Andrew Johnston, a research project leader from the University of East Anglia. Correcting the mistakes of the past, he states: "We were misled, twice over. First, because that distinctive smell is not ozone, it is dimethyl sulphide. And second, because inhaling it is not necessarily good for you."

That said, he declares the gas is a remarkably effective food marker for ocean-going birds such as shearwaters and petrels. It also plays a vitally important role in the formation of cloud cover over the oceans, cooling our overheated climate.

3V to 9V DC-DC Converter

Never buy another 9V battery



Bought a 9V battery lately? They're horribly expensive and they don't last very long if you want more than a few milliamps out of them. The solution: build this little DC-DC converter so you can use AA, C or D size cells instead.

By PETER SMITH

SAY YOU WANT a 9V battery to supply 40mA to a circuit. That's a pretty modest current but if you use a PP3 style 9V battery it won't last long at all. In fact, if you're using a typical 'heavy duty' 9V battery, it will last less than 20 minutes before the voltage drops to 7.8V. That may be enough to stop your circuit working. Or maybe you are using an alkaline type. Depending on the brand and price, you might get about two hours life. Not good.

By comparison, two AA alkaline cells driving this DC-DC Converter circuit to give 9V at 40mA will last about 7 hours. And rechargeable AA cells can be even better. Table 1 shows the comparisons.

This circuit can deliver up to 90mA at 9V (with less life from the cells) or can be set to deliver anywhere between 4.5V and 20V. You might never have to buy another 9V battery ever again.

This project is based around the Texas Instruments TL499A, its output voltage is programmable, making it suitable for use in a variety of low-power applications. This design is specified for use with two cells. This enables the converter to produce more realistic output current levels. For low-power applications, two cells are also more cost effective, as more of their energy is extracted before the terminal voltage falls below the converter's minimum input voltage.

We've also included support circuitry for the TL499's on-board series (linear) regulator, meaning that it can be powered from a plugpack when a mains outlet is available. In addition, a trickle-charge function is provided for use with rechargeable batteries.

The PC board is roughly the same size as a 2 × 'AA' cell holder, so in some applications it will be possible to build it right into the equipment that it powers. Alternatively, it could be housed in a small plastic box.

TL499A basic operation

A functional block diagram of the TL499A appears in Fig.1. It contains a switching regulator and series regulator. Let's look at the switching regulator section first.

The switching regulator operates as a conventional step-up pulse-width modulated (PWM) DC-DC converter. A variable frequency oscillator drives the base of a power transistor, which acts as a switch between one side of a 'boost' inductor and ground.

Referring to the circuit diagram in Fig.2 and also the block diagram Fig.1, you can see that one end of the inductor (L1) is connected to battery positive. The other end is connected to pin 6 of the TL499A – the collector of the switching transistor (Q1).

When the transistor switches on, the current through L1 ramps up with time, storing energy in the inductor's magnetic field. When the transistor turns off, the magnetic field collapses, generating an instantaneous voltage which causes the blocking diode to conduct, thereby transferring the

Main Features

- Use it to replace 9V batteries
- Runs from AA, C or D cells
- Up to 90mA current at 9V
- Can be set for 4.5V to 20V output
- Supports DC plugpack input
- Optional trickle charge for NiCad and NiMH batteries

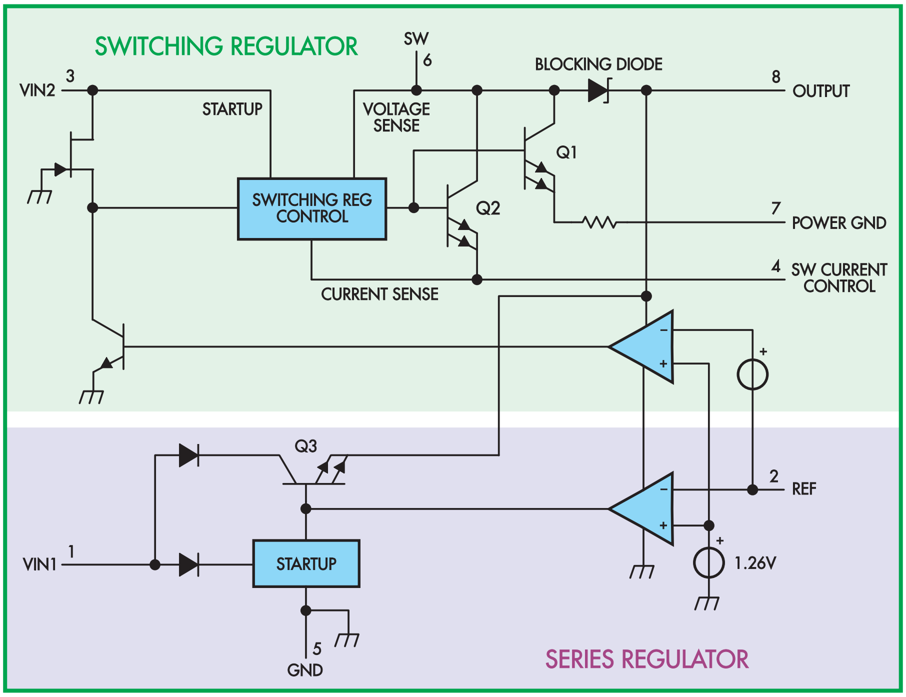


Fig.1: the functional block diagram of the TL499A. It's housed in an 8-pin DIL package and contains both series (linear) and step-up switching regulators.

inductor's energy to the output filter capacitor and load via pin 8.

The second transistor (Q2) forms part of a cycle-by-cycle current limiting circuit. This circuit turns off the switching transistor (Q1) when the current through it reaches a predetermined level. A 150Ω resistor from pin 4 to ground sets the peak current level to about 500mA.

The PWM circuit uses a fixed off time/variable on time scheme to maintain a regulated output voltage under varying line (battery voltage) and load conditions. Under light-load conditions, the switching frequency can be as low as a few kHz. With maximum load and minimum input voltage, it increases to over 20kHz.

Now let's turn our attention to the series regulator section. Again, this section is quite conventional, consisting of an NPN series pass element (Q3), a voltage reference and an error amplifier.

DC voltage applied to pin 1 is passed through to the output at pin 8 via transistor Q3. The base of Q3 is driven by an error amplifier, which compares a 1.26V (nominal) reference voltage on its non-inverting input with the voltage at pin 2.

Looking at the circuit diagram (Fig.2), you can see that resistors R1, R2 and R3 close the feedback loop, connecting the output voltage back to the error amplifier's inverting input. The output voltage is determined by the expression:

$$V_{OUT} = V_{REF}\ (1 + R1 \,||\, R2/R3)$$

Substituting our listed values gives:

$$V_{OUT} = 1.26\ (1 + 33k\Omega \,||\, 220k\Omega/4.7k\Omega) = 8.95V$$

In fact, by choosing appropriate values for R1 and R2, the output voltage can be programmed for any value between 4.5V and 20V. A handy list of resistor values for the most common voltage ranges is presented in Table.3.

Parts List

- 1 PC board, code 620 available from the *EPE PCB Service*, 59 x 29mm
- 1 14.8mm powdered-iron ring-core toroid (Neosid 17-732-22)
- 1 700mm-length (approx) 0.63mm enamelled copper wire
- 1 2 x AA (or C or D) cell holder
- 2 x 1.5V cells to suit cell holder
- 1 9V battery snap
- 1 panel-mount 2.1mm or 2.5mm DC socket (optional)
- 1 12V DC plugpack (see text)
- 6 1mm PC board pins (stakes)
- Hot melt glue or neutral cure silicone sealant

Semiconductors
- 1 TL499A Power Supply Controller IC (IC1). Available with PCB 620 from the *EPE PCB Service*
- 2 1N4004 1A diodes (D1,D2)
- 1 1N4732A 4.7V 1W Zener diode (ZD1)

Capacitors
- 1 470µF 25V PC electrolytic
- 1 220µF 25V PC electrolytic
- 1 100µF 25V PC electrolytic
- 1 1µF 50V monolithic ceramic
- 2 100nF 50V MKT polyester

Resistors (0.25W 1%)
- 1 220kΩ
- 1 150Ω
- 1 33kΩ
- 1 10Ω
- 1 4.7kΩ
- 1 270Ω 1W 5%
- 1 220Ω 1W 5% (for testing)

Regulator priority

A similar voltage feedback scheme is used by the switching regulator control circuits. In this case, however, the error amplifier circuit has been modified so that the output voltage will be about 2-3% lower than from the series regulator. This gives priority to the series regulator, because its slightly higher output voltage 'forces off' the switching regulator.

In practice, this means that when the unit is running from batteries and a plugpack is connected, switchover between the two sources occurs automatically. Power to the output is uninterrupted, ignoring the small increase in voltage (about 180mV for

Table 1: Battery Life Comparison

Type	Service Life	Conditions
9V Heavy Duty	≈ 18 min.	40mA Load, 7.8V Cutoff
9V Alkaline (Rayovac A1604)	≈ 2 hours	40mA Load, 7.8V Cutoff
2 x AA Alkaline	≈ 7 hours	230mA Load, (40mA Output), 1V/Cell Cutoff (9V Output)
2 x AA NiMH (2000mAh)	≈ 7.7 hours	230mA Load (40mA Output), 1V/Cell Cutoff (9V Output)

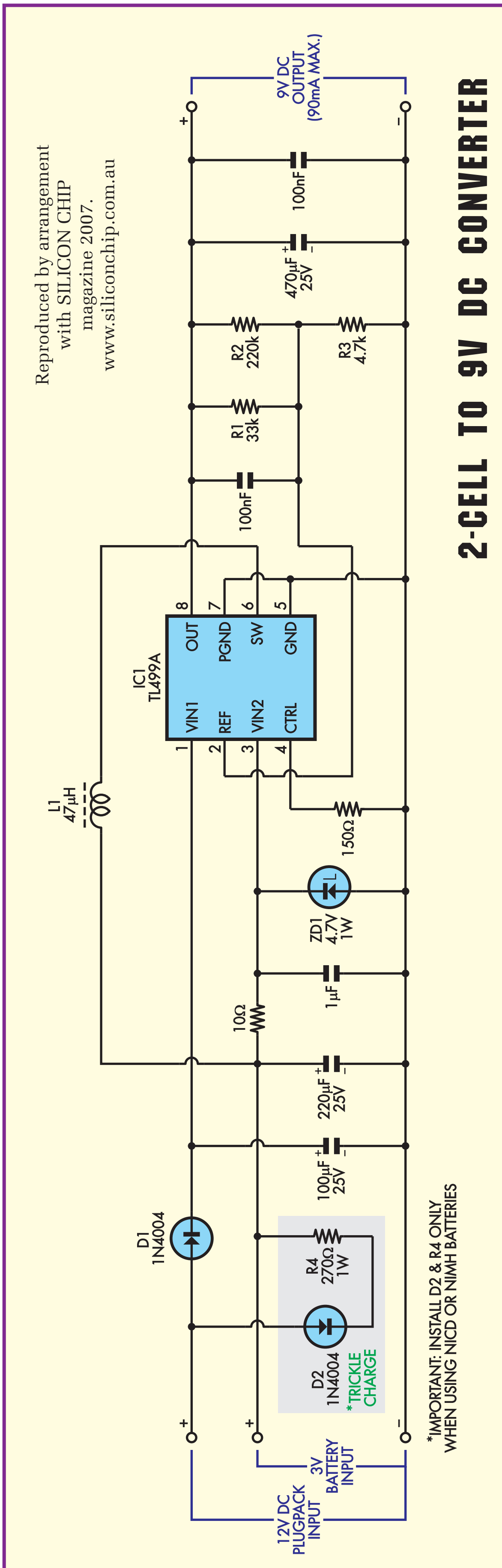


Fig.2: only an external inductor and a few passive components are required to build a complete power supply using the TL499A. D2 and R4 are optional, providing a trickle charge to the battery when a plugpack is connected.

9V out). When the series regulator is operating, the switching regulator shuts down and battery drain drops to just 15µA (typical).

Texas Instruments refers to the voltage difference between the switching and series regulators as the 'change voltage'. For more detailed information on the TL499A, you can download the datasheet from **www.ti.com**

Complete circuit

Very little external circuitry is required to construct a complete power supply using the TL499A. Looking first at the input side of the circuit (Fig.2), the DC plugpack input is polarity-protected with a series diode (D1) and then filtered with a 100µF capacitor before being applied to the series regulator input (pin 1).

At the battery input, a 220µF capacitor compensates for battery lead length, terminal contact resistance and increasing cell impedance during discharge.

Additional filtering is provided using a 10Ω resistor and 1µF capacitor before the battery voltage is applied to the switching regulator input (pin 3). This filter removes much of the high frequency switching noise present on the 'hot' side of inductor L1.

Zener diode ZD1 clamps the voltage on pin 3 to less than the maximum (10V) rating of the IC. It also prevents the trickle charge circuit from powering the output side of the circuit (via L1 and IC1), both unwanted side-effects that would otherwise occur when the circuit is powered from a plugpack without batteries installed.

Note: to keep board size to a minimum, polarity protection has not been provided on the battery input. As cell orientation is obvious for most battery holders, you may not be concerned about this omission. However, if your application demands input polarity protection, then the additional circuitry shown in Fig.4 can be inserted prior to the converter's input terminals. A simple series diode will not suffice in this case, as it would seriously impede circuit performance.

Trickle charge circuit

If you're using rechargeable cells, then D2 and R4 can be installed to provide trickle charging whenever a plugpack is connected. A resistor value of 270Ω limits the charge current to about 50mA, dependant on input and battery voltages. This current level is suitable for cells of 1000mAh and higher. For lower cell capacities, you should select a more appropriate value for R4 using the following formula:

$$R4 = (V_{IN} - V_D - V_{BATT}) / (Ah \times 0.05)$$

Where V_{IN} = plugpack voltage, V_D = diode voltage drop, V_{BATT} = fully charged battery voltage, Ah = battery capacity in amp/hours.

For example, if you're using 650mAh cells with a 12V unregulated plugpack that puts out 16V:

$$R4 = (16 - 0.7 - 3) / (0.65 \times 0.05)$$
$$= 378\Omega \text{ (use } 390\Omega)$$

Note that while the trickle charge function will top-up your batteries as well as compensate for self-discharge, it is not intended to recharge flat cells. Do not be tempted to increase the trickle charge current

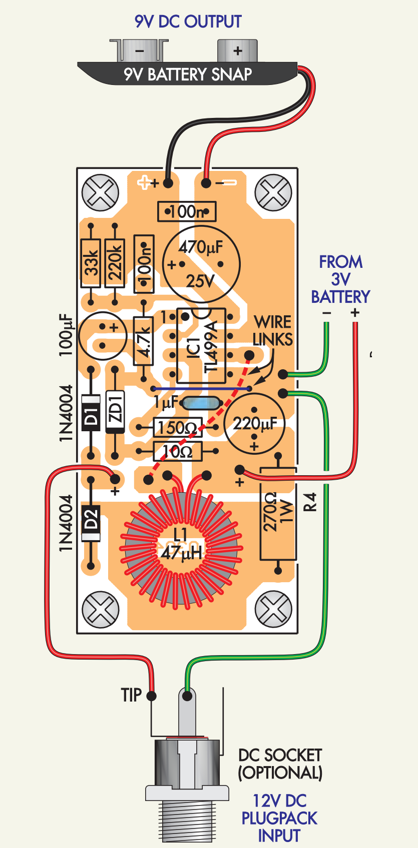


Fig.3: follow this diagram closely when assembling the board. There's no need to wire up the DC socket if you'll only be powering the converter from batteries. Note how the 9V battery snap is wired in reverse (red wire to negative terminal, black to positive) to mate with the existing battery snap in the equipment to be powered.

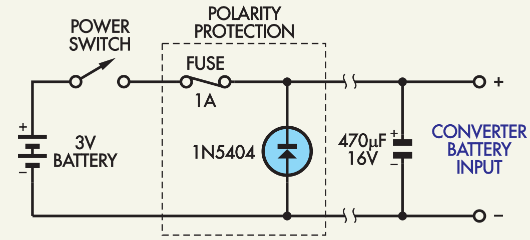


Fig.4: install these components in-line with the battery leads if 'fail-safe' polarity protection and/or battery switching is required. The 470µF capacitor may be needed to ensure that the DC-DC converter starts up and regulates properly with the additional series impedance introduced by the switch, fuse and associated wiring.

beyond the recommended 0.05C rate. Doing so may shorten the life of your cells, or in the extreme case, cause a fire or explosion! If in doubt, refer to the manufacturer's data sheets for the maximum recommended trickle charge rate.

On the output side of the circuit, the 100nF capacitor across the top two resistors reduces ripple and noise in the feedback signal to pin 2. Finally, 470µF and 100nF capacitors provide the maximum permissible filtering ahead of the output terminals.

Voltage and current limits

Using the component values shown, the series regulator (plugpack) input can be as high as 17V. This limit is imposed by the maximum continuous power dissipation of the TL499A (0.65W recommended), as well as power dissipation in the trickle charge circuit.

If you've programmed the output for less than 9V, then use a lower voltage plugpack (less than 12V) to keep IC power dissipation under control. Remember that unregulated plugpacks put out higher voltages than specified when lightly loaded. Ideally, the input voltage needs to be only about 3V higher than the output to achieve regulation and minimise dissipation.

The switching regulator can source up to 100mA of current. Table 4 provides a convenient method of determining the maximum available current for typical input and output voltage combinations when operating from battery power.

Although the TL499A includes in-built over-temperature and over-current protection, you should not exceed the listed current levels to avoid possible damage to the chip. Excessive loading will also cause high ripple voltage and loss of regulation at the output.

Also, note that being a step-up (boost) type converter, there is a current path from the battery, through the inductor (L1) and the internal blocking diode to the output, even when the switcher is shut down. The diode is designed for a maximum current of 1A, a level that could easily be exceeded if the output terminals are accidentally shorted together.

About efficiency & battery life

The switching regulator's efficiency depends on the input and output voltages and the load current. As shown in Table 4, the maximum output current with 3V at the input is 90mA. In this configuration, the circuit is about 55% efficient. Therefore, we can say that with a step-up ratio of 3:1, the input power will be about 1.25W at full load.

This represents a considerable current demand on the batteries. In the case of alkaline batteries, the voltage decays rapidly to less than 1V/cell

Table 2: Resistor Colour Codes

	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❑	1	220kΩ	red red yellow brown	red red black orange brown
❑	1	33kΩ	orange orange orange brown	orange orange black red brown
❑	1	4.7kΩ	yellow violet red brown	yellow violet black brown brown
❑	1	150Ω	brown green brown brown	brown green black black brown
❑	1	10Ω	brown black black brown	brown black black gold brown
❑	1	270Ω (5%)	red violet brown gold	not applicable
❑	1	220Ω (5%)	red red brown gold	not applicable

Table 3: R1 and R2 Values For Common Output Voltages		
VOUT	R1	R2
4.5V	22kΩ	27kΩ
5V	15kΩ	180kΩ
6V	33kΩ	39kΩ
7.5V	27kΩ	180kΩ
9V	33kΩ	220kΩ
12V	47kΩ	270kΩ
15V	56kΩ	560kΩ

Table.3: to program the converter for a different output voltage, just change the values of R1 and R2. Typical voltage ranges together with the necessary resistor values are listed here.

under heavy-load conditions, which means that available output power decreases as well.

The most important points to consider are:

(1). Alkaline cells are best suited for intermittent and/or light-load use. The high self-discharge rate of rechargeables (especially NiMH types) makes them unsuitable in this application unless trickle-charged.

(2). Rechargeable cells are best suited for high current, continuous-use applications. Although the initial terminal voltage is less than for alkaline cells, they have an almost flat voltage discharge curve. The lower (1.2V/cell) terminal voltage means that about 70mA max. output current is possible at 9V, but it will be sustainable over most of the battery life.

(3). Carbon cells are not recommended due to the high peak switching current drawn by the converter.

Assembly

Using the overlay diagram in Fig.3 as your guide, begin by installing the wire link (just below IC1) using tinned copper wire. Follow this up with all the resistors and diodes (D1, D2 and ZD1), taking care to align the banded ends of the diodes as shown.

Note that the 270Ω 1W resistor should be mounted about 1mm proud of the board to aid heat dissipation.

Important: D2 and R4 should only be installed if you'll be using rechargeable batteries and the plugpack input. Do not install these components if using alkaline batteries.

The TL499A (IC1) can go in next. It is important that this chip is soldered directly to the PC board – don't use an IC socket! This maximises heat transfer and eliminates contact resistance. The notched (pin 1) end must be oriented as shown on the overlay diagram.

Install all of the capacitors next, noting that the electrolytics go in with their positive leads aligned as indicated by the '+' symbol.

Winding the inductor

The inductor is hand wound on a 14.8mm powdered-iron toroid, Neosid Part No. 17-732-22 (or similar). You'll need about 700mm of 0.63mm enamelled copper wire for the job.

In total, 30 turns are required to achieve the 47µH inductance value. The wire must be wound on tightly, with each turn positioned as close as possible to the last. Do not overlap turns. One complete layer should make exactly 30 turns. Be careful not to kink the wire as you thread it through the centre of the toroid, otherwise you won't be able to fit all 30 turns in the available space.

Bend and trim the start and finish ends as necessary to get a neat fit in the PC board holes. Scrape the enamel insulation off the wire ends with a sharp blade and tin with solder prior to soldering to the PC board.

With the inductor in place, all that remains is to install an insulated wire link between pin 6 of IC1 and the spare hole on one side of the inductor. Make this link from medium-duty hook-up wire and keep it as short as possible. That done, the inductor can be permanently fixed to the PC board using hot-melt glue or neutral cure silicone sealant.

Hookup and testing

All connections to the board are

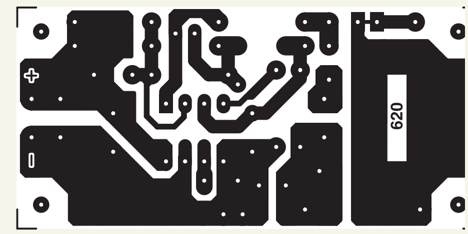


Fig.6: this is the PC board etching pattern.

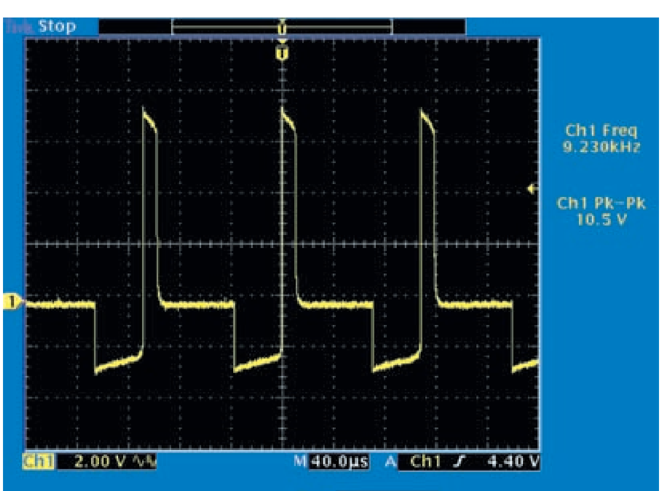


Fig.5: this waveform was captured on pin 6 of the TL499A switching regulator IC with a 40mA load (ie, the 220Ω test load). The switching frequency is a little over 9kHz in this case.

Table 4

OUTPUT VOLTAGE (V)	BATTERY INPUT VOLTAGE (V)							
	1.1	1.2	1.3	1.5	1.7	2	2.5	3
	MAXIMUM OUTPUT CURRENT (mA)							
20						20	25	30
15				15	20	30	45	55
12	10	15	20	25	30	40	55	70
10	15	20	25	30	35	45	65	80
9	20	25	30	35	40	50	70	90
6	30	35	40	45	55	75	95	100
5	35	40	45	55	70	85	100	100
4.5	35	45	50	60	75	95	100	100

Table.4: the maximum switching regulator output current depends on the input and output voltages. This table enables you to predict the maximum current for the chosen output voltage as battery voltage declines.

made with medium-duty hook-up wire. If desired, PC board pins (stakes) can be installed at each connection point rather than soldering the wires directly to the board.

Note that the wiring length from the battery holder to the input terminals must not exceed 100mm. Where possible, replace existing light-duty battery holder wiring with medium-duty cable and twist the leads tightly together to reduce radiated noise.

The converter draws a small quiescent current (a few milliamps) under no-load conditions. Therefore, for light-load or intermittent use, you'll need to install a switch in series with the battery. Use a switch with a 2A rating or higher.

Note: to counter the effects of switch contact resistance (and fuse resistance, if used), you may need to install a capacitor between the switch output and battery negative leads (see Fig.4).

In cases where the converter is to be used in place of a 9V battery, a battery clip can be used to make the connection to the existing battery clip in the equipment. **As shown on the overlay diagram (Fig.3), you'll need to wire the clip leads in reverse, so that it mates up with the correct polarity!**

Before using the converter for the first time, connect a 220Ω 1W resistor across the output terminals and apply battery power. Use your multimeter to measure the voltage across this resistor. If the switching regulator is doing its job, you meter should read close to the desired voltage.

If you'll be using a plugpack as well, then connect it up while monitoring the output voltage. As stated earlier, you should see a small increase in voltage (about 180mV), indicating that the series regulator has taken over and shut down the switching regulator. ***EPE***

Plugpack Operation Without A Battery

When the trickle charge circuit (D2 & R4) is installed and the converter is powered from the plugpack input without a battery connected, the output voltage will fall short of 9V. This occurs because the trickle-charge circuit is pulling the 'SW' pin higher than the 'V_{IN2}' pin, causing the TL499A to erroneously select the step-up switching regulator instead of the linear regulator.

If you must operate the unit from a plugpack without a battery installed, then you can solve this problem in one of two ways:

(1). Remove the trickle charge components (D2 and R4); or

(2). Fit a 2-pin header so that the trickle-charge circuit can be disabled (via a jumper shunt) at will. You will note on the circuit board layout that provision has been made for this directly beneath D2.

First, remove D2 and cut the small track that joins the two square pads. Install a 2-pin header and refit D2, noting that you'll probably need a new diode with longer leads so that it can be positioned between the new header and L1.

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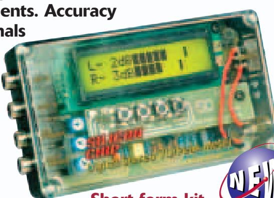
- Case not included use HB-6082 £2.95



NEW

Requires 9-12VDC wall adaptor (Maplin #JC91Y £14.99)

Short form kit

Jacob's Ladder High Voltage Display Kit

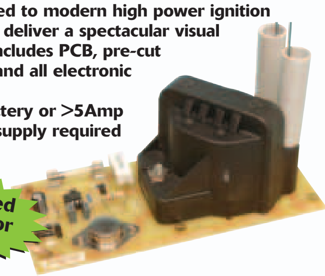
NEW

KC-5445 £11.75 + post & packing

DANGER HIGH VOLTAGE

With this kit and the purchase of a 12V ignition coil (available from auto stores and parts recyclers), create an awesome rising ladder of noisy sparks that emits the distinct smell of ozone. This improved circuit is suited to modern high power ignition coils and will deliver a spectacular visual display. Kit includes PCB, pre-cut wire/ladder and all electronic components.

- 12V car battery or >5Amp DC power supply required



Improved model for 2007

DC Relay Switch

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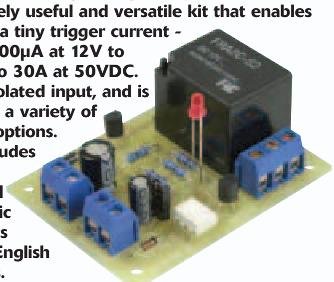
An extremely useful and versatile kit that enables you to use a tiny trigger current - as low as 400µA at 12V to switch up to 30A at 50VDC. It has an isolated input, and is suitable for a variety of triggering options. The kit includes PCB with overlay and all electronic components with clear English instructions.



Battery Zapper MKII Kit

KC-5427 £29.00 + post & packing

This kit attacks a common cause of failure in wet lead acid cell batteries: sulphation. The circuit produces short bursts of high level energy to reverse the damaging sulphation effect. This new improved unit features a battery health checker with LED indicator, new circuit protection against badly sulphated batteries, test points for a DMM and connection for a battery charger. Kit includes case with screenprinted lid, PCB with overlay, all electronic components and clear English instructions. Suitable for 6, 12 and 24V batteries

- Powered by the battery itself

Improved model for 2007

IR Remote Control Extender MKII

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Improved model for 2007

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This compact, low cost 50MHZ Frequency Meter is invaluable for servicing and diagnostics. This upgraded version, has a prescaler switch which changes the units from Mhz to GHz, kHz to MHz and Hz to kHz, and has 10kHz rounding to enable RC modellers to measure more accurately. Kit includes PCB with overlay, enclosure, LCD and all electronic components.

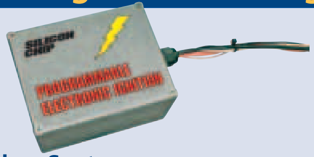
Other features include:

- 8 digit reading (LCD)
- Prescaler switch
- Autoranging Hz, kHz or MHz
- 3 resolution modes including 10kHz rounding, 0.1Hz up to 150Hz, 1Hz up to 16MHz and 10Hz up to 16MHz

Improved model for 2007

Requires 5VDC wall adaptor (Maplin L66BQ £7.79)

Programmable High Energy Ignition System



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- Kit supplied with PCB, and all electronic components

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Kit this Summer

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 '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.

3V - 9V DC-to-DC Converter Kit

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This little converter allows you to use regular Ni-Cd or Ni-MH 1.2V cells, or alkaline 1.5V cells for 9V applications. Using low cost, high capacity rechargeable cells, this kit will pay for itself in no time. You can use any 1.2-1.5V cells you desire. Imagine the extra capacity you would have using two 9000mAh D cells in replacement of a low capacity 9V cell. Kit supplied with PCB, and all electronic components.

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

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- As published in Everyday Practical Electronics Magazine

Recommended box UB5 HB-6015 £0.83

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KC-5400 £15.95 + post & packing

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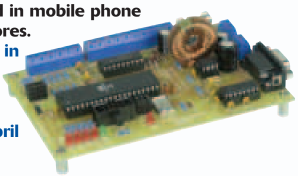
* Requires a Nokia data cable which can be readily found in mobile phone accessory stores.

- As published in Everyday Practical Electronics Magazine April 2007



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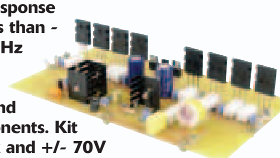


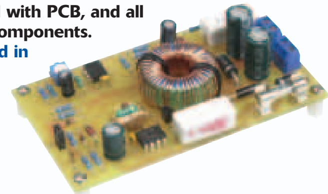
- As published in Everyday Practical Electronics October & November 2006

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 Everyday Practical Electronics Magazine April 2007

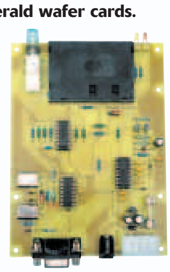


Smart Card Reader and Programmer Kit

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.

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. Includes a mic, PCB with overlay and all other parts.

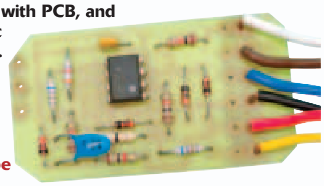
- Requires 9V battery (not included)
- Instructions included in kit

Fuel Cut Defeat Kit

KC-5439 £6.00 + post & packing

This simple kit enables you to defeat the factory fuel cut signal from your car's ECU and allows your turbo charger to go beyond the typical 15-17psi factory boost limit. - Note: Care should be taken to ensure that the boost level and fuel mixture don't reach unsafe levels.

- Kit supplied with PCB, and all electronic components.

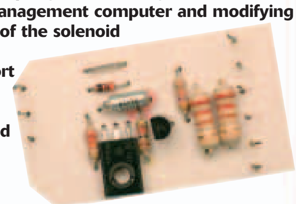


Note: Prototype shown

Variable Boost Kit for Turbochargers

KC-5438 £6.00 + post & packing

It's a very simple circuit with only a few components to modify the factory boost levels. It works by intercepting the boost signal from the car's engine management computer and modifying the duty cycle of the solenoid signal. Kit supplied in short form with PCB and overlay, and all specified electronic components.



Note: Prototype shown

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PIC N' MIX

MIKE HIBBETT

Our periodic column for your PIC programming enlightenment

Reviewing Microchip's PICkit2

THIS month we take a look at Microchip's PICkit2 Debug Express unit, a low cost combined programmer and debugger device suitable for use with virtually all PIC microcontrollers. Available for about £25 from Microchip Direct, it's a low cost tool that promises to 'get you going' in PIC development quickly, and at a reasonable cost.

Programming and debugging

Programming and debugging microcontrollers has come a long way in the last 15 years. Back in the early 90's debugging was still done with expensive emulators, which even for the small PIC processor cost over a thousand pounds. Hobbyists had no option other than to use the 'crash and burn' technique of programming a PIC, observing the bugs and then programming another chip with revised software.

Probing the internal operation of the PIC was done by writing software to generate debug output (over a serial port or sometimes just an LED) at strategic points in the code – a crude technique still used today in some cases. Special microcontrollers with UV erasable memory were used, which took 10 minutes or more to erase. It focused one's mind on the debugging activity!

Those engineers lucky enough to have access to an emulator live in a completely different world. Emulators use special 'bonded-out' variants of the processor which have extra pins to allow access to internal data signals. Application code runs in the emulator itself and a special header cable connects the processor's I/O pins to your target board, plugging in where the processor would normally fit. Emulators enable the user to single step each instruction, view the contents of registers and define complex breakpoints (for example, 'halt the emulator when this instruction has been executed 10 times', or 'halt on this instruction if the variable *i* equals seven'). These bonded-out processors are extremely expensive, and require a large amount of supporting electronics, hence the hefty price tag.

Fortunately, micrcontroller manufacturers realised how difficult the situation was, and so they started putting special interfaces on their microcontrollers to allow an external device – an in-circuit debugger – to take control of the processor. This typically involved providing a few pins on the processor that are dedicated to debug operation and a tiny amount of additional electronics inside the processor to manage some of the supporting functionality.

Debugger functions

These debuggers offer two main areas of functionality:

Halt: A signal from the debugger to the processor to stop what it is doing immediately and allow the debugger to examine the contents of registers.

Fig.1. PICkit2 supplied in its blister pack

Breakpoints: These are code memory addresses the user can specify, which, should the application code reach any of them while it is running, will cause the processor to halt and return control to the debugger.

To enable the debugger to examine the contents of registers once the application has halted requires a small 'background debugger' application to be downloaded into the processor alongside the main application to be debugged. The debugger hardware communicates with this program to extract the contents of memory for display on the PC.

This debug application is automatically downloaded when you start debugging your application; the process is invisible to you, although you do have to bear in mind that about 200 to 300 bytes of program space will be taken up by this support code. This should not cause any problems unless your application completely fills the flash memory.

By imposing these limitations – requiring a small amount of code space, and taking up a few I/O pins – microcontroller manufacturers were able to provide highly functional debugging tools at a tenth of the price of previous solutions.

These in-circuit debuggers offered an additional benefit over emulators: you could design your production PCB with a small header on it that would provide a debug interface, and not need to design a different board capable of accepting the emulator cable. This is an important factor if you are building small, compact circuits or employ surface mount technology.

PICkit2

The PICkit2 is supplied in a simple, small blister-pack, showing a tiny plastic cased device, a USB cable and a PCB (Fig.1). Apart from these hardware components, the PICkit2 comes with two CDs and four pieces of paper.

It's important when installing a new device like this to read everything first before plugging anything in. The documentation consists of a registration card, a contents list, a backing card (containing useful system requirements) and a typical 'Read First' card.

Oddly enough, the 'Read First' sheet doesn't really have any useful information on it. The most important information can be found on the text printed on the two CDs. One, the 'PICkit Starter Kit' CD includes the text 'Insert This CD First' – the only really useful information provided in all the printed documentation supplied. This 'first' CD contains the USB drivers, programming utility and assembly programming tutorials, and the second CD contains a copy of MPLAB.

In operation, the PICkit2 debugger consists of two main components: software that runs on the PC, and a hardware interface to connect the PC to your target board. A USB cable connects the debugger to the PC and a small 0.1 inch pitch header is provided to connect to your target hardware. You will need to provide a matching pin-header on your board to use the PICkit2, and full instructions are provided in the documentation. The PCB is supplied as a simple example of this.

As with any USB-based interface, care needs to be taken when installing the software. USB interfaces are sensitive to the order in which you install software or plug in interfaces, so it is always a good idea to read the supplied documentation carefully first before plugging anything in or inserting software CDs. USB interfaces require driver software to be installed before any applications that use them. It's important therefore to follow the manufacturer's instructions about the order in which software should be installed. 'Insert This CD First' is a clear indication of the order we should be installing them!

Internet Explorer

Something to bear in mind before you do insert that first CD is that it relies on Internet Explorer being the default Internet application present on the PC. The installation program uses Internet Explorer to copy the tutorial programs from the CD, and if you are using an alternative browser like Firefox (as millions of users do) then the tutorial programs will not load.

If you have been using Firefox then you must set Internet Explorer to be the default Internet application. To do this, run Internet Explorer, select 'Tools' from the main menu, then 'Internet Options' and click on 'Make default' under 'Default web browser'.

Inserting the CD causes the installation program to automatically start. This offers a number of options for installing documents such as a small selection of application notes and datasheets, plus the full schematics and source code for the hardware on the debugger itself. Kudos to Microchip for doing this – it's a great source of inspiration on to how to design and build real products.

There is a section on 'Lessons' which is rather confusing – these buttons link to just the source code examples. The tutorials themselves are found under the 'User Guide' section in the 'Low Pin Count Demo Board User's Guide'. Not exactly intuitive. These are not suitable for the PICkit2, but the correct ones are available for download free from the Microchip website.

Installing PICKIT2

Having taken some time browsing the various documents, it was time to install the PICkit2. Once installed we plugged in the PICkit2 to the PC via the USB cable, and started up the newly installed PICkit2 program.

Running the PICkit2 application revealed a dialogue interface not unlike many other PIC programming software packages. Options are clear and there is a helpful user guide available from the main menu.

Time to plug in the PCB. This is a small prototyping board equipped with a PIC16F917 processor, eight LEDs and a variable resistor connected to the ADC input. There is a small amount of prototyping area on the board which makes it ideal for someone starting out with PIC programming. As the PICkit2 is able to supply the board power through the USB port, you

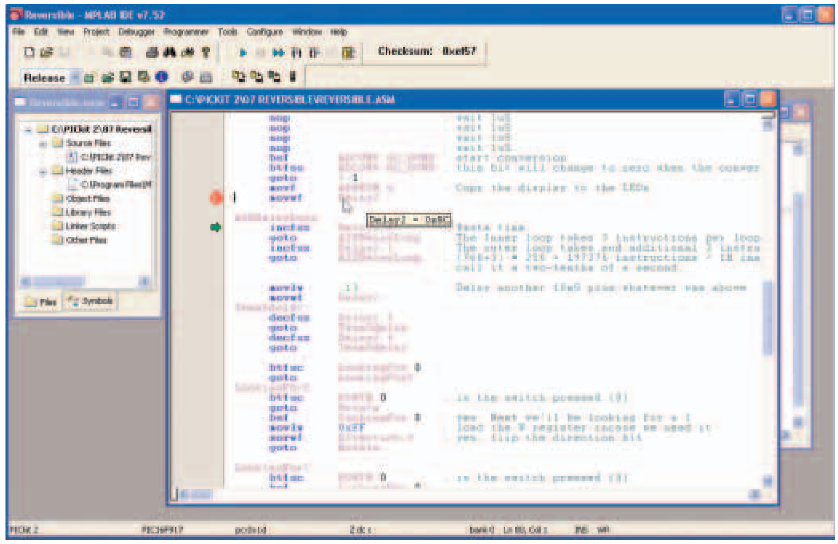


Fig.2. A typical MPLAB screen in debugging mode

don't even need an external power supply to power the target board (so long as it doesn't draw more than 100mA. If it does, you will have to power it using an external power supply.)

Plugging in the PCB, the programmer recognised the CPU type automatically, and a simple demo application, preloaded on the board, started to run. Easy.

Programming the PIC on the board is simple too – load the .hex file containing your code, click 'Program', and it's done in a few seconds. No need to remove the debugger while running your program, so you can run round the code->program->test->code loop quickly.

MPLAB debugging facilities

Looking round the options on the PICkit2 application, however, revealed no evidence of any debugging facilities – so where are they? This is where the second disk comes in – MPLAB.

MPLAB is a fully integrated editor, assembler, simulator and debugger program. We won't go into too much detail on MPLAB here because it will be covered in another article, but we will take a look at the debugger features offered within it.

Installation of MPLAB was again straightforward. The CD also offers the student edition of the Microchip C compiler – a very powerful high level programming language that we covered in a previous series of articles. For now, to examine the debugging capabilities we will focus on debugging assembly language programs but it should be pointed out that you can also debug C programs, should you wish.

The version of MPLAB supplied on the CD, v7.40, provided no support for the PICkit2 as a debugger! You have to obtain the latest version of the software, v7.52, from the Microchip website. That's a 40MB download which requires a broadband connection to download. Or a good natured friend!

Having downloaded and installed the latest MPLAB application it became clear that the PICkit2 programming utility is also out of date. The latest version of that is available on the Microchip website and was downloaded too.

Tutorials

To get you up and running quickly, the CD provides some tutorials on assembly language programming with example source code that you can load directly into the MPLAB application and start debugging immediately. Once again, there was a problem – the processor fitted to the prototyping PCB is as PIC16F917, yet the tutorial examples were for the PIC16F690, and would not work. Fortunately, Microchip provide an updated set of tutorials on their website, and once these were downloaded we were back in business.

The effort was worth the wait. Fig.2 shows an example of MPLAB debugging a program that is running on the target board. The program has been halted so that the variables can be viewed and the program single-stepped line-by-line to see each instruction being executed. While users of programs like Visual Basic will be very familiar with this kind of operation, it's a huge leap forward for those used to developing programs on small embedded processors.

In MPLAB you have windows for viewing/editing the source code, buttons that build and download the program and a window (as shown) that can be used to view and step through the program as it runs on the target board's PIC processor. You really have to play with this yourself to realise just how powerful all these integrated features are.

Although the list of processors supported for debugging is short – only the PIC16F690 and PIC16F917 are fully supported – Microchip are clearly moving forward quickly with new releases of software to provide support for further processors and additional features. The PICkit2 application supports a much wider range of PIC processors, but only for programming.

System requirements

As far as system requirements are concerned, you are going to need a modern

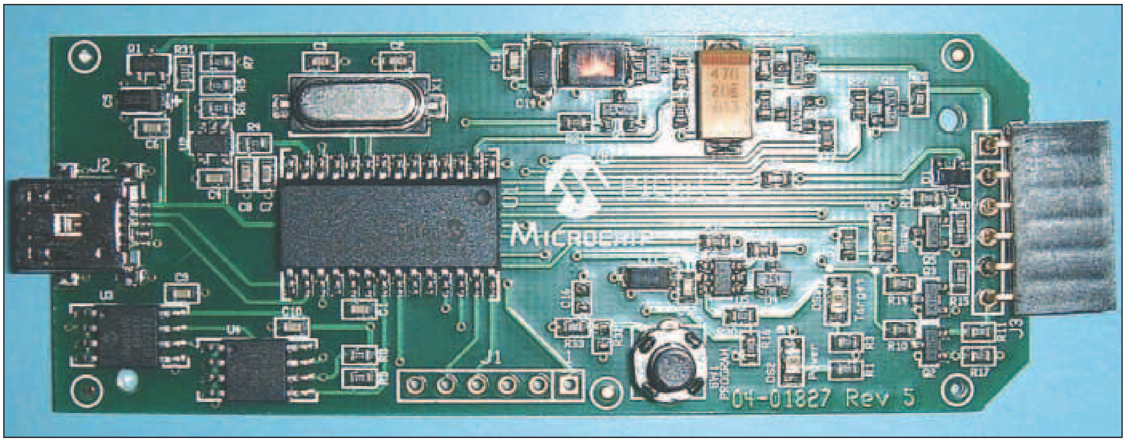


Fig.3. PICkit2 printed circuit board

operating system – at least Windows 98 Second Edition – and a few hundred MB of disk space. The PC must be equipped with a USB port, of course.

Our review was performed on a modern, low-end laptop, with Windows XP and 512MB of RAM. On this machine the MPLAB environment operated very smoothly.

Of course, like all engineers, we were curious about what is inside the PICkit2 debugger, so we dismantled the product to take a look. You can see the results in Fig.3.

Disassembly was quite easy – the case is a simple two-piece design that just clicks together. Inside is a single, double-sided PCB with a PIC18F2550, two EEPROM memory devices and a few discrete components. A large coil suggests that there is a voltage multiplier on-board (to provide the +12V programming voltage).

It's a tidy, simple design that looks like it could be quite reliable and safe to transport about – important if, like the author, you find yourself moving equipment around from one location to another. The board and case parts clipped back together again easily, but we would recommend that you do **not** try this yourself to minimise the risk of damaging the PCB.

Conclusion

Software installation was frustrating and time consuming requiring the downloading of large files from the Internet, but the effort was worth it. Although the range of microcontrollers supported is quite limited there is clear evidence that Microchip are working hard to fill the gaps. The IDE itself and the facilities provided are excellent and it provides an easy to use, polished professional interface.

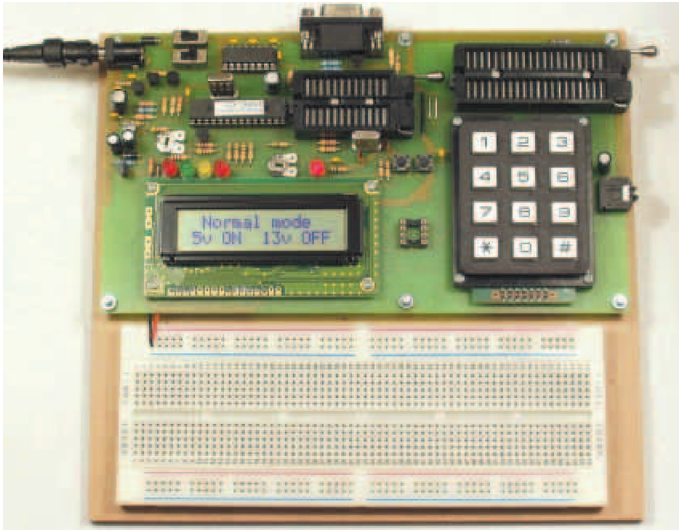
The software in the PICkit2 debugger itself – the debugger firmware – is stored in flash, and can therefore be updated easily. Microchip are making full use of this, having already raised the software from v1.20 to v2.20 so it looks like this low cost debugger will have a long operational life.

In summary, it's a great little device for a great little price. The installation instructions could do with some improvement and the supplied software is out of date, but once you have downloaded the latest versions from the Microchip website the integration of the hardware and MPLAB works perfectly. A great aid for anyone starting with microcontrollers or who wants a small reliable PIC programmer, but also ideal for the professional designer who wants to maximimse his productivity. We hope Microchip continue swiftly with the addition of support for existing processor types within the debugger.

Microchip's comments

Microchip comment that the PICkit2 supplied to us was an early production unit. When they manufacture the PICkit2 units they do issue all data. They also state that customers should always check the Mircrhip website for the latest update issue, all are free downloads.

Learn About Microcontrollers



PIC Training Course £159

The best place to begin learning about microcontrollers is the PIC16F627A. This is very simple to use, costs just £1.30, yet is packed full of features including 16 input/output lines, internal oscillator, comparator, serial port, and with two software changes is a drop in replacement for the PIC16F84.

Our PIC training course starts in the very simplest way. At the heart of our system are two real books which lie open on your desk while you use your computer to type in the programme and control the hardware. Start with four simple programmes. Run the simulator to see how they work. Test them with real hardware. Follow on with a little theory.....

Our PIC training course consists of our PIC programmer, a 300 page book teaching the fundamentals of PIC programming, a 274 page book introducing the C language, and a suite of programmes to run on a PC. The module uses a PIC to handle the timing, programming and voltage switching. Two ZIF sockets allow most 8, 18, 28 and 40 pin PICs to be programmed. The programming is performed at 5 volts, verified with 2 volts or 3 volts and verified again with 5.5 volts to ensure that the PIC works over its full operating voltage. UK orders include a plugtop power supply.

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+ PIC assembler and C compiler software on CD
+ PIC16F627A, PIC16F88, PIC16F870
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Experimenting with PIC Microcontrollers

This book introduces PIC programming by jumping straight in with four easy experiments. The first is explained over ten and a half pages assuming no starting knowledge of PICs. Then having gained some experience we study the basic principles of PIC programming, learn about the 8 bit timer, how to drive the liquid crystal display, create a real time clock, experiment with the watchdog timer, sleep mode, beeps and music, including a rendition of Beethoven's *Fur Elise*. Then there are two projects to work through, using a PIC as a sinewave generator, and monitoring the power taken by domestic appliances. Then we adapt the experiments to use the PIC16F877 family, PIC16F84 and PIC18F2321. In the space of 24 experiments, two projects and 56 exercises we work through from absolute beginner to experienced engineer level using the most up to date PICs.

Experimenting with PIC C

The second book starts with an easy to understand explanation of how to write simple PIC programmes in C. Then we begin with four easy experiments to learn about loops. We use the 8/16 bit timers, write text and variables to the LCD, use the keypad, produce a siren sound, a freezer thaw warning device, measure temperatures, drive white LEDs, control motors, switch mains voltages, and experiment with serial communication.

Web site:- www.brunningsoftware.co.uk

Visual C# Course £88

Visual C# Training Course comprising.....

Book Experimenting with Visual C#
+ AUX200 latching serial port
+ liquid crystal display assembly
+ programme text on CD
+ pack of components. £88.00
(Postage UK £8, Europe £14, Rest of world £22)

You will need to download Visual C# Express which is free. Full instructions are in the book.

In October 2003 Martin Crane purchased our original PIC training course and in September 2005 he updated to the latest version. Three weeks before Christmas 2006 we had a telephone call from Mrs Crane to order our Visual C# training course as a Christmas present for her husband. On 21st March 2007 we received an email from Martin Crane which includes his personal review of the course. Here are a few lines from his text......

For years I've wished to write my own applications that control external equipment from my PC.

Eureka!! Peter Brunning has shown just how simple it really is. I am up and running at last. Most people seem to start with Visual BASIC, I found it truly frustrating. C# has combined everything you could wish for and more besides. The visual interface will be instantly familiar to Visual BASIC users but with far more options. The code side is dealt with by Peter in such a way that with no knowledge what so ever you can within a very short time be using the serial port. Brunning Software's serial port interface (included with the course) comes preprogrammed but the code is listed in the book together with the available features. Congratulations Peter for producing a truly hands on training package.

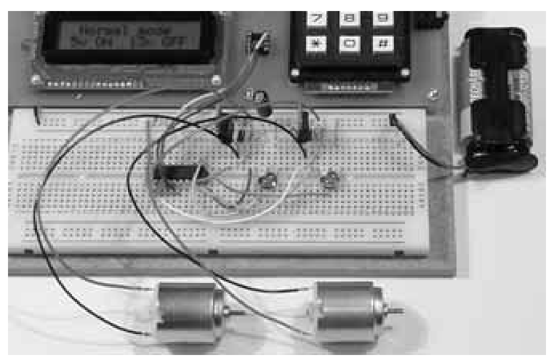
Martin Crane
(a very satisfied customer)

See:- www.brunningsoftware.co.uk/vcreview.htm

Ordering Information

Both training courses need either a free serial port on your PC or a USB to COM adapter (full details on website). All software referred to in this advertisement will operate within Windows XP, NT, 2000 or later.

Telephone with Visa, Mastercard or Switch, or send cheque/PO. All prices include VAT if applicable.



White LED and Motors

Our PIC training system uses a very practical approach. Towards the end of the second book circuits need to be built on the plugboard. The 5 volt supply which is already wired to the plugboard has a current limit setting which ensures that even the most severe wiring errors will not be a fire hazard and are very unlikely to damage PICs or other ICs.

We use a PIC16F627A as a freezer thaw monitor, as a step up switching regulator to drive 3 ultra bright white LEDs, and to control the speed of a DC motor with maximum torque still available. A kit of parts can be purchased (£30) to build the circuits using the white LEDs and the two motors. See our web site for details.

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BAT SONAR

By THOMAS SCARBOROUGH

Tune into the secretive world of bats with this low-cost detector. With the addition of just a few extra components you can even create a simple sonar system

THE author was at a loss as to what to name this project. While it is in the first instance a very sensitive bat detector, it is also an ultrasonic remote control – and, with some simple surgery, may serve as a sound navigation ranging system (sonar).

Although sonar is usually associated with navigation ranging under water, it may also be used to good effect in air (for instance, to detect boats in a fog). In this case, the circuit will detect objects at a specific distance (about eight metres), while ignoring them at greater or lesser distances (e.g. 6m or 10m).

Bats typically emit bursts of ultrasound in the range of 15kHz to 200kHz, depending on the species. However, sounds above about 80kHz are rare. Some cheap piezo input devices will pick up bats at up to about 60kHz, and this is suitable for most species.

Bats are, of course, not the only creatures which emit ultrasound. The author has picked up a number of unidentified creatures with bat detectors – presumably all of them insects.

Window of sound

As a bat detector, the circuit has a number of special characteristics; these being highlighted in the Features panel. The circuit further lends itself to converting it into a sonar system. Only a handful of additional components being required.

If one pulses a short stream of ultrasound, and opens up a 'window' for listening to the echo, one has a system that will detect objects at specific distances. One of the reasons why this has not been made a 'foreground' feature of this design is that dealing with bouncing (ultra) sound waves can be tricky, and may require a great deal of patience. However, details are included for the creation of an excellent sonar system.

Block diagram

The block diagram, shown in Fig.1, shows the simplicity of the design in concept. An extremely sensitive four-stage preamplifier (incorporating TR1 and IC1b to IC1d) amplifies the input from the piezo input device to the point where this is capable of clocking a divider.

The divider, in this case, divides the input frequency by 16. As an example, a 40kHz signal would be divided down to an audible 2.5kHz. This is then output to a loudspeaker and/or to an LED, as desired.

The Bat Sonar includes two innovations, without which it would be a far less capable circuit:

• Op amp oscillator IC1a resets divider IC2 at about 750Hz. This means that all frequencies below 12kHz (750Hz x 16) at the IC2 clock input will be trapped by the divider, not being fast enough to outpace the reset pulses. Since 12kHz is very high in the audio range, and since 12kHz *continuous* would be required for pulses to reach the output, natural sounds are all but completely excluded.

• One further innovation is required. Supposing that divider IC2 should be clocked between 12kHz and 24kHz. In this case, only a single divided-down pulse would exit the divider for every 16 to 32 pulses received at the clock input. That is, the sound output would be completely 'flat', where the input may vary considerably in frequency.

With this in mind, as soon as a pulse is detected at the output, a feedback circuit causes oscillator IC1a (the high-pass 'filter') to be momentarily disabled. Thus the circuit is capable of reproducing nuances of sound, e.g. an ultrasonic tremolo.

SPECIAL FEATURES

★ The circuit is exceedingly sensitive. As an example, with its high-pass 'filter' suitably adjusted, it will pick up the ultrasound created by hands (palm-prints) rubbing together at a distance of several metres.

★ It is extraordinarily flexible. It may use almost any piezo input device of one's choosing; whether a 40kHz ultrasonic receiver or a cheap piezo sounder. It also offers two audio outputs (loud and soft), and a visual output.

★ Filtering out of low frequencies is virtually total, so you can mount an output loudspeaker and a microphone on top of each other. Not only this, but the Bat Sonar will pick up ultrasound even where there is strong background noise, for example, a piano playing in the same room.

★ The one small disadvantage of this design is that the sound output is a square wave. Thus, the Bat Sonar has a harsher sound than some bat detectors, and a constant volume.

Circuit details

The full circuit diagram for the Bat Sonar is shown in Fig.2. The front end of the circuit is a simple, common emitter, transistor preamplifier (TR1). The base (b) of TR1 is biased through resistor R1. Transistor TR1 is a.c. coupled to a three-stage op amp preamplifier IC1b to IC1d, with the first stage being biased at the input through resistors R3 and R4. The gain of the first stage IC1b is adjusted through multiturn preset VR1. Typically, a mid-way setting will usually be found suitable.

The piezo input device (X1) may be any one of a range of devices: for example, a cheap piezo sounder; a 40kHz ultrasonic receiver; a small piezo cone tweeter; or a piezo speaker. The device which was found to perform best (better, in fact, than a 40kHz ultrasonic receiver) was a small piezo cone tweeter. This was found to work at up to about 60kHz. The least suitable devices are cheap piezo sounders, chiefly for the reason that they generate too much noise. They are capable of working up to about 40kHz.

The amplified signal at the output of preamplifier IC1b to IC1d then clocks divider IC2, a CMOS 12-stage ripple counter. The output (divided by 16) is taken from output Q4 (pin 5) of IC2.

Op amp relaxation oscillator IC1a sends short pulses to IC2's Reset pin 11, resetting IC2 at about 750Hz, and cancelling all input pulses below 12kHz – as described earlier. For this reason, no standard filters are included in the circuit – they are not required.

It needs to be borne in mind that in order for a 12kHz signal to exit the divider (IC2), this needs to be 12kHz *continuous*. This means that erratic ultrasound needs to be

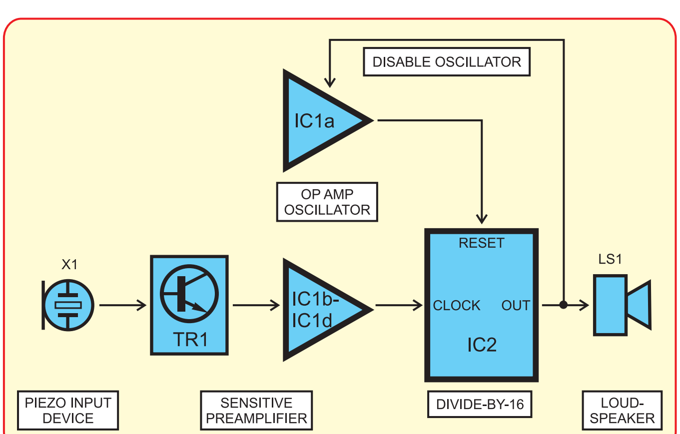
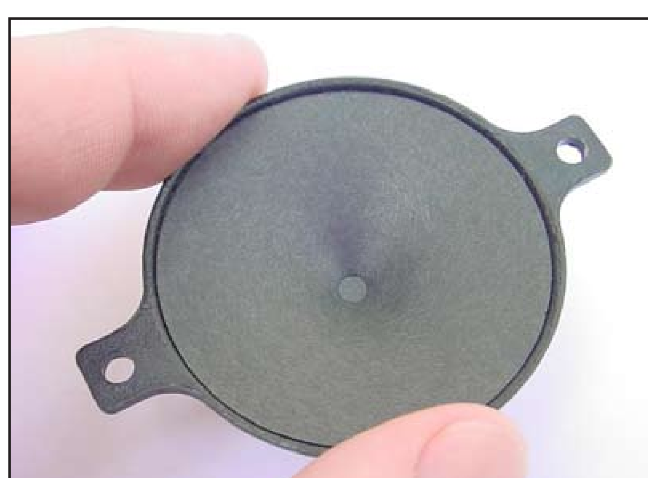


Fig.1. Basic block diagram for the Bat Sonar



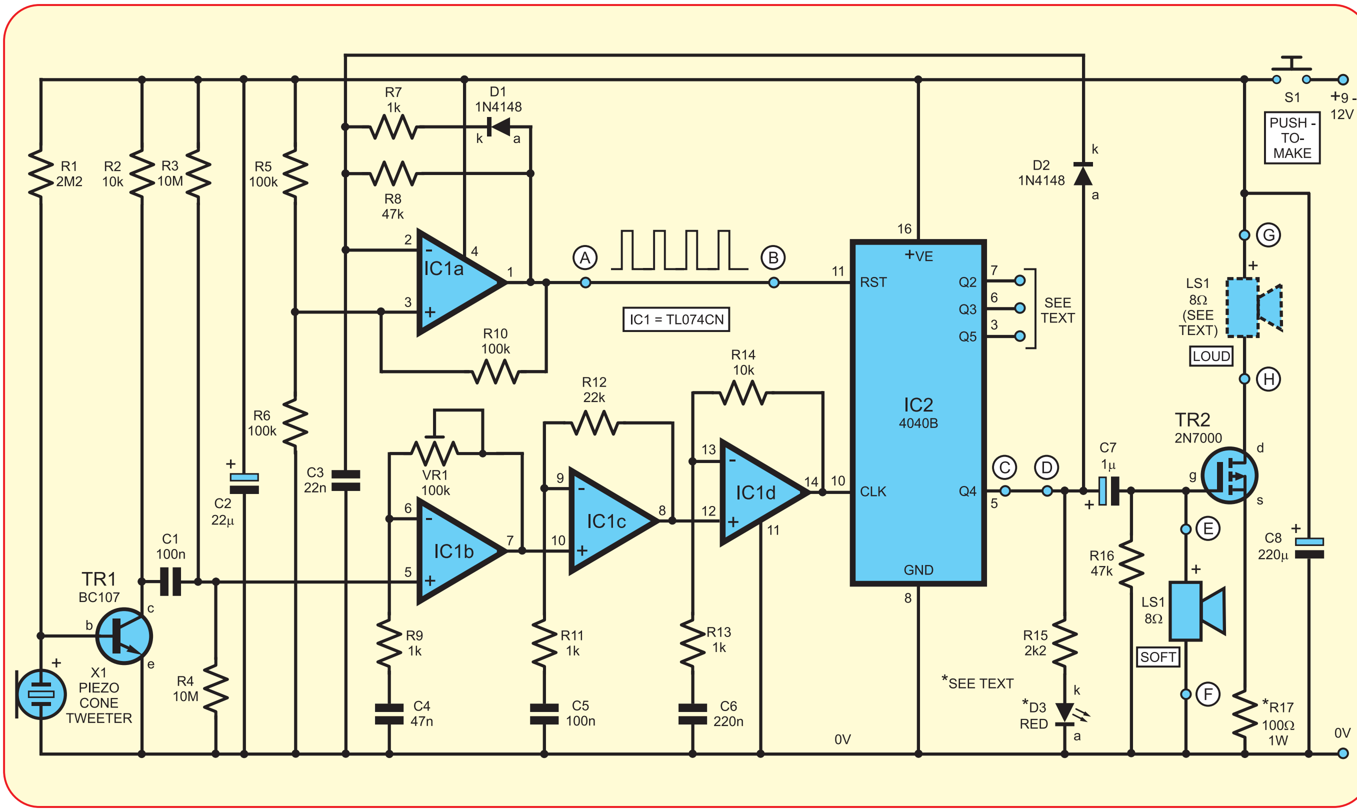


Fig.2. Complete circuit diagram for the Bat Sonar. The circled points on the circuit enable 'variations on a theme' to be undertaken as discussed in the text

somewhat higher than 12kHz to be detected. You can experiment with the frequency of oscillator IC1a by altering the values of resistor R8 and capacitor C3. A lower frequency (i.e. higher values for R8 and C3) would cause the circuit to hear near-ultrasound or random ultrasound, e.g. the crinkling of plastic.

Finally, IC2's output is taken to a small loudspeaker (LS1). There is effectively no feedback, so the speaker may be mounted close to the piezo input device. A loudspeaker *must* be used here, and not a piezo tweeter. LED D3 may be used with or without a loudspeaker, and provides a visual indication of ultrasound. This could be very useful if you should not wish to disturb animals or insects being listened to.

Two circuit options are provided for a loudspeaker. The output may be taken directly from points E and F, and this is recommended. Alternatively, it may be taken, much amplified by FET TR2, from points G and H. However, there may then be a slight loss of sensitivity to the circuit. This latter option is not only for the benefit of noise-freaks – it is also capable of switching a relay (see below).

Remote control

The circuit is very easily converted to a remote control system. Due to its complete elimination of lower frequencies, it could, for example, be used to open a garage door, without one needing to be concerned about the system being triggered by dogs barking or cars hooting etc.

In this case, resistor R17 is replaced with a link wire, and the dashed speaker LS1 with a relay. The relay coil being connected between points G and H on the circuit. An electrolytic capacitor is wired across points E and F, observing the correct polarity – and the value of resistor R16 is raised to perhaps 1MΩ. Capacitor C7 is replaced with a 1N4148 diode, with its cathode (k) pointing to TR2's gate (g).

In this way, R16 and the added capacitor serve as a simple timer. The timing period will be a little less than $t = CR$. For example, a 1MΩ value for R16 and 100µF for the added capacitor would switch the relay for more than a minute. The relay should have a coil resistance greater than 60 ohms.

An ultrasonic oscillator (the transmitter) is, of course, required to trigger such a circuit. This may be virtually any simple oscillator tuned to an ultrasonic frequency, using a suitable output device, e.g. a piezo tweeter. Datasheets for the 555 timer or the CMOS 4047B multivibrator include such simple circuits, as well as the equations to calculate the output frequency.

Note that the Bat Sonar may not only be used as a remote control, but with simple modifications to the input, it may be used to switch when, for example, machinery runs too fast or too slow.

Sonar system

The Bat Sonar may be converted to a sonar system with remarkable ease (see Fig.3.). This is accomplished by simply inserting the add-on circuit of Fig.3 between points A and B (IC1a pin1 and IC2 pin11) of the main circuit (Fig.2.).

This switches an ultrasonic oscillator, then waits several milliseconds before opening up a 'window' to listen for the return stream of ultrasound. If the distance to the object being detected is correct, the ultrasound will enter the 'window' and the circuit will trigger. The remote control circuit described above may be used to switch a relay.

Note that this is not a silent circuit. In theory, it would seem to be – however, the switching of the ultrasonic transmitter causes the output device to emit sound at the frequency at which it is switched. Alternatively (see below) it may emit a click every time it is strobed.

While the author successfully tested the circuit shown in Fig. 3, when tried in his workroom, it was found that the ultrasound may bounce all around the room. Ideally, the sonar would be used to detect objects blocking a clear path, e.g. boats on the water, or cars on the road. The author would suggest setting up the circuit on a clear surface with a single wall in front of one, e.g. a wall on a tennis court.

One may further need to adjust the sensitivity of the circuit, calculate the required period of bounce, and balance the frequency of ultrasonic transmission against the number of return pulses required to trigger the circuit.

At any rate, as a start, you can easily wire up the circuit shown, and go from there. Suitable holes are provided on the printed circuit board (PCB) to make this 'a snap'. It is suggested that, instead of taking the output from IC2 ouput Q4 as shown in Fig. 2, this should be taken from output Q3 (Q2 and Q5 are also provided for experimentation). Output Q3 requires only eight pulses at IC2's clock input instead of sixteen, thus making reception of the return pulse less tricky. Note that the circuit board link between points A and B is omitted when IC3 is inserted into the circuit.

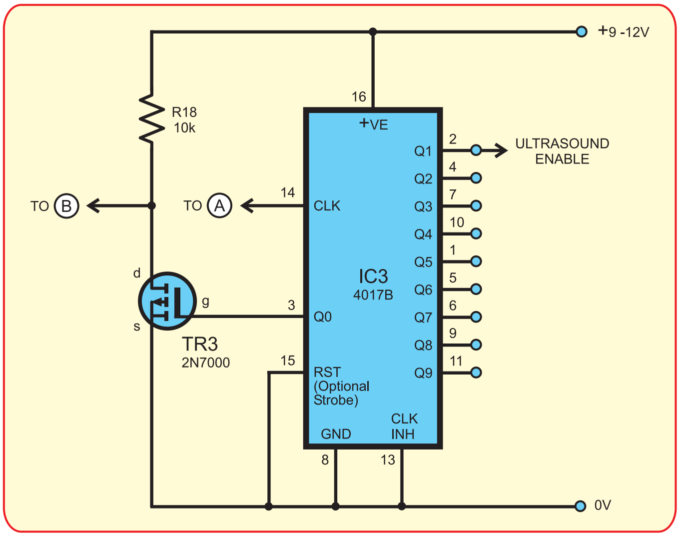


Fig.3. Add-on circuit for converting to a sound sonar system

IC3 output 1 (pin 2) enables an ultrasonic oscillator. A standard 555 astable oscillator would suffice for a few metres' range, with its Reset (pin 4) being used to enable the oscillator. It is suggested that the ultrasonic oscillator should have a separate power supply, with the 0V rail of both circuits being commoned.

There is almost no limit to the power of the ultrasonic oscillator. For instance, a power amplifier wired as a relaxation oscillator, together with a piezo speaker, could achieve a considerable range – as much as tens of metres.

At present, if (as suggested) IC3 is switched at about 750Hz, and IC3 cycles through nine stages before opening up a 'window' to receive the return stream, one has a delay of 12ms between transmission and reception. Since sound travels at about 330 metres per second, this is about four metres return, or two metres to the target. The calculation is 330 metres per second / 750Hz × 9 stages = 3.96 metres return.

The frequency of oscillator IC1a may be lowered to extend the range of the sonar system, and different output pins (Q2 to Q5) may be tried to widen or narrow the 'window' which receives return pulses.

If the frequency of IC1a is halved, and IC2 output Q4 (pin 5) is used, this should be suitable for a range of 8m return – assuming that the ultrasonic oscillator (the transmitter) has sufficient volume. For 16 metres return, the frequency of IC1a would be halved again, and output Q5 (pin 3) may be tried.

Needless to say, the frequency of the ultrasonic oscillator will also come

Parts List – Bat Sonar

1 PC board, code 621, available from the *EPE PCB Service*, size 90mm x 42mm
1 plastic case, size and type to individual choice
1 piezoelectric input device (preferably a small cone tweeter – see text) (X1)
1 100kΩ cermet preset – top adjust (VR1)
1 miniature loudspeaker – see text (LS1)
1 pushbutton switch, push-to-make (S1)
1 9V or 12V battery, with clips (see text)
1 14-pin DIL socket (IC1)
1 16-pin DIL socket (IC2)

Solder pins (8 off); plastic covered, single-core link wire; multistrand connecting wire; solder etc.

Semiconductors
2 1N4148 signal diodes (D1, D2)
1 5mm or 3mm red ultra-bright LED (D3)
1 BC107B *npn* transistor (TR1)
1 2N7000 *n*-channel FET (TR2)
1 TL074CN quad FET op amp (IC1)
1 4040B CMOS 12-stage ripple counter (IC2)
1 4017B decade counter (optional, see Fig.3.) (IC3)
1 2N700 *n*-channel FET (optional, see Fig.3.) (TR3)

Capacitors
1 22nF polyester or ceramic (C3)
1 47nF polyester or ceramic (C4)
2 100nF polyester or ceramic (C1, C5)
1 220nF polyester or ceramic (C6)
1 1μF radial elect. 16V (C7)
1 22μF radial elect. 16V (C2)
1 220μF radial elect. 16V (C8)

Resistors (0.25W 5% carbon, except R17)
2 10MΩ (R3, R4)
1 2M2 (R1)
3 100kΩ (R5, R6, R10)
2 47kΩ (R8, R16)
1 22kΩ (R12)
2 10kΩ (R2, R14)
1 2k2 (R15)
4 1kΩ (R7, R9, R11, R13)
1 100Ω 1W (or >68Ω – see text) (R17)
1 10kΩ (optional, see Fig.3.) (R18)

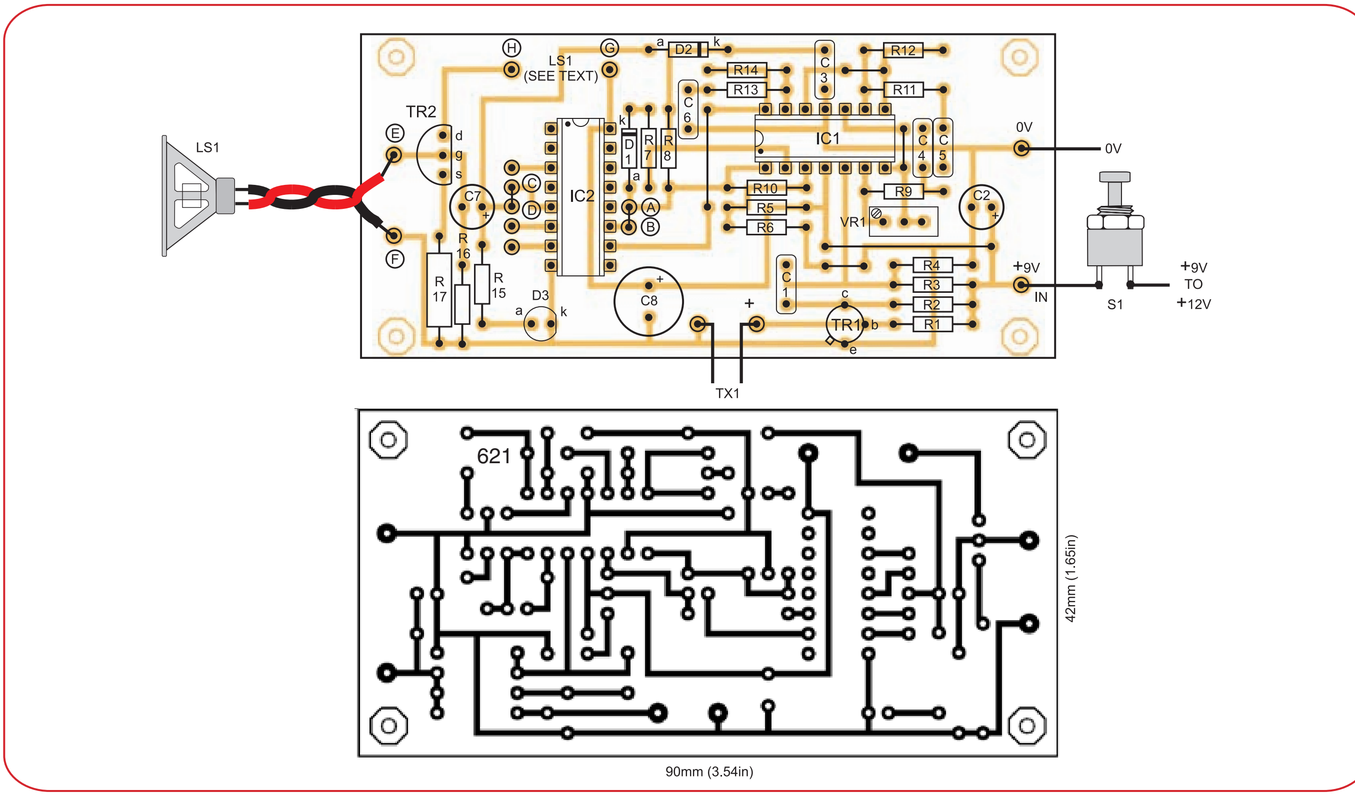


Fig.4. Bat Sonar printed circuit board component layout, wiring details and full-size underside copper foil master

into play. The lower its frequency, the fewer pulses there are to clock IC2. A signal of around 15kHz was used in the author's experiments.

In this form, as described, the Bat Sonar may be a noisy animal, emitting a 750Hz drone as it pulses the ultrasonic transmitter. There is a possibility for greatly improving this by strobing IC3 at reset pin 15. This being the case, the circuit would only send out a pulse as often as required. For instance, it could send out a click (a stream of ultrasound) only once every so many seconds – bearing in mind that its response to moving objects may no longer be immediate.

Construction

The printed circuit board (PCB) measures 90mm x 42mm (3.50in x 1.66in) and is available from the *EPE PCB Service*, code 621. Since IC2 is a CMOS device, dual-in-line (DIL) sockets are used, and anti-static precautions are advised for IC2 (in particular, discharge your body to earth before handling this IC).

It needs to be noted that IC1 is used here as a sensitive preamplifier, therefore any *unsound* solder joints may disrupt its operation far more easily than would normally be the case. Any trouble-shooting should put this possibility high on the list.

Referring to Fig. 4, begin construction by soldering in position the six link wires. Solder the eight solder pins, and the two DIL sockets – observing the correct orientation of the sockets. Continue with the resistors and capacitors – noting the polarity of the electrolytic capacitors – and preset VR1. Note that VR1 may be replaced with a 100kΩ, front panel mounting, rotary potentiometer if desired, with a little loss of precision.

Solder in position diodes D1, D2, LED D3 and transistors TR1 and TR2, noting their polarities. Finally, solder the battery clip to its solder pins, inserting a push-to-make pushbutton switch in the positive wire as shown – being careful again to observe correct battery polarity. A mistake here could destroy the circuit. Solder the piezo pickup device X1 to its solder pins (polarity is not crucial here), and if desired, a loudspeaker either to solder pins E and F, or G and H (again, polarity is not crucial).

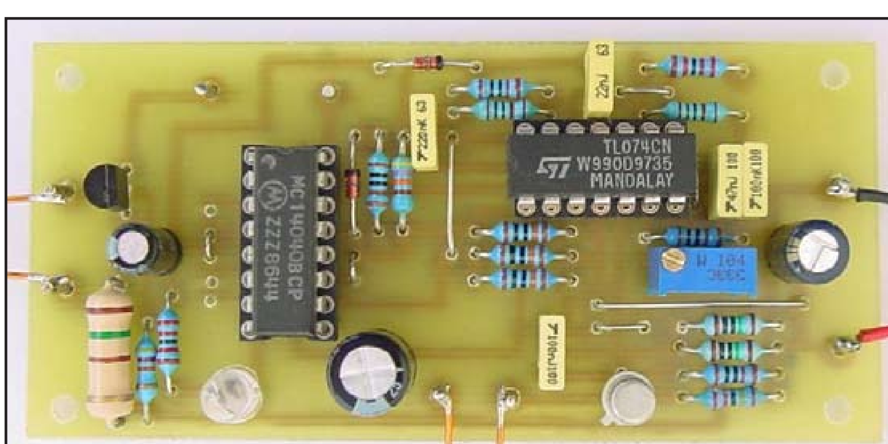


Fig.4. Components mounted on the completed 'bat board'

Bats found in Britain and Ireland

Bat type	Abundance	Region	Wingspan (cm)	Body (cm)
GREATER HORSESHOE	Scarce	SW England	34	6.4
LESSER HORSESHOE	Common	Wales, SW England, W. Eire	25	4
PIPISTRELLE	Abundant & Widespread	All Eng, Scotland, Wales, Eire & NI	22	3.5
NOCTULE	Common	All Eng (except for north). All Wales	36	7.5
LEISLERS	Rare	Central England	30	3.5
SEROTINE	Common	S & E England up to Midlands	36	6.4
COMMON LONG-EARED	Abundant & Widespread	All Eng, Wales & Scot (Except northern areas). All Eire & NI	25	4.5
NATTERER'S	Common	All Eng & Wales, SW Scot. All Eire & NI	28	4.5
BARBASTRELLE	Uncommon	SE & mid England, S Wales	27	4.5
MOUSE-EARED	Rare (Extinct?)	Sussex, Dorset	40	7
BECHSTEIN'S	Very rare	Dorset	28	4.5
WHISKERED	Common	All Eng, Wales, S. Scot	24	4
DAUBENTON'S	Widespread	All Eng, Wales. Most Scot, Eire-except SW	25	4.5

Note that some ultra-bright LEDs may confuse as to their polarity. The most reliable indicator is the 'flat' on the side of the plastic encapsulation, which is on the side of the cathode (k) pin.

Insert IC1 and IC2 in their DIL sockets, ensuring that they are inserted the right way round – again observing anti-static precautions for IC2.

In use

Press pushbutton S1 to turn on the circuit. Red LED D3 may or may not illuminate. If it does not illuminate, turn preset VR1 clockwise – alternatively, turn VR1 anti-clockwise.

Adjust multiturn preset VR1 until there is only intermittent pulsing of LED D3, or intermittent crackling in the loudspeaker. At this point, the circuit is set to its maximum sensitivity. Such sensitivity may, however, not be required or even desirable – for example, if the Bat Sonar should be used as a remote control system.

The sensitivity of the circuit can drift a little as battery power wanes. Therefore, to use the circuit continuously at maximum sensitivity, you might wish to drill a hole in the case for the adjustment of multiturn preset VR1 – or use a potentiometer mounted on the case. *EPE*

The Power of Mechatronics

Part One – Mechatronics Design

IN this, the first of a series of articles on mechatronic design, we look at how mechatronics can add a whole new level of control and intelligence to your projects. Each article in the series will explore a different mechatronics project, including motor control with PIC16/18 microcontrollers, migration to 16-bit microcontrollers or Microchip dsPIC digital signal controllers, virtual simulation using Proteus VSM, wireless connectivity and how to make your application talk back.

These projects, and more, are based on Microchip's PICDEM Mechatronics Development Board. This easy-to-use board helps you to explore this emerging technology and is available from ACAL Semiconductors with an exclusive discount of 20% for all *EPE* readers.

The basics of mechatronics

Mechatronics has been defined in many different ways over the years. Definitions include:

- "Incorporating electronics more and more into mechanisms,"
- "The integration of mechanical engineering with electronics and intelligent computer control in the design," and
- "The application of complex decision making to the operation of physical systems."

In essence, mechatronics is adding intelligence to a mechanical design or replacing mechanical designs with an intelligent electronic solution. As technology advances, designs that were once purely mechanical are now best done with electronics or a combination of both.

There are many benefits to a mechatronics solution. These benefits include:

1) Enhanced features and functionality
2) More user-friendly
3) Precision control
4) More efficient
5) Lower cost
6) Flexible design (reprogrammable)
7) More reliable
8) Smaller
9) Safer

More features

Incorporating a PIC microcontroller into a design allows for expanded features and functionality. A mechanical design typically provides only one function. Designing with a microcontroller offers the flexibility of adding features like LCD displays, lighting LEDs, a user interface, programmability, safety features, speed control, soft-startup . . . the list goes on and on.

Modern washing machines, for instance, offer many features over the mechanical designs of old. These features include a display that gives cycle information as well as providing a stain removal guide. These machines use microcontrollers to more effectively (and efficiently) vary the speed of different cycles based on the content being washed.

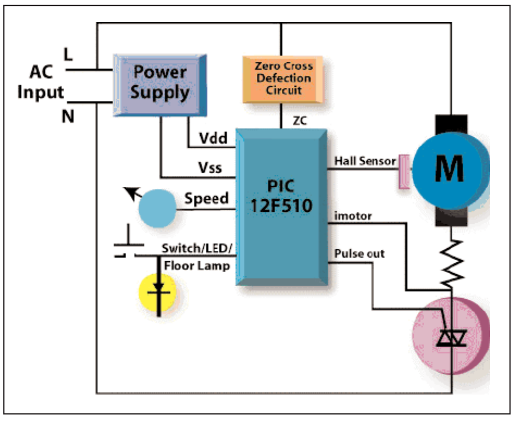


Fig.1. Pulse Width Modulation (PWM)

User-friendly

Mechatronics solutions also appeal to consumers because they are more user-friendly. The improvement in automotive technology over the past decades is evidence of this fact. Power windows, power door locks, keyless entry, and numerous other conveniences testify to the fact that consumers prefer mechatronic solutions.

Precision control

Flow rate, speed, position and any number of other variables can be controlled precisely with a microcontroller. In many applications, purely mechanical solutions are not as efficient, nor as precise as mechatronic solutions. Cruise control in an automobile is a great example of how a mechatronic solution allows for precise control.

A microcontroller-based solution will factor in many different variables (ie velocity, acceleration, cumulative changes in velocity) in order to give the car a smooth acceleration to the desired speed, as well as maintaining a constant velocity over varying load conditions.

More efficient

The efficiency of a system can be improved by adding intelligence to the design. Certain portions of the system can be shut-off when not in use or a microcontroller can make better use of the energy available by offering the precision control described previously. Techniques such as pulse width modulation (PWM) can be used instead of resistive elements to vary the voltage and current to a load, thereby increasing the efficiency of the system.

Lower cost

In some cases, a mechatronic solution costs less than the alternative mechanical solution. A complex mechanical solution may be simplified using a microcontroller-based approach. Design time, product size, and reliability can all be improved with a mechatronic solution. All these factors impact the cost over the lifetime of a product.

Flexible design

Design flexibility is a huge advantage to designing with a microcontroller. The specifications of a product can change during the course of its design. When a PIC microcontroller is used, the timing of a signal, the sequence of events, or any number of software controlled parameters can be changed quickly without the need for a product redesign. This flexibility also allows the same hardware to be used in different products. The software is simply changed to meet the needs of each product.

Increased reliability

Mechanical designs are prone to wear and tear over time. In many situations a mechatronic solution is more reliable. A good example of this is the odometer in your car. Mechanical odometers use a direct drive system that consists of a flexible cable running from the transmission to the odometer gauge. The solution is unreliable because the cable is prone to failure. The modern mechatronic solution consists of a slotted wheel and optical encoder or toothed wheel and magnetic pickup and a digital display, which increases system reliability.

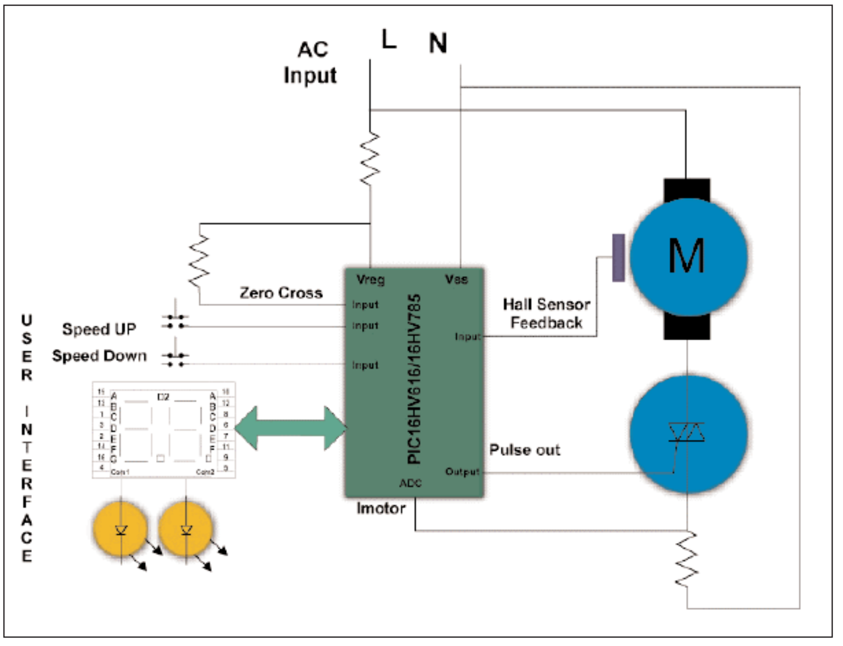


Fig.2. Design flexibility of a microcontroller

Smaller size

Adding a microcontroller to a system may result in space savings. Motor drive circuits, for instance, traditionally had to have over-sized drive stages to handle in-rush current. In-rush current can be limited and the size of the drive stage can be reduced by implementing soft-startup using a microcontroller.

Safer

Adding intelligence to a system makes it safer. Whether you add an automatic shutdown to a coffee pot or sense when a system is over-heating, numerous safety checks can be easily added to a system when a microcontroller is controlling the system.

Mechatronics as a system

A mechatronics design is a control system. One or more inputs are fed to a microcontroller. These inputs may have to undergo some signal conditioning before being read by the microcontroller. The microcontroller then implements a control algorithm that interprets the various inputs into the appropriate output or outputs. Again, signal conditioning may be necessary on the output side of the system before driving an actuator or display.

In a closed-loop system, feedback is received so that the microcontroller is able to monitor and adjust the output as necessary. Providing power to the microcontroller is the last piece of the mechatronic system. In summary, the components of a mechatronic system are input, output, a control algorithm, signal conditioning (if necessary), and power.

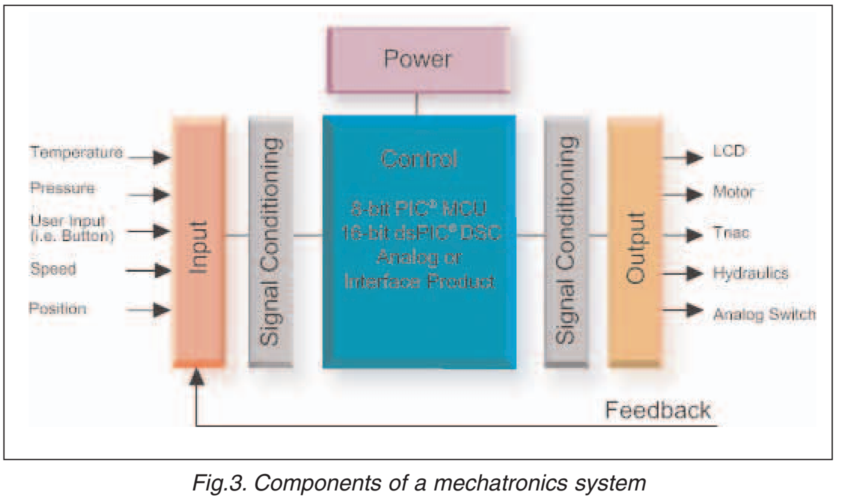


Fig.3. Components of a mechatronics system

Application notes

Good examples of Mechatronic applications are described in two of the many Microchip applications notes. These are:

AN958 Low-Cost Electric Range Control Using a Triac
www.microchip.com/stellent/idcplg?IdcService=SS_GET_PAGE&nodeId=1824&appnote=en021266

AN861 Smart Air Handler using ProMPT™ and the PIC18F2539
www.microchip.com/stellent/idcplg?IdcService=SS_GET_PAGE&nodeId=1824&appnote=en012062

Exclusive development board offer

The Microchip PICDEM Mechatronics Development Board not only supports all of the projects featured in this series of articles but also includes nine example projects, each complete with source code:

- Switch debouncing and lighting an LED
- How to read an analogue sensor
- Brushed DC motor speed control

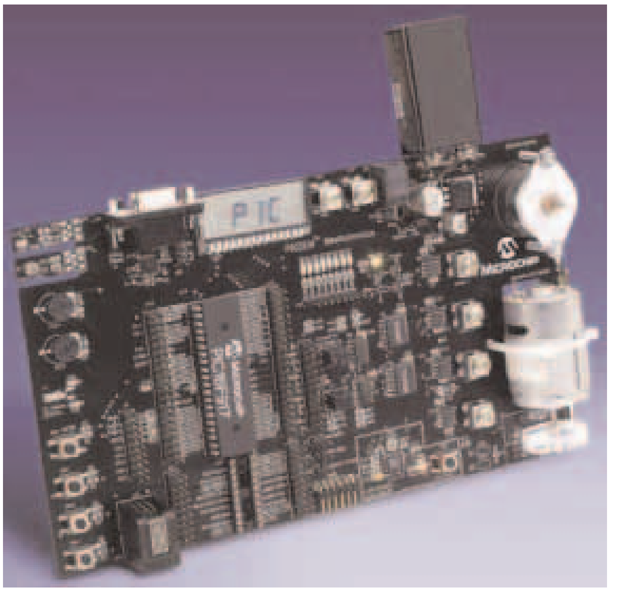


Fig.4. The Microchip Mechatronics Development Board

- Speed feedback
- Stepper motor control
- How to use the USART for RS-232 communication
- How to use the Capture, Compare and PWM module
- How to use comparators

To claim your exclusive *EPE* 20% discount on the Microchip PICDEM Mechatronics Development Board contact ACAL Semiconductors on Telephone: +44 (0)118 902 9702. Fax: +44 (0)118 902 9614. Email: sales@acalsemis.co.uk. Website: **www.acalsemis.co.uk**

References:

1.*The Mechatronics Handbook*, Bishop, Robert
www.microchip.com/mechatronics

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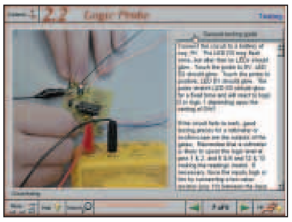
ELECTRONICS CD-ROMS

ELECTRONICS PROJECTS

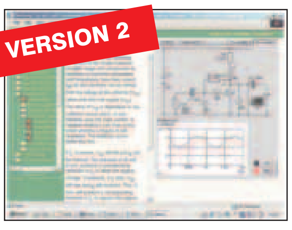


Logic Probe testing

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

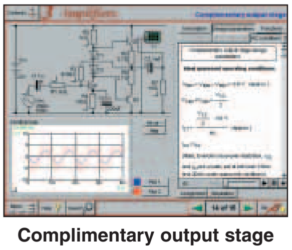
VERSION 2



Circuit simulation screen

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

ANALOGUE ELECTRONICS

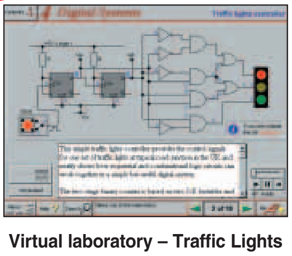


Complimentary output stage

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

DIGITAL ELECTRONICS V2.0

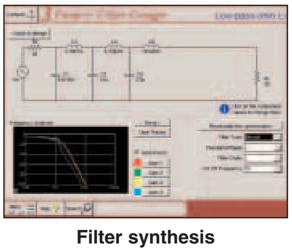
VERSION 2



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.

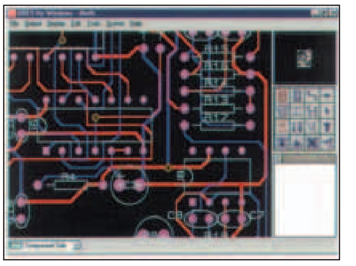
ANALOGUE FILTERS



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

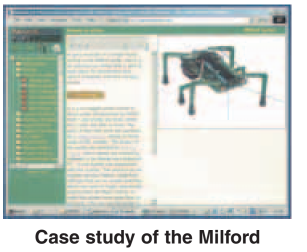
ELECTRONICS CAD PACK



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
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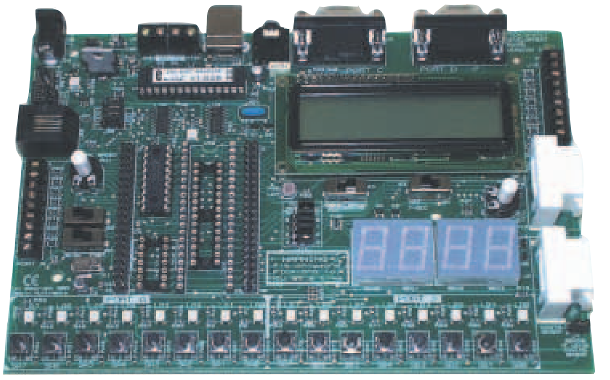

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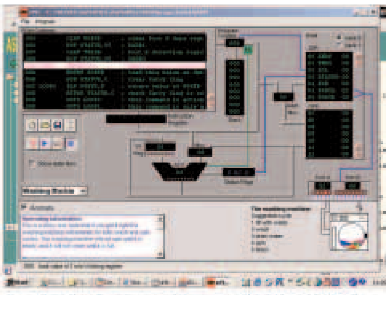

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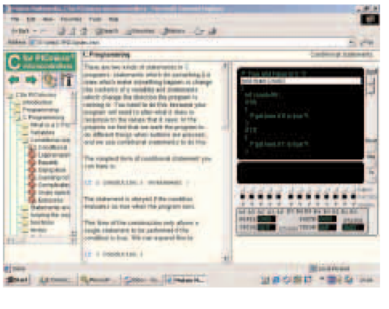

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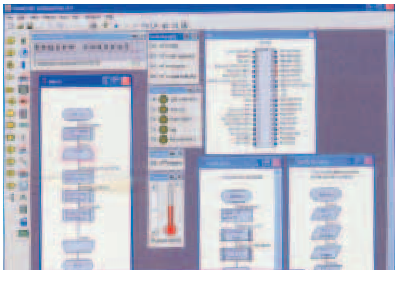

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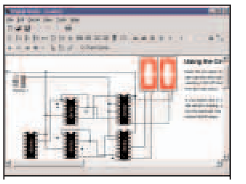

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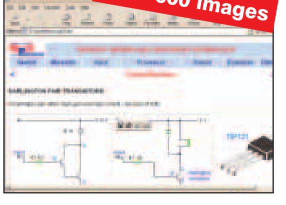

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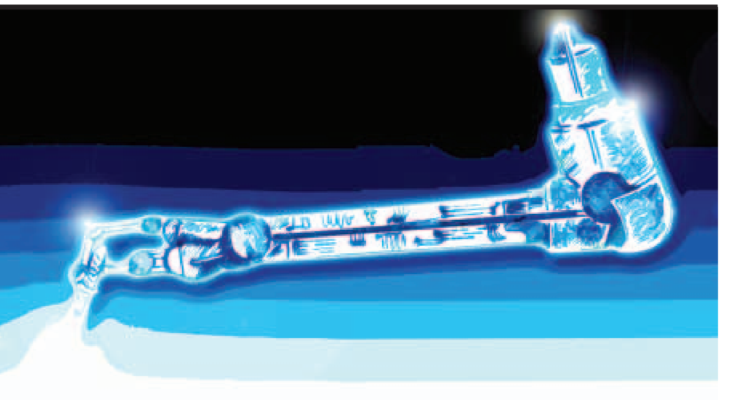


Ian Bell

Step-up Converters Using Transformers

A WHILE ago on the *EPE Chatzone* (via **www.epemag.co.uk**), user ***Poriet*** mentioned using a Royer converter for producing 200V to 400V DC from a 12V DC supply. Poriet asked about the most appropriate frequency to use for step-up converters using transformers. We will look at the Royer circuit first and then discuss a few general points about power converters.

Royer converters

The Royer converter is a classic power converter circuit first described by G.H. Royer in 1954, and is shown in its basic form in Fig.1. These days the most common use of Royer converters is probably for generating the high voltages needed for display backlighting (using CCFLs – Cold Cathode Florescent Lamps).

The Royer circuit is self-oscillating, with feedback provided from a transformer winding. The oscillation is square wave in nature rather than sinusoidal because the transformer is driven into saturation (an appropriate transformer must be used to achieve efficient operation). The resistor network provides bias and ensures that the circuit starts oscillating when power is applied.

The transistors switch on and off out of phase with one-another, with a duty cycle of 50%. The voltage induced in the secondary winding depends on V_{in} and the transformer turns ratio. Appropriate transistors should be used and they must have high gain (h_{FE}), low $V_{CE(sat)}$, low on-resistance ($R_{CE(sat)}$) and high collector-base breakdown voltage. Transistors specifically designed for high current switching applications should be used.

Royer circuit

In Fig.2 is shown a modified Royer converter based on a circuit from a design note from Zetex, who make transistors such as the ZTX650, ZTX849 and ZTX449, which are suitable for use in these circuits. The circuit is a slight modification of that in Fig.1, which does not need a centre-tapped feedback winding.

The Zetex circuit uses two ZTX449 transistors, two 560Ω resistors and two ceramic 0.1µF decoupling capacitors, together with a toroidal transformer with windings W1 and W2 (primary) each having 10 turns, W3 (feedback) having four turns, and W4 (secondary) having 28 turns. The output is 12V at 2W from a 5V supply at 77% efficiency and has an operating frequency of over 80kHz. Increasing the input voltage or the number of secondary windings will give a higher output voltage (adjust resistors and capacitors to suit). Other Zetex switching transistors (or equivalent) may be used in more demanding versions of the circuit.

The Royer circuit is often used in conjunction with a controller. A simple circuit of this type is shown in Fig.3. The controller (typically a specialist IC) drives a Buck switchmode power supply circuit (Q3, L1, D1, C2) which regulates the input to the Royer circuit. The controller may use a feedback signal from the output of the Royer converter (in the case of a CCFL supply this would be the lamp current).

A number of ICs have been produced which can control Royer converters, particularly from Linear Technology (**www.linear.com**). These include the LT1172, LT1182, LT1186, LT1372 and LT1697, and are typically aimed at CCFL power supplies.

Waveforms

Although use of sinewaves is not necessary, there are Royer-based step-up converters that use sinusoidal oscillation. Use of sinewaves cuts the level of harmonics of the basic switching frequency, which can be responsible for radio frequency noise and interference. Fig.4 shows a modified Royer circuit in which sinusoidal operation occurs due to the presence of inductor L1 and capacitor C1. We have not shown the

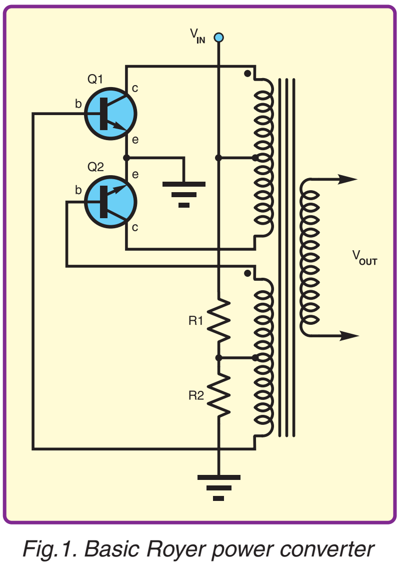


Fig.1. Basic Royer power converter

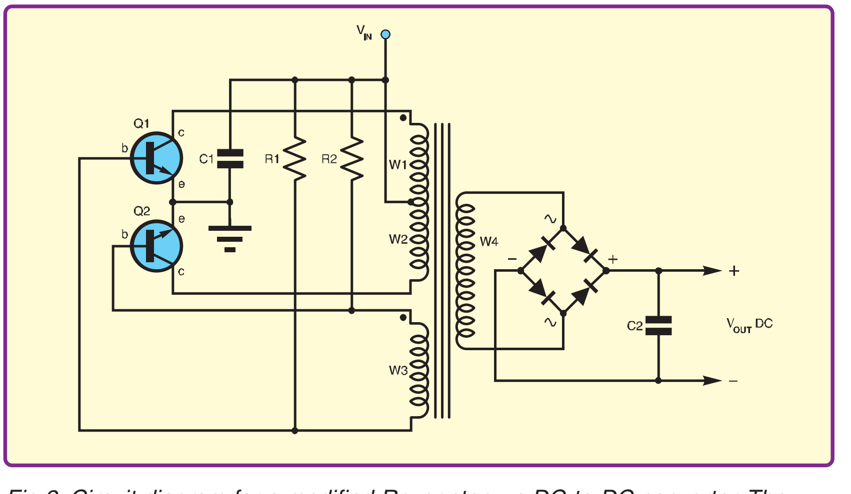


Fig.2. Circuit diagram for a modified Royer step-up DC-to-DC converter. The circuit is a slight modification of Fig.1 in that it does not need a centre-tap in the feedback winding

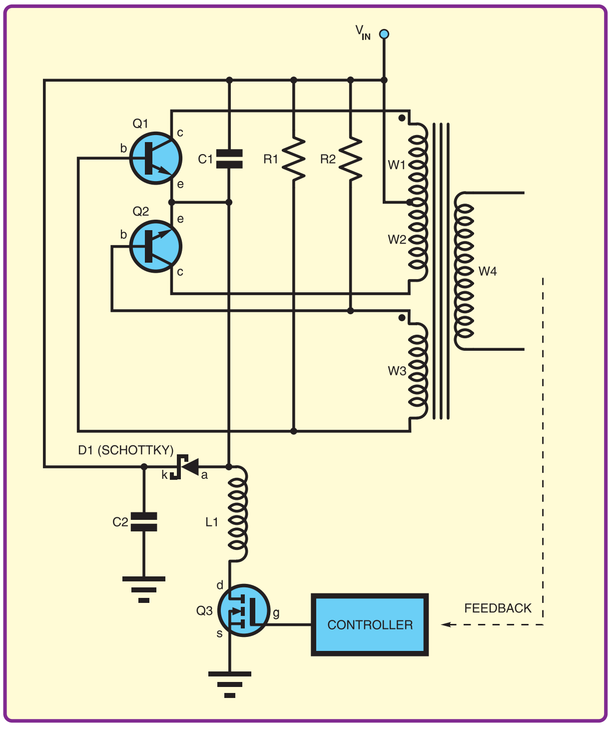


Fig.3. Circuit diagram of a Royer converter with controller

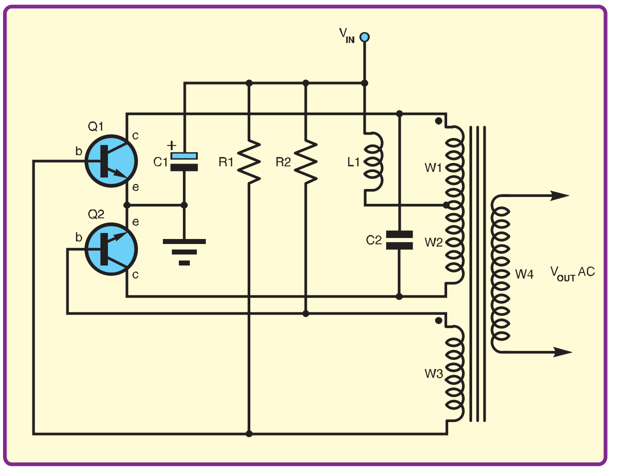


Fig.4. Version of Royer circuit with sinusoidal operation

Fig.5. Transformer suitable for use with Royer converter circuit

rectifier and smoothing capacitor in Fig.4 in order to save space.

The transformer provides the voltage step-up in accordance with its turns ratio and must be driven by a varying voltage (only AC signals are coupled to the secondary of transformer). In mains power supplies the input to the transformer primary is a 50Hz or 60Hz sinewave.

For DC-to-DC converters, neither a sinewave nor a frequency as low as this has to be used. Higher frequencies enable smaller transformers to be used, and if above audio frequencies will give silent operation.

Pulsed inputs to the transformer (or other inductor) are commonly used in switching power supplies, as they are relatively easy-to-generate using control logic. This logic often uses pulse modulation (switching pulses on or off, or modifying their length) to control the output voltage as the load varies.

Transformer sources

One company making suitable transformers for Royer converters is Coiltronics (a brand of Cooper Bussmann). Coiltronics produce a range of these transformers using ferrite core material (see Fig.5). The transformers can supply output current up to 30mA and operate at frequencies in the range from 40kHz to 80kHz. They can deliver output power from 2.5W to 14W.

The maximum continuous primary voltage ranges from about 10V to 25V RMS and the maximum secondary voltage is 1340V RMS. The transformers have a small physical size and are available both in through-hole and surface mount versions. Small size is important in the CCFL application for which these transformers are targeted because they are often used in portable products.

For data on the Coiltronics transformers use the CCFL/ link on web page **www.cooperet.com/3/CooperCoiltronicsDataSheetList.html**.

Efficiency and regulation

Efficiency is often a key parameter in power conversion. Power is given by voltage × current, so if a power converter is 100% efficient we get $P_{in} = V_{in} \times I_{In} = P_{out} = V_{out} \times I_{out}$. If the converter is less than 100% efficient then P_{out} will be less than P_{in} by the efficiency factor.

In this application we need high efficiency so that the battery is not drained too quickly. The ideal $V_{in}I_{In} = V_{out}I_{out}$ also shows us that if we increase the voltage ($V_{out} > V_{in}$), then the current available at the output will be proportionally less then I_{in}.

So for example, with a perfect converter 5mA at 48V would draw 27mA from a 9V input. A real converter would take more current, this should be borne in mind when considering battery life.

Another important general power supply specification is regulation; in fact there are two factors to consider here – line regulation and load regulation. Line regulation indicates how much the output voltage changes as the input voltage changes and is calculated using:

Line Regulation =

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

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

Load Regulation =

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

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

PLEASE TAKE NOTE

Caravan Lights Check
(May '07)

Page 29, Fig.1. Please note that the type number shown on the circuit diagram for dual op amp IC2 is incorrect. It should be a type **LM358**. The parts listing is correct.

A Poor Man's Q-Meter

By Maurie Findlay, MIEAust

This simple unit is made from a few inexpensive components and allows you to make measurements which usually require an expensive Q-meter. In conjunction with a signal generator and an electronic voltmeter, inductance and 'Q' can be measured quite accurately.

EXPERIMENTERS and even professionals setting up a test bench have to think hard before buying test instruments.

Depending on the special interest, items such as a multimeter, regulated power supply, counter, oscilloscope, RF and AF signal generators would come high on the list.

Money can be saved by building test gear described in *EPE* over the years. Sometimes out-of-date equipment from schools and government departments can be overhauled and brought into service. But for most people, the purchase of a Q-meter would probably be pretty low on the priority list.

There are at least two reasons for this. Inexpensive hand-held bridges can measure inductance reasonably accurately, provided the values are not too small (say below 10μH). Second, the selective components used in modern equipment usually come in block form such as ceramic, crystal or mechanical filters with the characteristics specified by the manufacturer.

No longer does the designer have to specify the inductance and Q of a whole series of coils to make up a filter for, say, the intermediate frequency (IF) section of a receiver.

On the other hand, inductances to a fraction of a μH are used in the signal frequency circuits of both transmitters and receivers for filters, tuning, coupling and decoupling circuits.

Inductors used for coupling between tuned circuits and to active devices are usually quite critical but they are not adjustable.

So this discussion is about a simple test jig which, when used in conjunction with a signal generator and an electronic voltmeter, allows the inductance and Q of small coils to be measured accurately by resonance with a known value capacitor.

It comes into its own when dealing with inductors below about 10µH. It can easily be adapted to measure a range of inductance by altering the value of the capacitor.

Most readers will regard this as an ideas article rather than a constructional project to be copied component for component. The model illustrated is just one of many ways the basic idea can be used.

Now let's get down to the principles and then the practice.

When an inductor is placed in parallel with a capacitor to form a tuned circuit, the resonant frequency is given by:

$$f = \frac{1}{2\pi\sqrt{LC}}$$

where f, L and C are in the basic units of Hertz, Henries and Farads.

If we know f and C, the equation can be rearranged to give the value of L in microhenries (µH) when C is in picofarads (pF) and the frequency in megahertz (MHz). C is known and fixed. We vary the frequency and calculate L.

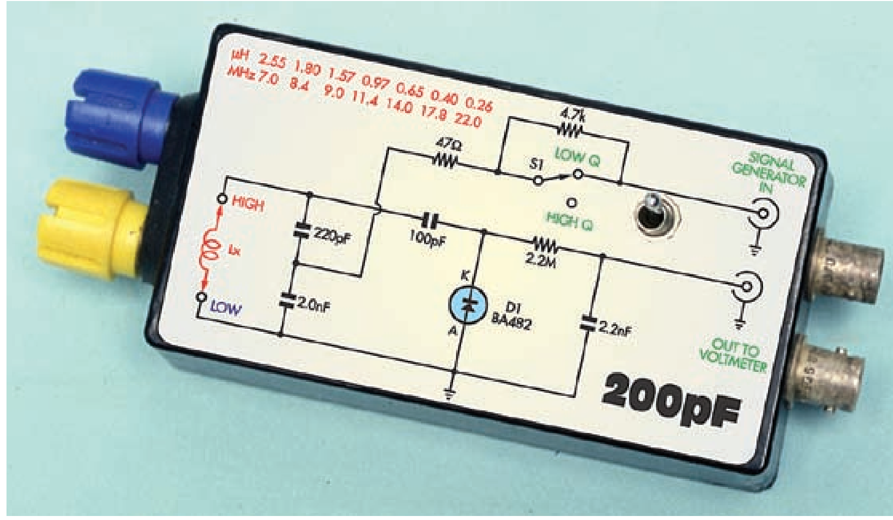
This can be done from the formula, or more conveniently from a graph plotting inductance against frequency. For convenience, we present graphs for C = 50pF, 200pF and 500pF (see Fig.2).

C is the value of the capacitor which effectively appears between the 'HIGH' and 'LOW' terminals of the test jig (see Fig.1) and is made up of two capacitors in series, the one connecting to the LOW terminal being about 10 times the value of the capacitor connecting to the HIGH terminal.

Accuracy of the readings depends on the accuracy of the latter.

Mica and polystyrene capacitors can be obtained with a 1% tolerance, but these days you won't find such items on many component suppliers shelves.

In general terms, ceramic capacitors are not suitable for this job. This capacitor is the only critical component required for the project.



With less than a dozen components, a digital multimeter and practically any RF signal generator, you can measure Q and inductance very easily. The old-style point-to-point wiring is housed in a shielded metal box.

We have found capacitors with 1% tolerance in ex-military equipment. Alternatively, you may have to ask a favour of a friend with access to laboratory test equipment.

It is unlikely that you will be able to get the values of C required with a single capacitor and so various combinations of serial and parallel may be needed.

The value of two capacitors in series is calculated by multiplying the two values and dividing this figure by the sum of the two values (remember resistors in parallel?).

For 220pF in series with 2000pF this works out to be 198.2pF. Not bad but you can always select a nominal 2000pF capacitor which is a little on the high side.

For most purposes, the reading from the graph will be accurate enough. If you need greater accuracy, calculate the value of inductance from the formula.

For measurements to be made, it is necessary to excite the tuned circuit formed by the fixed C and the unknown L and measure its response.

To do this, some of the RF energy must be fed into this tuned circuit. It is not possible to do this without having some effect on both the frequency and the losses of the tuned circuit. In practice, the errors are acceptable provided the frequency and natural Q of the tuned circuit are not too high.

Some expensive commercial Q-meters go to a great deal of trouble to reduce errors. With the simple techniques used here, the accuracy is acceptable for most purposes up to about 300MHz and a Q of 200.

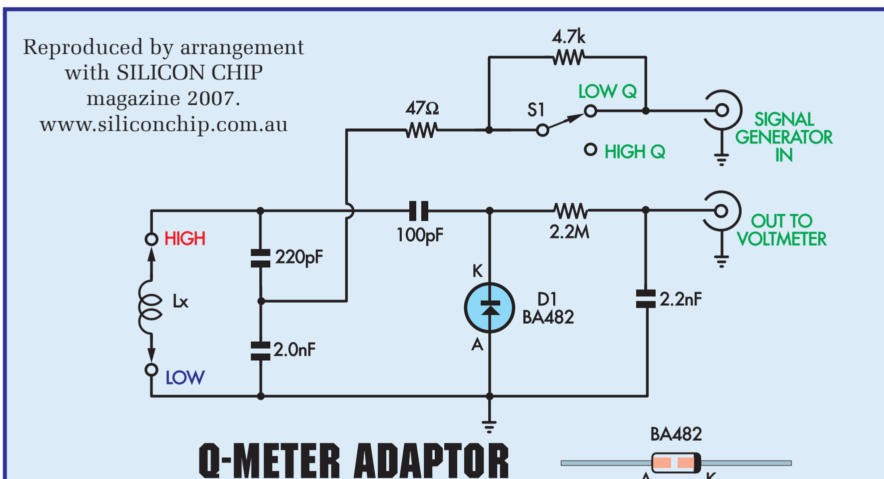
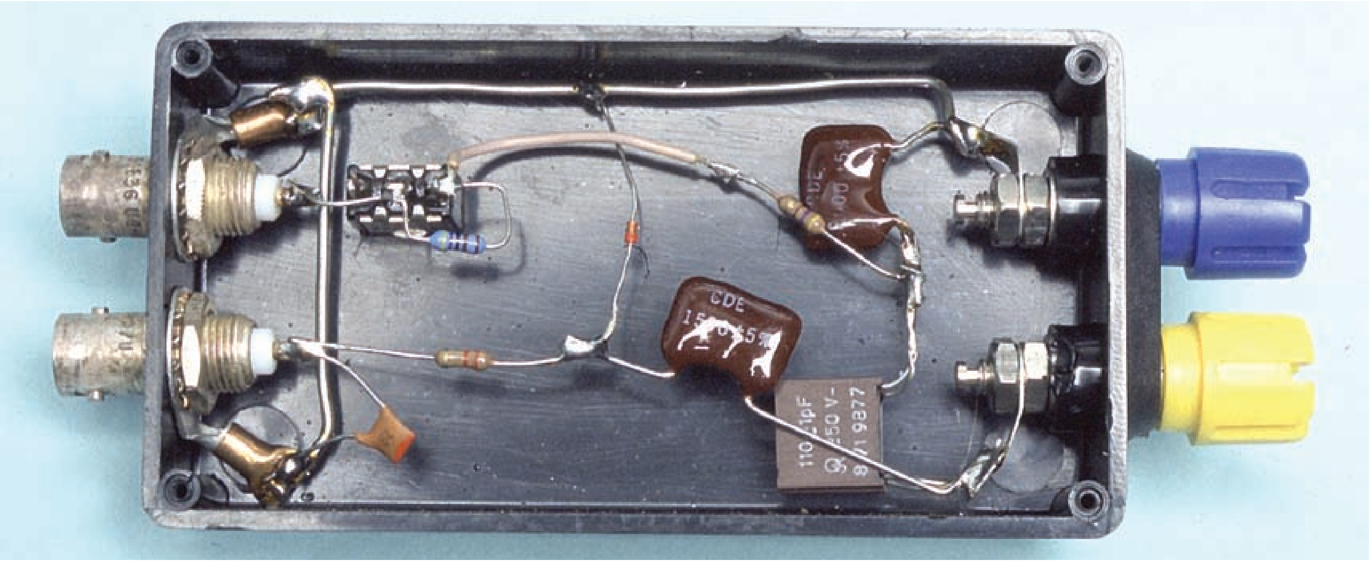


Fig.1: because frequency generation is undertaken by a signal generator and readout by a digital voltmeter, the circuit is delightfully simple.



Inside the box: four capacitors, three resistors, a diode and a switch make up the total component count. BNC connectors have been used for the oscillator input and multimeter output, but these are not mandatory.

Standard practice for Q-meters is to excite the tuned circuit by inserting a small value, non-inductive resistor in series with the inductor under test. The output of the signal generator is applied across this resistor, sometimes through an RF transformer. The instrument measures the RF current through the resistor and the Q (magnification factor) can be measured by an RF voltmeter across the circuit.

The simple system used here couples into the tuned circuit partly by reactive and partly by resistive components. It fits in with the usual signal generator that is designed to feed into 50Ω. Modern generators usually have a maximum output of 1V RMS and the older types 100mV with ×2 switching if used without amplitude modulation.

The suggested circuit shows a switch labelled 'HIGH Q' and 'LOW Q'. This switch is left in the HIGH Q position if you have a high output signal generator and a sensitive voltmeter in order to keep the coupling between the generator and the tuned circuit low. However, with low-Q tuned circuits and low output signal generators, you can at least get a reading, even if it is less accurate.

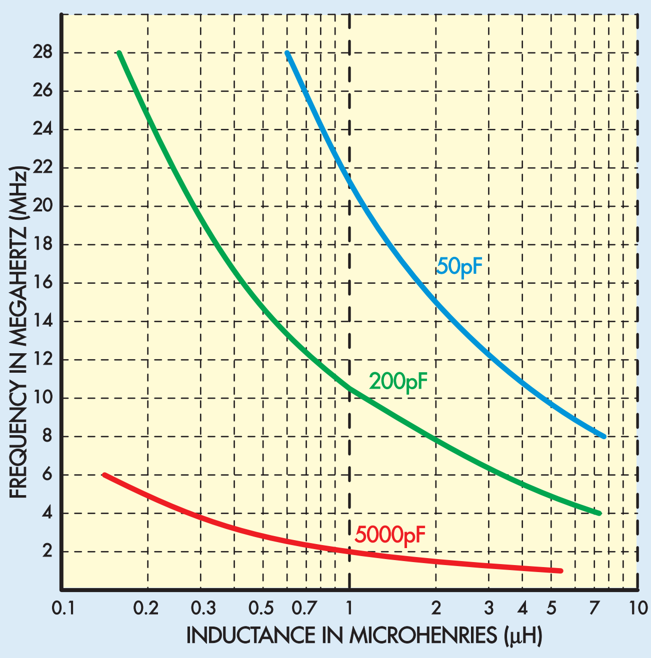


Fig.2: in many cases, you'll be able to read values straight off these graphs without having to resort to formulas. We've shown three easily-arranged capacitance values.

Don't worry about the signal generator not being correctly terminated. In this case, it doesn't matter.

Again, looking at the suggested circuit (Fig.1), the detector is in a shunt diode arrangement using a BA482 low-capacitance, low-loss silicon diode. There are other diodes which will do the job just as well.

The output of the detector is fed to a connector and then to a DMM set to a DC scale. Most DMMs have an input resistance of 10MΩ or greater. The older valve electronic voltmeters usually have a 0-1.5V scale, while the most sensitive range for modern DMMs may be 200mV.

The net result of losses brought about by the exciting signal and the loading of the detector is that the measured Q of very efficient inductors will be less than the true value. The same applies to expensive commercial Q-meters, although some of the best of them do have built-in circuits to partially compensate.

Because we don't know the precise value of the RF used to excite the tuned circuit, the value of Q has to be measured by indirect means.

Use is made of the universal selectivity curve (see Terman *Electronic and Radio Engineering* and others). The curve has the same general shape, regardless of the value of Q and the frequency and can be of great value when designing tuned filters with special characteristics.

For the purposes of measuring Q we are interested in the response at three frequencies. These are: the maximum; the frequency lower than the maximum at which the response is 0.707 (-3dB); and the frequency above the maximum at which the response is 0.707.

The difference between the two -3dB frequencies is the bandwidth. The Q of the circuit is the centre frequency divided by the bandwidth.

If you are making a lot of measurements, it soon becomes a matter of routine and given a pocket calculator, you can work very quickly.

There will be cases where you do not need to know the precise value of Q and you can zip through a series of readings by noting that the reading on the voltmeter is above a certain value.

The Q-meter jig pictured here was originally set up to check the inductors for low-pass filters used in HF radio transceivers operating between 2MHz and 20MHz. Inductance values between about 0.2µH and 3.0µH were used and the values needed to be within about 5%. A parallel capacitance of 200pF brought the resonant frequencies within the range of even the older HF signal generators.

To cover a wide range of inductance values, there is always the possibility of installing switched capacitors or a calibrated variable capacitor, but the jig is so simple that two or more separate units may be just as easy. For very small value inductors, as may be used in VHF equipment, a switched arrangement may not be practical.

Having made up the jig in a form that suits your purpose, find a low-Q inductor, ideally of known value, and work out the resonant frequency.

With the signal generator and voltmeter connected, tune the signal generator for maximum indication. The signal generator should be set for maximum output. Note the reading of the DMM. If too low for convenience you can reduce the value of the 4.7kΩ resistor as required. The lower the value the greater the reduction in the measured Q.

Similarly, you can increase the reading of the voltmeter slightly by reducing the value of the series resistor, marked 2.2MΩ on the circuit, to about 1MΩ.

Using a 47Ω resistor in series with a 50Ω output signal generator (ie, the switch in the LOW Q position), a coil with a true Q of 250 will measure only about 50. If you are only concerned with the inductance value, this may not matter.

Having adjusted the set-up to suit your instruments, the routine for measurement goes like this:

Inductance

- Connect voltmeter and signal generator
- Connect unknown inductor
- Tune signal generator for maximum meter deflection and note the frequency
- Read the inductance from the graph for the corresponding value of C or calculate the inductance from the formula

Q value

- Using the signal generator's attenuator, reduce the output by 3dB
- Note the meter reading
- Return the signal generator's attenuator to the setting for full output
- Adjust the signal generator's frequency higher, to the point where the meter reading drops to the -3dB point
- As above, but on the low-frequency side. Subtract this frequency from the one above to obtain the bandwidth
- Q is then the centre frequency divided by the bandwidth

If your signal generator has a digital readout or you can connect a counter to read frequency, very good accuracy can be obtained.

Happy measuring! *EPE*

Using MPLAB

How to use MPLAB when writing the source code for your PIC projects
Part One – An introduction to MPLAB by Mike Hibbett

MICROCONTROLLERS are useless without software. Writing software, unless you started programming in the 1970s on PDP-8s and are a whizz with toggle switches, is a Herculean task without some kind of tool (an assembler) to help you. Over the years, higher level languages have come along which significantly improve the design and implementation of software, and alongside the language supporting programs – editors and debugging environments – have improved too.

For years users worked with simple text editors to enter their programs, then ran an assembler or compiler to turn that text into the binary representation used by the microcontroller. Initially this was quite natural – computers of the day could only support one single, text-based application running at a time – but as computers grew in power to support graphical displays and multiple, simultaneously operating programs, a more user-friendly set of tools began to appear, called Integrated Development Environments (IDE). These programs provide live, simultaneous multiple window views of your program – the source code, file registers, debugger etc.

To be fair, many users are still content to use the simple text-based editor to develop their software, and declare that it is a more efficient way to write software. But there are also many who consider the IDE to offer an enormous productivity advantage, once the 'learning curve' associated with an IDE is conquered. Hopefully, this series of articles will get you through the learning curve with the minimum of pain, and then you can decide for yourself which approach is best for you.

Visual IDE concept

You may already be familiar with the visual IDE concept if you have used the Microsoft Visual Basic or Borland products for developing software on a PC. These products were first developed years ago, driven by the large number of users who develop software for PCs. Tools for the embedded market took a little longer to catch up, but there are now many different IDEs available for the different microcontrollers available on the market and PICs, being such a popular microcontroller, have a number of IDEs available from different vendors.

Microchip realised that it is easier to sell microcontrollers if there are good tools available and have been developing their own range of software tools, many available for free, to support the sale of their core products. The MPLAB IDE is their offering, and this product is provided for free download from their website. It's a large download – some 40MB – which means that for those only with dial-up access to the Internet, it is inaccessible. Fortunately this month we are able to offer on our cover-mounted CD a full copy of the most recent version of this program.

Microchip are constantly updating this program so if you do have broadband access to the Internet (or a friend who has) then you can download the updates as and when they appear. The updates tend to be minor (adding support in the debugger for new processor variants, for example) so although the version on the cover CD may quickly become outdated, it should be more than suitable for your needs for some time to come.

In this series of articles we will slowly introduce the features of MPLAB and help you through the initial, steep, learning curve that often puts first-time users off. If you have used an IDE such as Visual Basic before, the basic concepts will be familiar to you, but there will still be a number of new concepts to get to grips with – programming for an embedded processor is very different to programming for a PC. Walking through a few examples over the next few months will enable you to get to grips with the basic features, and later on we will introduce the more powerful features available – and they are indeed powerful!

But we are jumping ahead. We should first introduce the process of writing software using MPLAB, so let's define some of the technical terms that are used.

Definitions

Editor: A program (or Window, in the case of an IDE) that is used for typing in program instructions.

Source file: A text file that contains the assembly language instructions that you will type in using the editor. One or more source files are typically used in a project.

Header file: Sometimes called an *include* file, this is a file that contains text that can be included into another text file by specifying its name. Typically used to include processor specific register definitions, such as the names of SFRs and bit fields.

Workspace: A file used by the IDE to identify the files and settings associated with a project. There is normally one workspace per project.

Assembler: A program (or menu option in the IDE) that translates assembly code in your project's source files into object code, the raw binary instructions used by the microcontroller. It may also create a standard **.hex** format file that can be read by programming software.

Object File: A binary format file that contains all or parts of a program. Normally collated with other files by the linker to create the final application program file.

Linker: A program that collects several object code files together and adds the 'links' so that calls to routines in different files match up. It also generates the text format output file that can be read by programming software.

Librarian: A program that can collate many object code files into a single file, called a **.lib** file. This can be useful if you want to create re-usable utility modules and share them among several projects.

Build, Make: Generic terms which refer to the act of running the assembler and optionally the linker and librarian on a collection of one or more source files to create a program file.

IDE purpose

The purpose of the IDE is to translate your source file or files into a program file containing the binary representation suitable for use by your chosen processor. In general, the build process can work in one of two ways: *Absolute* or *Relocatable*. In Absolute mode you specify the starting address in flash where blocks of code will be placed, using an ORG statement within the source files. This is the technique that most people start off with, since it is the simplest way to write an application and requires the least thought.

For more complex projects, or one where you want to be able to re-use software in other projects, then Relocatable mode is provided. In this mode your source files do not specify exactly where individual sections of code go; instead, you specify a 'section name'. The linker program is run to take your assembled source files and a 'linker script', written by yourself, which specifies the absolute locations where each section of code will start. If several source files use the same section name then the linker will choose itself where the code of individual source files will end up inside that section of memory. Fig.1 and Fig.2 give an overview of the process.

As it is more complex, we will be covering relocatable projects later in the series, and start with Absolute mode.

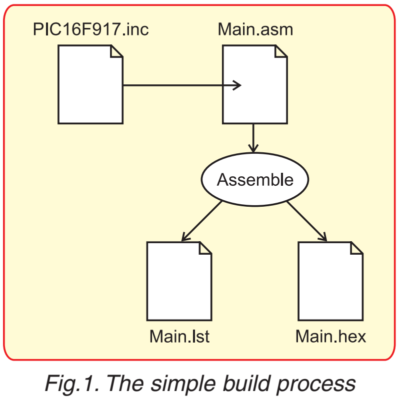


Fig.1. The simple build process

Software Building

MPLAB is capable of building programs written in the C high level language using a freely downloadable C compiler that

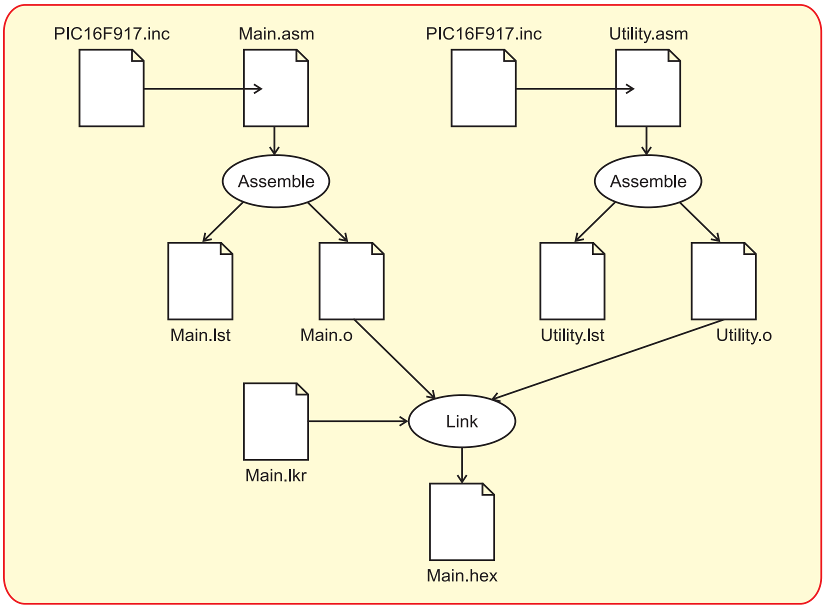


Fig.2. The advanced build process

integrates seamlessly in the IDE. As we have already covered this feature in earlier articles we will concentrate on programming in assembly language. The techniques, tools and approach are all very similar, however, so what you learn here can be easily transferred to programming in C.

For those of you more used to building your software using a command line assembler, you will know that the method of building programs is a simple single command line, probably not unlike:

C:\picasm main.asm -iPIC16F917.inc -main.hex

which instructs the assembler program **picasm.exe** to take the source files **main.asm** and **PIC16F917.inc** and turn them into the program file **main.hex**, which you could then download to your PIC. You would probably use your favourite text editor to create the source files. It probably took a while to get the hang of the command line options, but there were not many and so you no doubt very quickly picked up the appropriate options and have been able to forget about them, concentrating instead on adding assembly instructions to your text files.

An IDE presents a radically different approach. Apart from offering many features above and beyond your simple assembler, it presents them *all at once*, in a Windows menu and dialog box driven user interface. MPLAB provides the following features, all within the one program:

Editor
Assembler
Compiler (optional)
Linker
Librarian
Programmer
Simulator
H/W Debugger

With all these features presented in one program, it's no wonder things appear complicated!

So lets return to the overview of how programs are created, and how MPLAB helps in the process.

The old way

Programs are entered into a text file using any text editor, often into a single file for small programs. For larger programs you might place code in additional text files that are 'included' into the main file by a **#include filename** line (called a directive). Assembly language files are typically given the file extension of **.asm**, although that is not mandatory. These files are called *source files*.

You would then close the editor and run the assembler program. This is responsible for converting the source files into a format suitable for loading into the chip. This effectively performs two steps in one: converts your text into the actual binary data required by the processor, then translates that into a standard format recognised by the programming software that we use to actually move the program into the processor. This final format, typically a text file itself, is normally given a file extension of **.hex**. Not all assemblers produce a seperate binary file, going straight for a hex file.

You would then connect your target board or microcontroller chip to the programming interface, run the programming software and transfer the program down to the microcontroller.

Finally, you would power up the target board, play with it to find errors, and if any are found, go back to the beginning, editing your source files, presumably with either a correction to the errors found, or some 'debugging output' to try to understand the problem. Repeat, often late into the night.

The MPLAB way

IDEs like MPLAB improve on the old way by bringing the editor, assembler and programmer into a single program. But the sum is much greater than the parts, because each of the previously independently functioning programs now know about each other and co-operate together. The IDE program acts like a coordinator. When you open the programmer menu, it already knows what your program file name is, and in seconds you can download load it and run it while still viewing your source file. Even better, if an error occurs during the assembly process, you simply click on the error message in the output window and the IDE automatically opens the relevant source file and positions the cursor on the offending line.

On top of this, MPLAB provides an integrated debugger – a function that allows you to visually step through the execution of your program, either in a built-in simulator or while running on a real processor. This feature alone justifies the effort of learning how to use MPLAB. You no longer have to observe the operation of your software from the outside: now you can watch every branch, and inspect register values at each step.

There is a lot of ground to cover which we will do over the next few months. First, we need to install MPLAB.

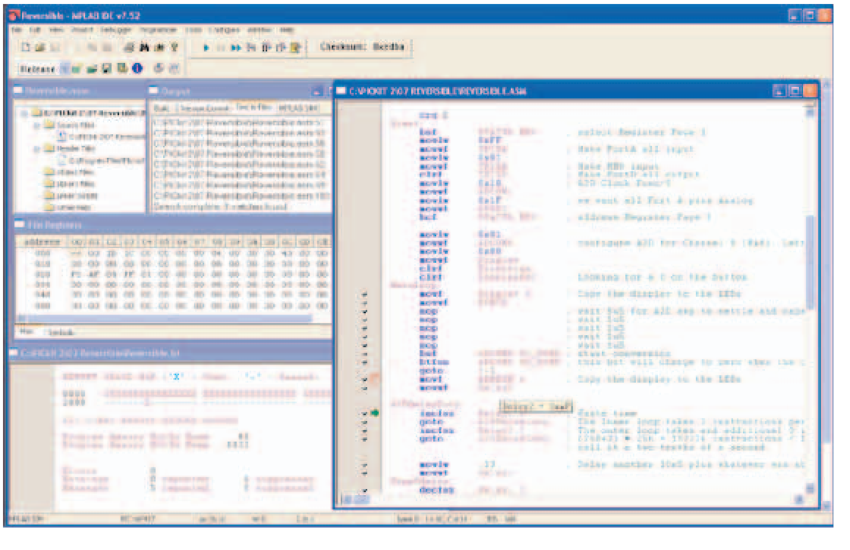


Fig.3. MPLAB in use

Installation

If you want to download MPLAB from the Internet, go to the Microchip website (**www.microchip.com**), and on the main page under the heading 'Design' click on the 'MPLAB IDE' link. Download MPLAB IDE – 'MPLAB IDE v7.xx Full Zipped Installation' from the bottom of the page under 'Software Downloads'. Save it to your hard drive.

Once the file is downloaded, double-click on the file **MP7xx.zip** and extract the files into a temporary folder on your desktop. In that directory, double click on **MP7xx_setup.exe** to start the installation. Accept the defaults, answer 'I agree' to the usual license statement and the installation will start. When the MPLAB IDE Document Select dialog appears, close it.

Alternatively, the current version of MPLAB is present on this month's cover-mounted CD. Simply insert the CD, wait for the installation program to start and follow the instructions. For now, install only MPLAB, to ensure the detailed instructions in the tutorials can be followed.

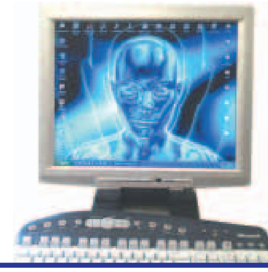
Documentation for the IDE can be found on the Microchip website at the bottom of the page where you downloaded the install file. The 'Users Guide and Quick Start Guide' should be downloaded, if you have Internet access. Additional help can be found within the IDE under 'Help', 'Topics'.

Next Month

Next month we write our first application and debug it in the simulator. For now, though, feel free to play with the user interface and look at the documentation. Don't be afraid to experiment; in the unlikely event that you delete some important files re-installation is straightforward.

To whet you appetite, Fig.3 shows a typical debugging activity on a program running on the simulator – and we shall get to that stage next month!

INTERFACE



Robert Penfold

MORE ON WINDOWS VISTA COMPATIBILITY

THE problems associated with interfacing your own hardware to a PC running Windows Vista were mentioned in the previous *Interface* article. In particular, there is a problem in using the **Inpout32.dll** add-on to enable Visual BASIC 6 and other programming languages to communicate with devices in the PCs input/output map. This method has been used extensively with *EPE* projects that interface via the printer ports, and it is also the method normally used with circuits featured in this series of articles. Unfortunately, **Inpout32.dll** seems to be ignored when using Windows Vista.

As pointed out previously, the failure of **Inpout32.dll** to work with Windows Vista was something of a surprise. The whole point of the Windows XP version of this file is that it uses approved methods of contacting the ports, making it compatible with the more pernickety versions of Windows, such as Windows 2000 and XP. It seemed reasonable to assume that it would therefore work just as well with Windows Vista.

Vista UAC

A discussion on the Logix4U website suggests that the problem is due to **Inpout32.dll** installing a driver when it is run:

www.logix4u.net/forum/index.php?topic=15.0

Installing the driver requires administrative privileges, and the usual dialogue box should appear so that the user can provide the necessary authorisation. However, for some reason the dialogue box does not appear, and the user cannot provide permission. Consequently, the driver is not installed and **Inpout32.dll** fails to work. Superficially the main program appears to work, and in most respects it is operational, but no communication with the ports takes place.

The problem is due to a security feature of Vista called User Account Control (UAC). This new feature tends to make its presence apparent soon after you start using Vista, and periodically thereafter. You find that it is necessary to provide permission before some programs will run, even if you are using an account that has administrator privileges. This does not usually occur when using large application programs that have been properly installed, but it is very likely to happen when running small applications such as compression/decompression programs.

The purpose of UAC is to prevent malicious programs from being installed, leaving the user blissfully unaware that anything has happened. The user will be asked to provide permission if something tries to install a malicious program, and the installation process can then be blocked by operating the appropriate button.

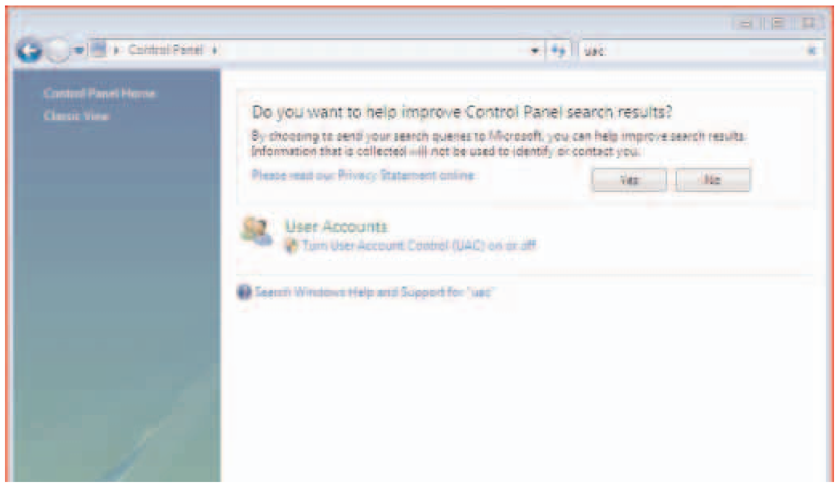


Fig.1. The search produced this window, which has a link to the UAC control window

Setting a program to work in the Windows XP compatibility mode is the obvious way around the **Inpout32** problem, but it does not provide a solution. Vista will still require permission in order to run **Inpout32.dll**. On the face of it, **Inpout32.dll** can be made to work by switching off the UAC feature, and this does indeed seem to solve the problem.

However, with UAC totally disabled, so is the added security that it would otherwise provide. This is probably of little consequence with a standalone PC that does not have an Internet connection, but it is not something that can be recommended with a PC that is on a large network and (or) has an Internet connection.

Check-in or check-out

One way of switching off UAC is to first launch the Control Panel via its entry in the Start menu. Then type 'UAC' into the search textbox near the top right-hand corner of the window, which should produce a screen that looks something like Fig.1. Left-clicking the 'Turn User Account Control (UAC) on or off' will change the window to the one shown in Fig.2. Here the tick is removed from the checkbox and the OK button is operated. You are then given the option of restarting the computer, and the change will not take effect until the computer has been rebooted. Essentially, the same method can be used to reinstate UAC, but the checkbox is ticked at the window of Fig.2. Once again, the change will not take effect until the computer has been rebooted.

This method certainly seems to work well, with **Inpout32.dll** working in the same way that it does with Windows XP. The obvious problem is that an important security feature of Windows Vista is lost if this operating system is used with UAC switched off. Whether it is worth taking the risk is something that each user has to assess individually. It is not a good long-term solution for a PC that has a permanent Internet connection.

Strangely, it does not seem to be necessary to leave the UAC feature switched off. If it is switched off, a program that uses **Inpout32.dll** is run, and then UAC is switched back on, any programs that use **Inpout32.dll** then seem to work normally. While it is not possible to guarantee that things will work this way on all PCs running Windows Vista, it seems quite likely that they will. Anyway, for anyone needing to use **Inpout32.dll** on a Vista based PC it is worth trying this method.

Pre-loading

An alternative to simply switching off UAC is to use an installer program that loads the necessary driver before the main program is run. It is possible to obtain such a program, together with 32-bit and 64-bit versions of **Inpout32.dll**, from this web site:

www.highrez.co.uk/Downloads/InpOut32/default.htm

This method seems to require the version of **Inpout32.dll** supplied with the installer rather than one of the earlier versions from other sources. The obvious advantage is that it does not require the user to alter any of the system settings in order to get programs to work properly, which is an important point for those supplying software for third-parties to use.

Possibly a fully user-friendly version of **Inpout32.dll** will become available in due course. On the face of it anyway, it would not require much change to the XP version, which does work with Vista once the UAC problem has been circumvented. In the meantime, at least it is possible to use *EPE* projects that use **Inpout32.dll** with a PC that runs under Windows Vista. It just requires a certain amount of preamble before everything will work properly.

Back to BASICs

As pointed out in the previous *Interface* article, Visual BASIC 6.0 will run under Windows Vista, but only just. Errors occur when it is installed, and more are often produced when it is run. It is probably usable provided only relatively simple programs are produced, but it is difficult to have much confidence in a program that operates in this fashion. Microsoft does not guarantee anything beyond 'it just works' compatibility.

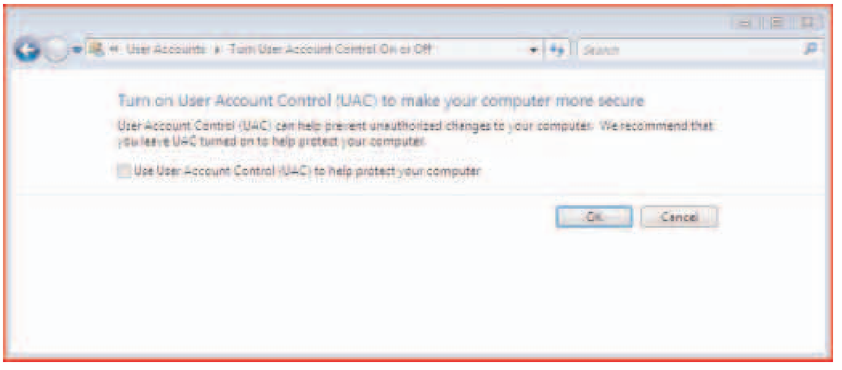


Fig.2. The checkbox is ticked in order to switch on the UAC feature, or the tick is removed in order to switch it off. The computer must be restarted before the change will take effect

There is potentially a problem with software produced using Visual BASIC 6.0 not running properly on a computer that is running under Windows Vista. Again, Microsoft only guarantees 'it just works' compatibility. This could result in programs running in something less than perfect fashion under Vista, and this could occur regardless of the operating system used by the computer to produce the software.

In other words, the fact that Visual BASIC 6.0 is run under Vista does not guarantee that it will produce fully Vista compatible programs. In practice, though, this does not seem to be a major problem, and trying a few programs written using Visual BASIC 6.0 produced perfectly acceptable results under Vista.

The way to obtain guaranteed compatibility with Windows XP and Vista is to use a more modern version of Visual BASIC, but this does require a certain amount of adjustment. There are numerous differences in the way things are handled using Visual BASIC 6 and more recent versions of this language. However, it seems that it will be necessary to move on to a more up-to-date version as Windows XP is gradually phased out in the coming years.

Free launch

It is worth pointing out that the free version of Visual BASIC (Visual BASIC 2005 Express Edition) is still available as a download from the Microsoft web site. There has been a certain amount of confusion over this program, which was originally made available at no charge for one year from its launch date. This time limit was later removed, and it is still available as a free download. Although some people seem to be under the impression that the current download is only a 30-day trial version, this is not actually the case. It will only run for 30-days if it is not registered with Microsoft. However, registration is free, so the 30-day limit can be removed at no charge.

The registration site seems to be inaccessible at times, but with a bit of persistence the program can eventually be registered. The program can be downloaded here:

http://msdn.microsoft.com/vstudio/express/downloads/

Visual BASIC 2005 Express will run under Windows Vista and XP, as will the programs produced. This programming language is compatible with **Inpout32.dll**. However, the BAS file supplied with **Inpout32.dll** cannot be used to integrate it with Visual BASIC 2005 Express. This problem has been covered in previous *Interface* articles, and is easily solved. It is just a matter of adding a short piece of code ahead of the code for the form, and any components. This is all that is required:

```
Option Strict Off
Option Explicit On
Module InpOut32_Declarations
'Inp and Out declarations for port I/O
  using inpout32.dll.
Public Declare Function Inp Lib
  "inpout32.dll" Alias "Inp32" (ByVal
  PortAddress As Short) As Short
Public Declare Sub Out Lib
  "inpout32.dll" Alias "Out32" (ByVal
  PortAddress As Short, ByVal Value
  As Short)
End Module
```

The Inp and Out commands will operate like normal Visual BASIC instructions once this has been added. The usual hint text should appear when typing these commands. Something has gone awry if the hint text does not appear and parts of the command are underlined in blue.

Check that the code is correct in every detail and that it is placed ahead of any other code. Of course, when running Visual BASIC 2005 under Windows Vista it is still necessary to get **Inpout32.dll** to load properly before programs can be compiled and tested, but there should be no further problems once this has been done.

Visual BASIC 2005 Express does have a few limitations, as discussed in previous *Interface* articles. In particular, its graphics capability is not equal to those of the full versions of Visual BASIC. On the other hand, this program is still more than adequate for producing most software for PC add-ons, it is free, and it is fully compatible with Windows XP and Vista. Despite its limitations, it is a good choice for producing the software for your own projects.

Fundamentals

In this series of articles it is not possible to cover the basics of PC interfacing each time a circuit or program is featured. Some of the fundamentals of interfacing are covered from time-to-time, but things are still likely to be difficult for those who are new to PC interfacing.

Information about PC interfacing can be found on the Internet, but the quantity is not vast, and much of it is many years out of date. There are some excellent sites though, and some of these provide some useful information for beginners.

The original **Inpout.dll** add-on was designed by Jan Axelson, and her excellent web site at **www.lvr.com** has a great deal of information about PC interfacing, plus links to sites where further information is available. There is a useful and well produced web page at: **www.codeproject.com/useritems/Inpout32_read.asp** that provides some information about using Visual BASIC 2005 Express plus **Inpout32.dll** to interface via a PC's parallel port.

The XP version of **Inpout32.dll** is available from **www.logix4u.net/inpout32.htm**. The web site and the additional files supplied with **Inpout32.dll** explain the way in which it is used. Many of the questions received about **Inpout32.dll** are actually covered by one or other of these. The main point to remember is that this file can only work if it is available to the system. It should either be placed in the Windows\system32 folder, or in the same folder as the program it supports.

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Mobile Phone Switch – *Freely phone home and control an appliance*

THERE are several designs that the author has seen for controlling appliances remotely via a mobile phone, but they have all involved connecting a microcontroller to the serial port of the phone and either using the Caller ID, or parsing data from an SMS message. Not only are these devices complex to build, they are also specific to a particular model of phone.

The circuit prsented in Fig.1 is much easier and cheaper to build and should work on any mobile phone, as long as the screen lights up when it receives a call. The way it works is simple, the mobile phone receives a call causing its screen to light up, a light dependent resistor (LDR) detects this and triggers a flip-flop (IC1) which turns a relay on or off, thus controlling the power to whatever is connected to the relay contacts. Finally, as the circuit does not answer the call, nor receive an SMS message, there are no call charges incurred.

The circuit is based around a 4013 dual flip-flop IC, which is configured in such a way that its two outputs change state with each high-going pulse to its trigger input. LDR1, which is an ORP12 light dependent resistor, is placed so that it faces the screen of the mobile phone. The sensitivity of LDR1 can be adjusted by VRl.

When the phone rings and the screen lights up, the resistance of LDR1 falls, this turns on transistor TR1, which could be any sort of general purpose NPN transistor. Capacitor C1 acts as a smoothing capacitor, which maintains a continuous high logic level even if the screen on the mobile phone flashes when it rings. If the screen of the phone you are using doesn't flash then this component can be omitted.

Resistor R2 pulls the input to IC1 low and also discharges C1 when the phone is not ringing. Transistor TR2 is controlled by the Q1 output of IC1 and is used to turn

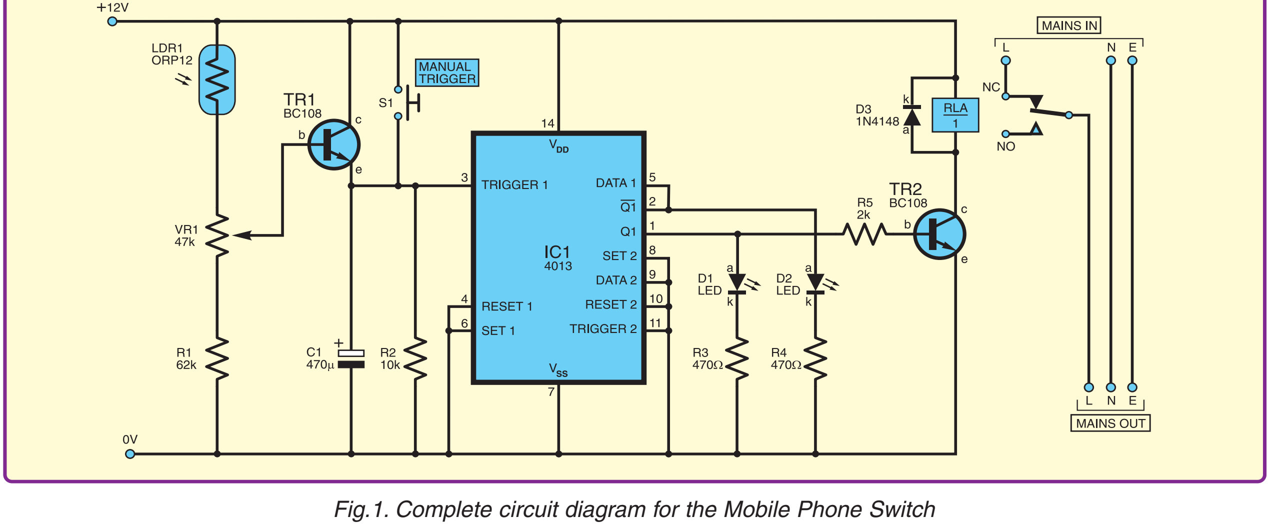


Fig.1. Complete circuit diagram for the Mobile Phone Switch

on or off the relay, RLAl, which controls the *Live* mains supply of the attached device.

LEDs D1 and D2 indicate whether the relay is on or off and diode D3 protects the circuit from the back EMF pulse induced at the moment that the relay coil is turned off. Switch Sl can be used to manually trigger the circuit and can be omitted if not required.

The whole circuit, along with the phone, should be mounted in a lightproof enclosure so it is not accidentally triggered by ambient light. If the circuit is to be in permanent operation then you should ensure the phone's charger is connected to prevent the battery running out.

It is a good idea to use a brand new sim card, which can usually be obtained for free, or very little cost, from most of the major mobile network providers. This will make the circuit more reliable as only you will have the telephone number to operate the device. However, the circuit will still be triggered by the occasional wrong number, or text message sent by the network provider, so it shouldn't be used to control any critical appliances.

Ian Hill, Plymouth

Ding-Dong Doorbell – *All Bells But No Whistles*

The traditional 'ding-dong' doorbell is well known. Often it uses two tuned metal pipes which serve as inexpensive 'bells'. These are then struck in a ding-dong sequence. This circuit (Fig.2.) emulates such a ding-dong doorbell. While it replicates the sound quite effectively, it is not the bells of St. Paul's! It might best be described as the sound of Swiss cowbells!

Note that Channel 2, with the exception of IC1b, is identical to Channel 1, and is therefore not shown in the circuit diagram in Fig.2.

How it works

The traditional ding-dong doorbell employs two small hammers, which strike the tuned metal pipes in sequence when the doorbell pushbutton is pressed. The Ding-Dong Doorbell replicates this 'striking' action with monostable IC1, used as a decoder. This distinguishes between the press and the release of S1. On press and release respectively, a brief, timed negative-going pulse is created at IC1 output pins 7 and 9 simultaneously.

If one should wish to create only a 'ding', as is created, for example, by a domed bell at a hotel reception, then alternative, simpler (optional) connections are shown in the insert in Fig.2.

While the traditional ding-dong doorbell has a fundamental frequency, it also creates harmonics to produce a rich sound. For this purpose, two oscillators are employed for each of Channels 1 and 2 (i.e. four oscillators in all). Frequently, electronic projects use only a fundamental frequency, and this produces an all-too-obviously cheap 'electronic' sound. The two Channel 1 oscillators comprise IC2a to IC2c and IC2d to IC2f, with surrounding components. Each oscillator may be adjusted by means of the multiturn presets VR1 and VR2, to create the desired tone and harmonics.

In order to create harmonics, the frequencies of the two oscillators need to be mixed. For this, an unusual mixer is employed. Inverters IC2c and IC2d each create mirror images of the oscillators' sound outputs. If the mirror images are of about the same amplitude when mixed, then they cancel each other out. This is the quiescent state of affairs.

However, when TR1's gate (g) goes 'low', these amplitudes become unbalanced, and a sound is generated. Quite a rich blend of harmonics can be created, covering almost the entire audio spectrum. In fact, even ultrasonic sounds may be mixed to create audible harmonics into the bass region.

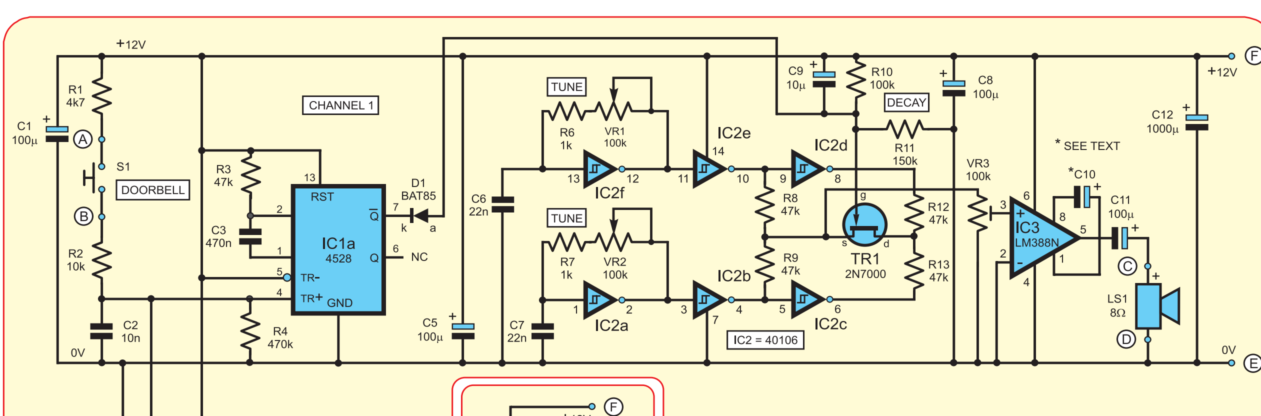
The sound of a traditional ding-dong doorbell has *decay* – that is, it decays or fades quite quickly after the pushbutton is pressed. With this in mind, when S1 is pressed, TR1 switches off as C8 instantly charges, thus taking TR1's gate 'low'. The conductance of TR1 then gradually increases as C8 again discharges. This again, gradually, brings the 'mirror image' tones into opposition. One may experiment with decay by changing the values of C8 and R11 in particular. Preset VR3 also controls the decay rate, as well as setting the output amplitude.

Finally, amplifier IC3 is employed to produce up to about 1W RMS in speaker LS1 (there is also a 3W RMS version of this IC, the LM386-3). Capacitor C10 may be inserted to increase volume, and this may be chosen to suit, between about 100nF and 10µF. This would be required in particular if a supply voltage lower than 12V is used. The author simplified the design by omitting the Zobel protection network, and this should not be missed here. Details may be obtained from the LM386 datasheets.

To set up the circuit, VR3 needs to be adjusted to create the desired decay. If it is incorrectly set, there may be no sound at all. Once this is done, VR1 and VR2 are adjusted for a suitable tone and harmonics.

It may be tricky to find a rich and pleasing sound, since small adjustments can send the harmonics 'all over the place'. However, there will be no difficulty obtaining a 'ding' or a 'dong' of some sort to begin with. If Channel 2 has been built as well, the same procedure is followed there.

The circuit draws a fairly high current, of over 10mA. Observant electronics enthusiasts might notice, however, that when the doorbell pushbutton is pressed, it takes a short moment for C2 to go 'high'. If, therefore, S1 could trigger a circuit which caused the Ding-Dong Doorbell to power up faster than C2 goes high, then the circuit could be on standby with nearly zero current consumption (say, a few microamps).



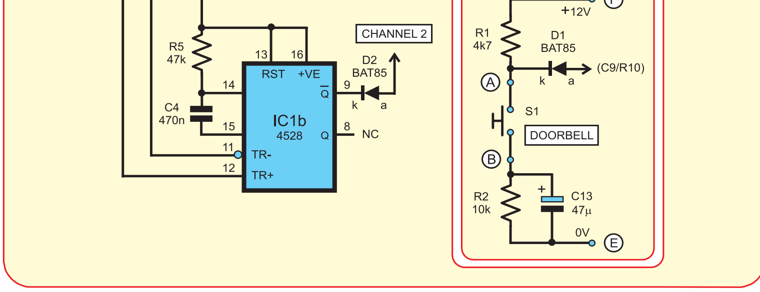


Fig.2. Ding-Dong Doorbell circuit diagram

However, amplifier IC3 would need to be switched off cleanly, or the circuit would make strange sounds on powering down. The Ding-Dong Doorbell circuit is not fussy, and would run happily on a 12V unregulated supply.

Thomas Scarborough, Cape Town, South Africa

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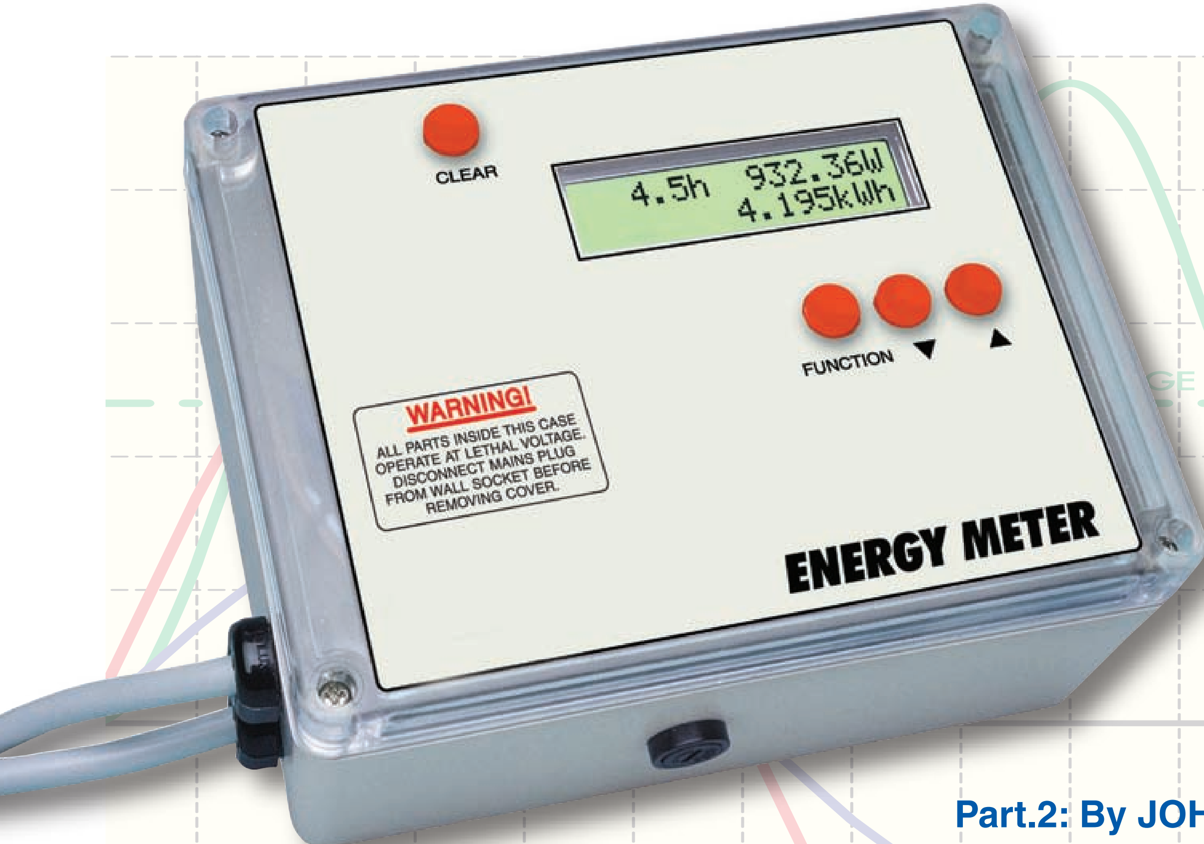


Part.2: By JOHN CLARKE

Control your power costs with the: ENERGY METER

Last month, we looked at the main features of the Energy Meter and described the circuit. This month, we present the full construction details and give the calibration procedure.

BUILDING THE ENERGY METER is quite straightforward but make sure that you refer to our warning panel. This is not a project for the inexperienced!

As shown in the photos, all the parts are mounted on two PC boards: (1) a main PC board coded 616 (138 × 116mm); and (2) a display PC board coded 617 (132 × 71mm) for the LCD module and switches. Both boards are available from the *EPE PCB Service*.

Note that the display board was designed to accept three different LCD modules. The straight-line 14-pin connection caters for two types of modules, while the dual 7-way connection is for the third type.

Begin by checking the PC boards for the correct hole sizes. The LCD module and transformer require 3mm mounting holes, while the switches require 6.5mm holes. In addition, 2mm holes are required for the mains wire connections.

Check also that there are no breaks in the copper tracks or shorts between any of the tracks or pads. Note, however, that one of the tracks on the main board has no connection at one end (ie, near the 10Ω resistor, to the right of the transformer). This is correct – this track simply functions as an earth guard, so don't join it to anything.

Display board assembly

Fig.8 shows the component layout on the display board. Install the wire link first, followed by trimpot VR1 and

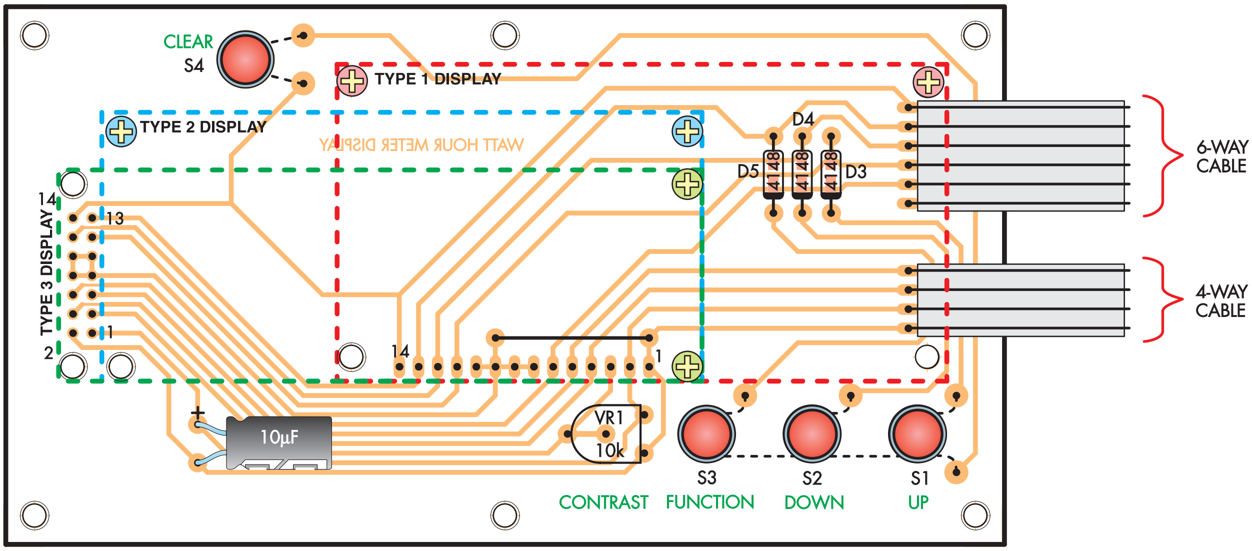


Fig.8: follow this layout to install the parts on the display PC board.

diodes D3-D5 (make sure the diodes are all oriented correctly)

That done, install the 10µF capacitor, again taking care with polarity. It must be mounted with its leads bent at right angles, so that the capacitor lies on its side against the board. This is necessary to provide clearance when the assembly is later secured to the lid.

If you are using the Type 1 LCD module, the 6-way and 4-way rainbow cables need to be soldered into position now, since the LCD module covers the wiring points. Both cables should be about 120mm long. Similarly, you should also fit the six PC stakes adjacent to the switch positions – ie, two adjacent to S1, one each next to S2 and S3, and two adjacent to S4.

Now for the LCD module. Both the Type 1 and Type 2 modules are connected to the PC board using a single in-line 14-pin header, while the Type 3 module uses the dual 7-pin header instead.

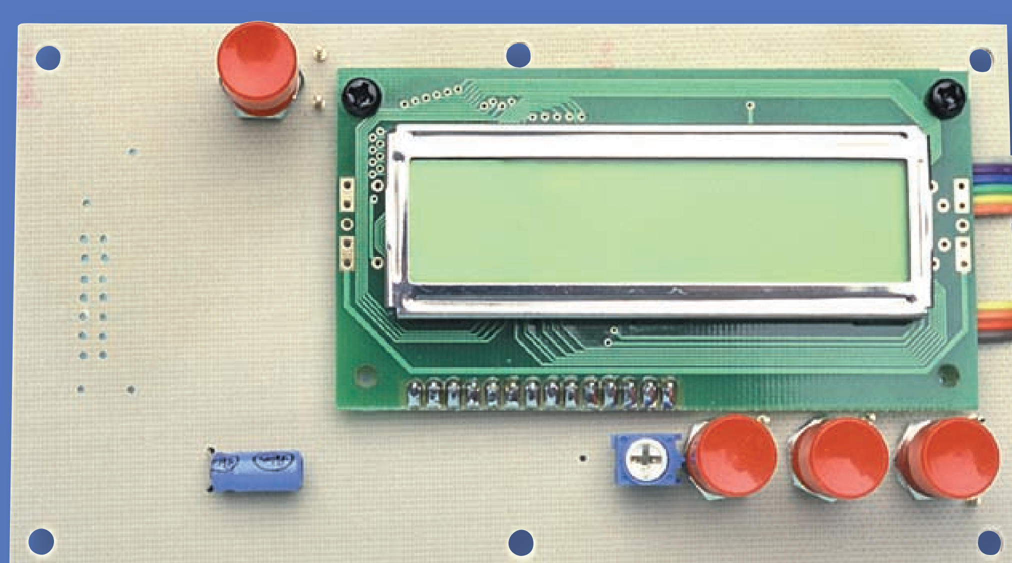
Before mounting the module, fit two M3 x 9mm Nylon screws and nuts to the two corner positions opposing the header – see Fig.8. Do the nuts all the way up, then push the module down onto the PC board and secure it using two more Nylon nuts. Finally, make sure that the header is pushed flush against the PC board before soldering all the header pins.

The display board assembly can now be completed by installing the four pushbutton switches. The switch terminals are wired together and soldered to the PC stakes using 0.7mm tinned copper wire as shown on Fig.9.

Main board assembly

Fig.10 shows how the parts are installed on the main PC board. Begin by installing the links and the resistors but don't install the 0.01Ω 3W resistor (R1) or link R2 at this stage. You can use the colour code table (Table 1) as a guide to selecting each resistor but it's also a good idea to check the values

This photo shows the completed display board assembly with the Type 1 LCD module in place. Two flat ribbon cables are used to connect it to the main board, via header sockets.



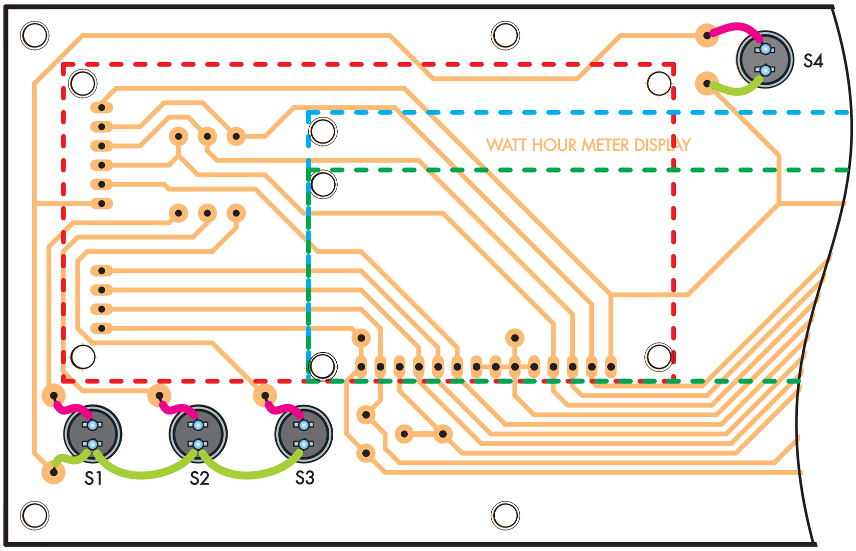


Fig.9: the switch terminals are wired together and soldered to adjacent PC stakes on the display board using 0.7mm tinned copper wire.

using a digital multimeter, as some colours can be hard to read.

Next, install the diodes and bridge rectifier BR1, taking care to orient them as shown. That done, IC1 can be soldered directly to the PC board and a socket installed for microcontroller IC2. Don't plug the IC in yet – that step comes later, after a few initial checks.

The capacitors and crystals can be mounted now. Make sure that the 100µF and 1000µF 25V electrolytic capacitors are placed in the correct positions and check that all electrolytics are oriented correctly. Once they're in, install transistor Q1 with its metal tab facing towards the battery. Similarly, install regulator REG1 as shown.

The next step is to install PC stakes at all those points marked with a green asterisk (*). There are eight PC stakes in all. Follow these with the MOV and the 4-way and 6-way pin headers (the plastic guide tabs on the headers go towards the centre of the board).

Resistor R2 is next on the agenda. It is made using 0.2mm enamelled copper wire. Note that you must remove the enamel insulation from the wire where it is soldered to the PC board, so that the solder flows onto the bare copper. This can be done by heating the wire with a soldering iron so that the insulation melts, before applying the solder.

Resistor R1 (0.01Ω) can now be installed and soldered in place. Finally, complete the PC board by installing the 3-pin header (ie, to take link LK1 or LK2).

Battery back-up

The back-up battery is required only if the Energy Meter is to be used for long term measurements, where the elapsed time and kWh tally must be kept in memory if there is a blackout. **Most people will elect to leave the battery out, since they don't need this facility.**

If you do intend to use the battery, solder the battery clip lead to the PC stakes. A hole is also provided on the PC board for the battery holder and this is secured using an M3 × 6mm screw, nut and shakeproof washer. A dab of silicone sealant can be used to ensure that the nut cannot come loose.

Resistor R3 (680Ω, 0.5W) is installed on the PC board only if you intend using a rechargeable battery. Also, don't install the battery clip if you elect not to use battery back-up, as it could short out other components.

Although the battery holder provides a firm grip on the battery, it's possible that the battery could come loose if the case is subject to rough treatment or vibration. To prevent this, two M3 × 15mm tapped Nylon spacers are installed on the PC board at either end of the battery, to prevent horizontal movement. Alternatively, these two Nylon spacers can be attached to the side of the case instead.

A third Nylon spacer is later fastened to the side of the case above the battery to prevent vertical movement, thus effectively trapping the battery in its holder (see photos).

Note that all spacers should be attached using M3 × 6mm Nylon screws (DO NOT use metal screws here). A countersunk Nylon screw is used to secure the spacer that's attached to the side of the case.

Attaching the header sockets

The next step is to attach the ends of the rainbow cable leading from the display PC board to the 4-way and 6-way header sockets using the supplied metal crimp connectors. These are crimped to the stripped wire ends and secured in place with the insulation clamp using small pliers. The connectors are then slid into the pin header

Table 2: Capacitor Codes

Value	µF Code	EIA Code	IEC Code
100nF	0.1µF	104	100n
33nF	0.033µF	333	33n
1nF	0.001µF	102	1n0
33pF	–	33	33p

Table 1: Resistor Colour Codes

❏	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❏	2	2.2MΩ	red red green brown	red red black yellow brown
❏	1	10kΩ	brown black orange brown	brown black black red brown
❏	5	1kΩ	brown black red brown	brown black black brown brown
❏	1	680Ω	blue grey brown brown	blue grey black black brown
❏	1	68Ω	blue grey black brown	blue grey black gold brown
❏	1	10Ω	brown black black brown	brown black black gold brown

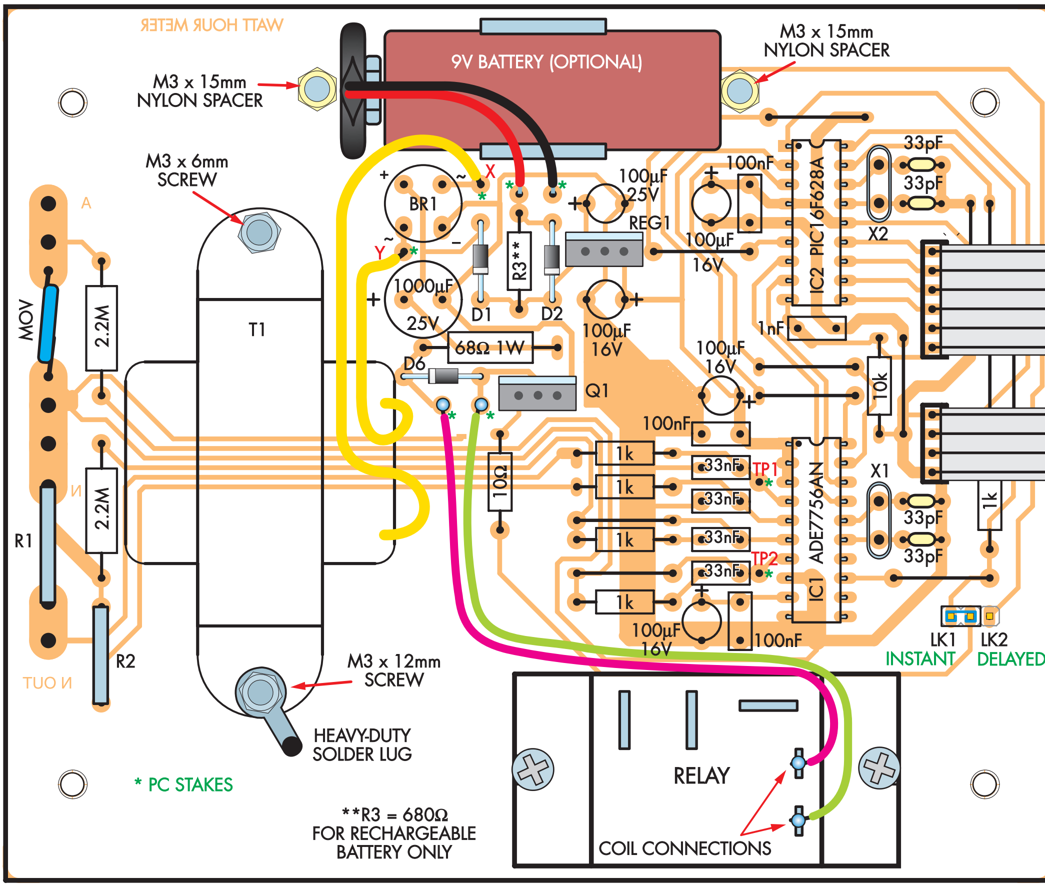


Fig.10: here's how to install the parts on the main PC board. Resistor R3 is installed only if a rechargeable back-up battery is used. Do not install the battery clip lead if you are not using a back-up battery, as it may short other components.

socket shells (but make sure you get the headers the right way around).

That done, it's a good idea to go back over the two boards and check that all parts are correctly oriented and are in the correct locations.

Initial tests

Now for some initial tests of the PC board assemblies. In the interests of safety, these tests are carried out using a low-voltage DC or AC power supply (eg, from a plugpack). The step-by-step procedure is as follows:

(1). Connect a 12V DC or 10-12V AC supply to the X and Y PC stakes adjacent to BR1. If you're using a DC supply, it can be connected either way round since the bridge rectifier takes care of the polarity.

(2). Measure the voltage between REG1's tab and its output pin – you should get a reading of 5V. If the voltage is less than 4.75V or more than 5.25V, switch off the power immediately and check for incorrect component placement and orientation.

(3). Assuming everything is OK, switch off, plug IC2 into its socket (make sure that it is oriented correctly) and adjust trimpot VR1 on the display board, so that the LCD module shows good contrast between the background and the displayed characters.

(4). Check that the switches work by pressing the Function switch – the display should now show the cost in '£' rather than the 'kWh' value (ie, at the lower righthand side of the display).

(5). Hold the Function switch down until the display goes to the cost per kWh calibration mode. When it does, check that the initial 10.0c (in the UK this value is for pence) value can be increased with the Up switch and decreased with the Down switch.

(6). Press the Clear switch and hold it down for five seconds. The display should go back to the kWh reading.

Assuming it all works, you can disconnect the low-voltage power supply and move on to the next stage in the construction – installing power transformer T1 and the mains wiring.

Transformer mounting

Transformer T1 and the relay can now be mounted. The relay is secured

WARNING!

This circuit is directly connected to the 230V AC mains. As such, all parts may operate at mains potential and contact with any part of the circuit could prove FATAL. This includes the back-up battery and all wiring to the display PC board.

To ensure safety, this circuit MUST NOT be operated unless it is fully enclosed in a plastic case. Do not connect this device to the mains with the lid of the case removed. DO NOT TOUCH any part of the circuit unless the power cord is unplugged from the mains socket.

This is not a project for the inexperienced. Do not attempt to build it unless you know exactly what you are doing and are completely familiar with mains wiring practices and construction techniques.

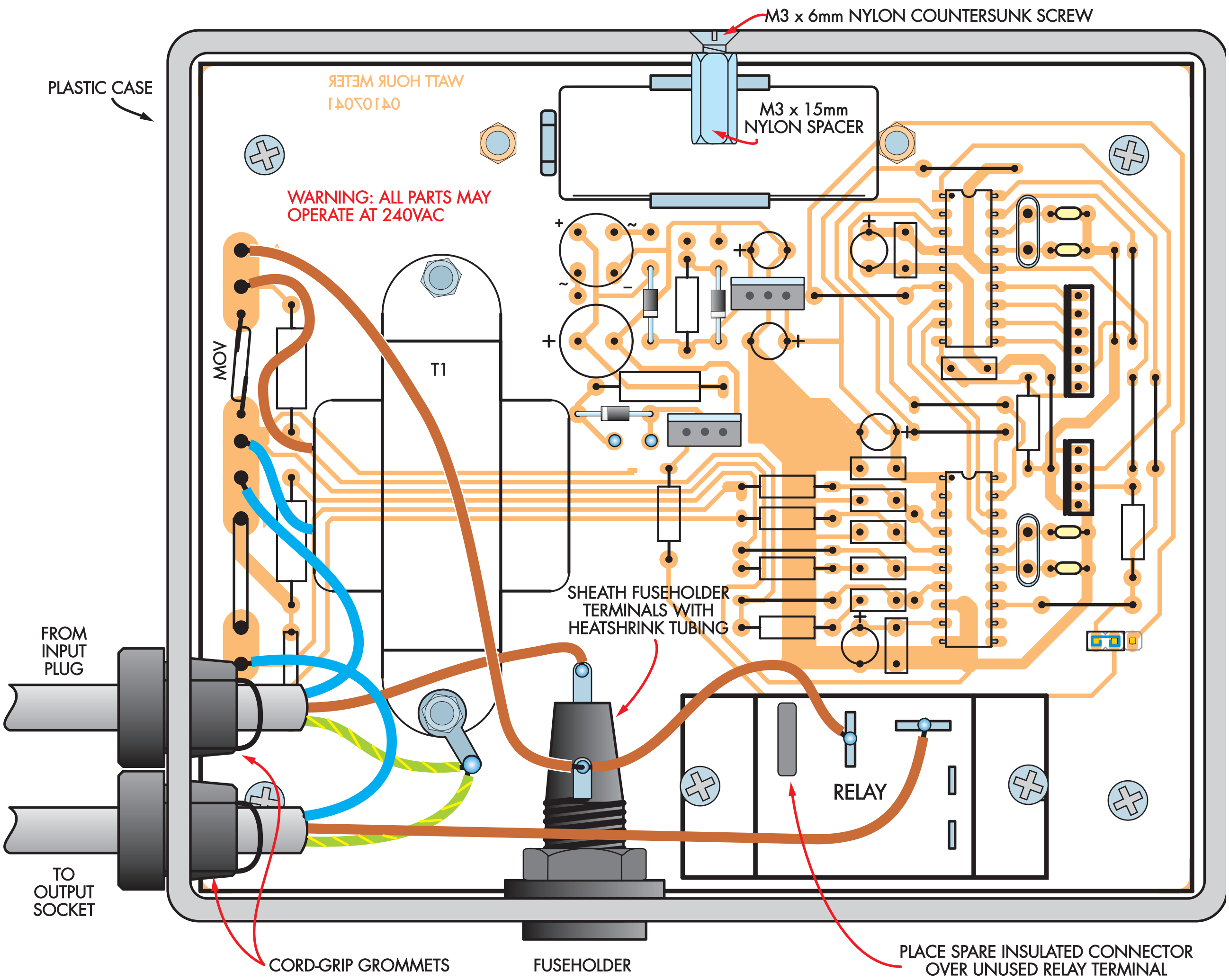


Fig.11: this diagram shows how to install the mains wiring. Note that all mains wiring connections to the PC board should be directly soldered (do not use PC stakes to terminate these connections).

using two M3 × 6mm screws and nuts, while the transformer is fastened using an M3 × 6mm screw, nut and star washer on one side and an M3 × 12mm screw, nut and star washer on the other. The latter mounting screw is also used to secure the earth solder lug, by fitting an additional star washer and lock nut – see Fig.12.

After mounting the transformer, connect its 12.6V secondary leads to the X and Y PC stakes on the PC board. Similarly, connect its brown and blue primary wires to the Live and Neutral positions on either side of the MOV – see Fig.11.

Mains wiring

To ensure safety, be sure to use a plastic case to house the Energy Meter. There must be no metal screws going into this case. DO NOT use a metal case for this unit.

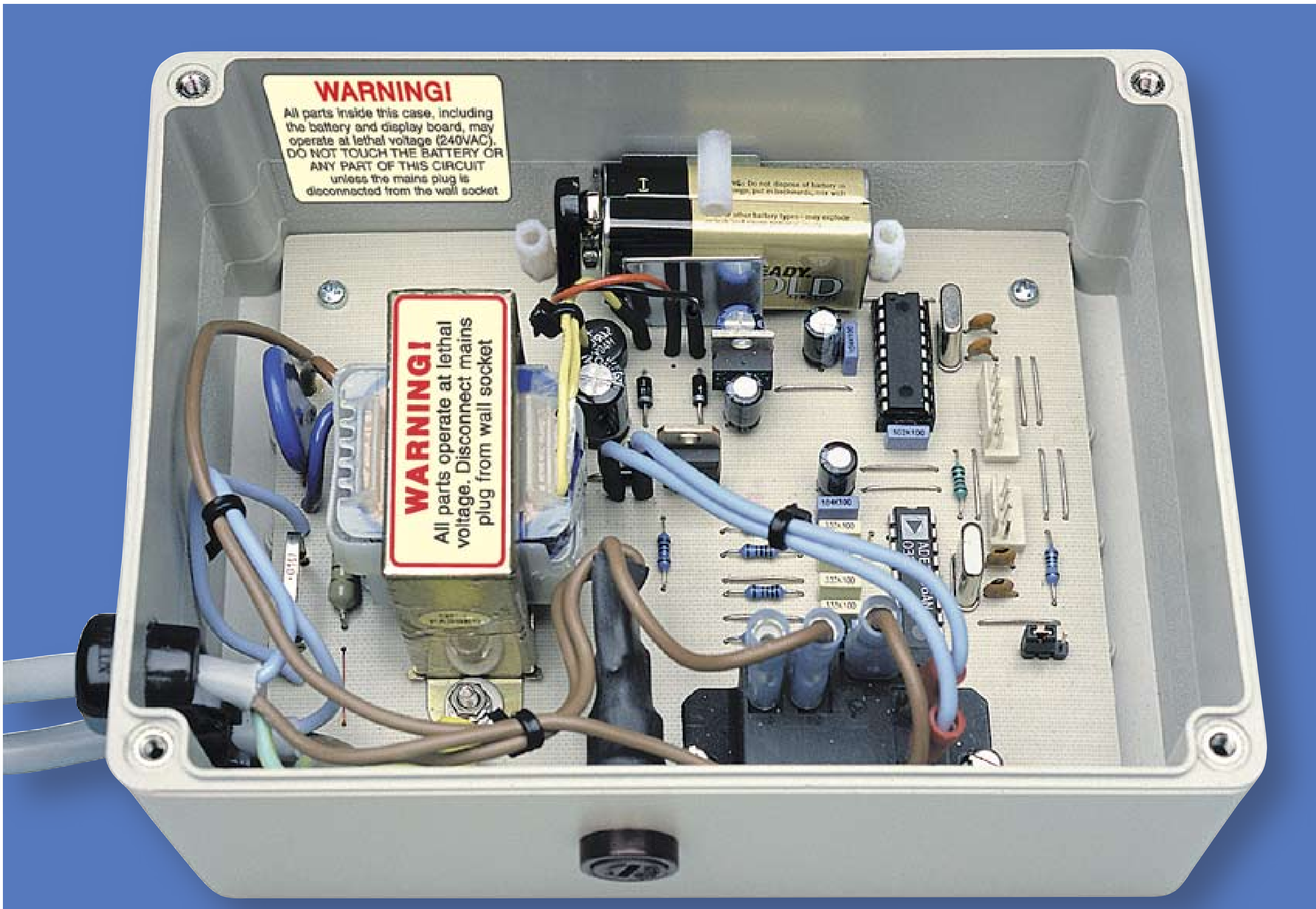
Begin the mains wiring by stripping back about 150mm of the outer sheath from each cable, then feed the two cables through the entry holes in the case (output cable at top). Solder their Neutral leads directly to the PC board, as shown in Fig.11 (do not use PC stakes here). Shorten each lead as necessary before soldering it to the PC board but don't make them too short – you don't want any strain on the leads once everything is in the case.

Once that's done, you can mount the safety fuseholder **(be sure to use a safety type suitable for 230V AC, as specified) and run the wiring to it. Note that the lead from the mains input cord goes to the end terminal of the fuseholder,** while two other leads connect the middle terminal to the PC board and one of the relay terminals.

To ensure safety, the fuseholder should be sheathed in heatshrink tubing (see photo). This involves slipping a 35mm length of heatshrink tubing over the three leads before soldering them to the fuseholder terminals. That done, the heatshrink tubing is slid into position over the fuseholder body and shrunk down with a hot-air gun.

All connections to the relay are made by terminating the leads in insulated spade crimp connectors. Be sure to use a ratchet-driven crimping tool for this job, to ensure a professional result. Don't use a cheap crimp tool as supplied with automotive terminal sets – they aren't good enough for crimping mains connections.

Note also that for safety reasons, it is wise to place a spare insulated connector over the unused NC terminal of the relay – see Fig.11. Having said



Use cable ties to bind the mains wiring as shown here, to prevent the wires from coming adrift. The fuseholder terminals are sheathed in heatshrink tubing and an insulated crimp connector is placed over the unused relay terminal to provide an extra margin of safety. Note, however, that all the circuitry operates at mains potential.

that, all parts and wiring in this unit could be at 230V AC (depending on the house wiring) but there's no harm in minimising the risk of contact.

Mains earth wiring

Now for the mains earth wiring – see Fig.12. First, slip a 25mm length of 6mm-diameter heatshrink tubing over the two earth leads, then twist the bared wire ends together and feed them through the hole in the solder lug. If the wires won't fit, it's simply a matter of slightly enlarging the hole by running an oversize drill bit through it

That done, the leads should be soldered to the lug and the heatshrink tubing pushed down over the connection and shrunk down to protect the joint and provide strain relief (see photo).

Finally, the solder lug can be attached to the transformer mounting screw using another nut and shakeproof washer. This arrangement not only securely anchors the solder lug but also provides earthing for the transformer case.

Be sure to follow the earthing arrangement exactly, as it's important for safety. In particular, note that the earth wires must be soldered. DO NOT rely on a crimp connection.

You can now complete the wiring by running the leads between the relay coil connection terminals and the PC board. These leads are crimped to 2.8mm spade connectors at the relay end and soldered to PC stakes at the other end. It's a good idea to cover the latter connections with 2.8mm heatshrink tubing, to prevent the wires breaking at the PC stakes.

Final assembly

Now that the wiring has been completed, the PC board can be secured

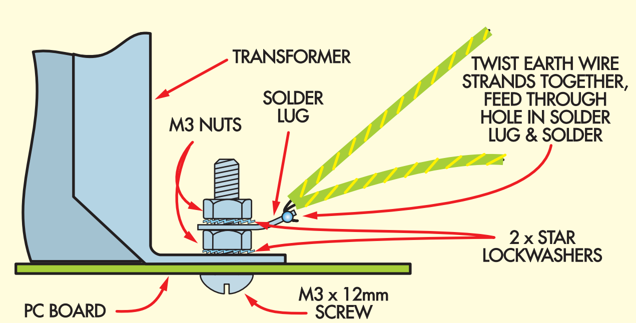
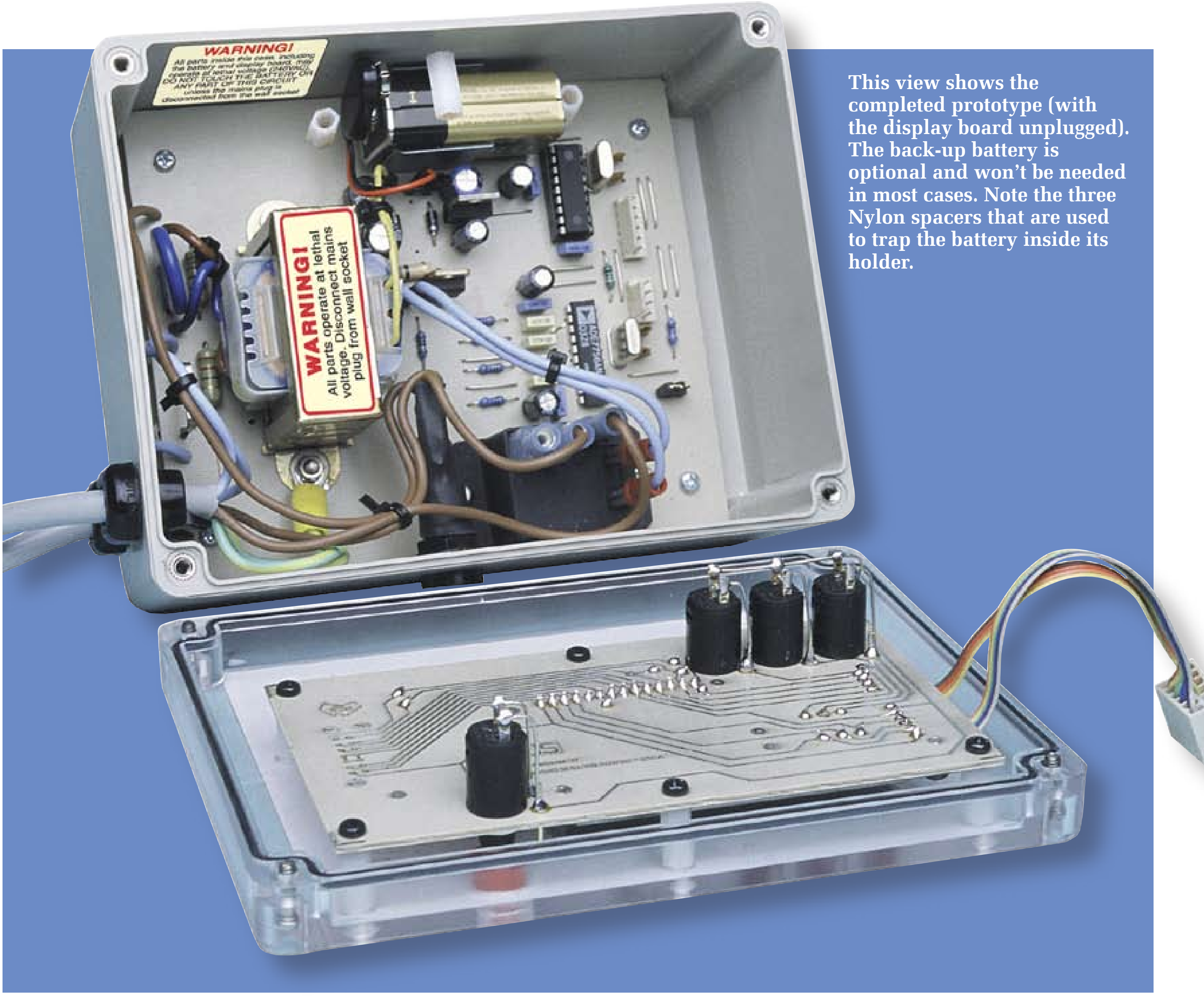


Fig.12: the mounting details for the earth solder lug. Twist the two earth wires securely together and feed them through the hole in the solder lug before soldering the connection.



This view shows the completed prototype (with the display board unplugged). The back-up battery is optional and won't be needed in most cases. Note the three Nylon spacers that are used to trap the battery inside its holder.

inside the box using the four supplied self-tapping screws (one at each corner). These screws go into integral mounting pillars within the box. That done, the mains cords should be clamped securely in position using the supplied cord clamp grommets.

Note that these cord clamp grommets must grip the mains cords tightly – you must not be able to pull the cords out, even if you place considerable strain on them.

With the cords now secured, use cable ties to lace the mains wiring together, as shown in the photos. This not only keeps the wiring looking neat and tidy but also prevents the leads from breaking since they can no longer move about.

Next, secure the display board to the lid of the case as shown in Fig.13. This is mounted on six M3 × 12mm Nylon spacers, which in turn are secured to the lid using M3 × 6mm countersunk Nylon screws.

Important: you must use Nylon screws where indicated on the diagrams and in the text, to ensure that all mains voltages remain within the case. There must be NO metal screws protruding through the Energy Meter's case.

The display board headers can now be plugged into their corresponding header pins on the main board. That done, the optional back-up battery can be installed by fitting the battery clip, then pushing the battery down into its holder, so that it sits between the two board-mounted Nylon spacers at either end. The remaining M3 × 15mm Nylon spacer should then be installed immediately above the battery (see Figs.10 and 11) and secured using an M3 × 6mm countersunk Nylon screw.

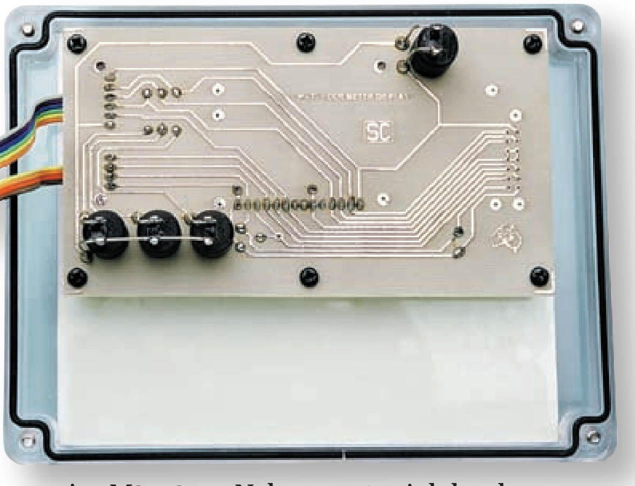
Next, place a shorting link onto either LK1 or LK2. Select the LK1 position if you want the relay to immediately switch on when power is restored after a brownout or blackout. Alternatively, choose the LK2 position so that the relay only switches on after an 18-minute delay when power is restored.

Finally, glue the warning label into place on the side of the case (near the battery) and attach the case lid, making sure that no components are shorted as the lid closes. The supplied metal screws can be used to secure the lid to the case, since they do not go inside the box.

A second warning label must be securely affixed to the front panel.

Calibration

The Energy Meter is now ready for calibration so that it will display the correct wattage, kWh and energy



The six 12mm-long M3 Nylon spacers are secured to the lid of the case using M3 x 6mm Nylon countersink-head screws. The display is then secured to these spacers using cheesehead M3 x 6mm screws.

costs. Calibration will also allow the brownout operation to function correctly.

Make sure that the lid is fitted before plugging the unit into the mains. In particular, note that ALL parts inside the case, including the battery and display board, operate at lethal voltage (ie, 230V AC) if Live and Neutral are transposed in the house wiring (eg, behind a wall socket). In that case, the entire circuit will be live and dangerous when it is plugged in, EVEN IF THE POWER SWITCH IS OFF.

For this reason, you must not remove the cover or touch any part of the circuit without first unplugging the unit from the wall socket.

As detailed in the accompanying panel, the various calibration modes are accessed by holding down the Function switch. Here's the procedure for each mode:

(1). COST: for the energy cost adjustment, the display will show CENTS/kWh on the top line and the cost (eg, 10.1 Cents) on the lower line (in the UK this value is for pence). The correct rate can be obtained from your electricity bill but note that some electricity suppliers have different rates, depending on the amount of electricity used.

This means that you will need to decide which rate applies to the appliances being measured.

(2). ZERO OFFSET: the OFFSET adjustment is made without a load connected. Press the Up or Down switch so that the wattage value stays at 0.00W (if a negative value is showing, the calibration value should be increased till it shows 0.00).

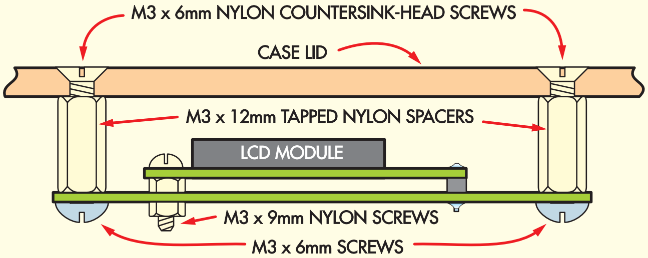


Fig.13: this generalised diagram shows the mounting details for the LCD module and the display board. Be sure to use Nylon screws and nuts where indicated.

Generally, the value should not need to be altered much from the default setting. When changing values, it is important to wait for at least 11 seconds so that the wattage value will update to its current reading with the new offset value.

(3). POWER ADJUSTMENT: the POWER adjustment sets the calibration of the wattage reading. This is done by connecting a high-current resistive load, such as a two-bar heater which can draw at least 5A (ie, a heater with a rating of 1000W, or 1kW).

Here's the procedure:

(a). First, you need to measure the resistance of the heater when the elements are hot. To do this, set your multimeter to measure ohms and plug the heater into a mains socket. Allow the elements to heat up to fully red for a few minutes, then pull out the mains

The bared ends of the two mains Earth leads are twisted together, fed through the hole in the soldering lug and then soldered. A piece of heatshrink tubing is then slid down and shrunk over the connection to keep the leads together and provide strain relief. Use a small drill to enlarge the hole in the solder lug to accept the twisted Earth wires if necessary.

Calibration Selections

(1) The first calibration selection is the **ENERGY COST ADJUSTMENT**. The display will show 'CENTS/kWh' on the top line and the cost (eg, 10.0 cents) on the lower line. The cost/kWh can then be adjusted from 0 cents to 25.5 cents in 0.1 cent steps by using the Up and Down switches to select the required value. (In the UK this value is for pence).

(2) The next calibration selection is the **OFFSET**. This is used to zero the wattage reading to 0.00W when no load is connected.

Basically, the Offset adjustment removes the effect of crosstalk between the current and voltage signals, which could otherwise cause a wattage reading to be displayed with no load connected. Setting this adjustment also prevents the kWh reading from increasing when the load is connected but there is no load current.

During calibration, the word 'OFFSET' is shown on the lefthand side of the display, while the current wattage value is shown to the right. Below this is the offset calibration value, which is shown between < and > brackets. The initial value is 7 but this can be adjusted from -2048 to +2048 in steps of 1 using the Up and Down switches. Each step represents an adjustment of about 0.12% in the wattage reading.

(3) The **POWER** adjustment is next in the sequence and is used to calibrate the kWh value. The power calibration values are adjustable from -2048 to +2048 in steps of 1, with each step representing a change of 0.0244%. This gives an overall adjustment range of ±50%.

(4) Next comes the **PHASE SHIFT** adjustment facility. This alters the phase difference between the measured voltage and measured current.

With a resistive load, the phase difference between the voltage and the current should be 0 – ie, they are in phase. However, the mains voltage monitoring and the current detection circuitry used in the Energy Meter can introduce small phase changes that need to be compensated for.

These phase differences can be trimmed out in 62 4.47μs steps, ranging from -138.6μs to +138.6μs. This is equivalent to 0.08° per step at 50Hz, with a 2.49° maximum leading or lagging adjustment.

(5) The next pressing of the Function switch displays the Brownout **SAG LEVEL**. If the mains voltage falls below this preset value, then a brownout condition is flagged on the lower lefthand side of the display (ie, the display shows 'SAG'). Typically, the brownout voltage can be adjusted from 290V all the way down to 0V in 57 steps of about 5.1V each.

(6) The **SAG LEVEL CAL** is the next mode in the sequence. This calibrates the voltage reading shown for the brownout (SAG) threshold level and the hysteresis, so that the unit trips correctly at the set voltage. This adjustment is available in 180 steps using the Up and Down switches, with each step changing the voltage reading by about 5V.

(7) Next comes the **SAG HYSTERESIS** (Brownout hysteresis) adjustment. This sets the voltage above the SAG LEVEL to which the mains must rise before the brownout indication (SAG) switches off. Again, this voltage is typically adjustable in 5.1V steps from 0-290V.

This hysteresis is included to prevent the brownout detection from repeatedly cycling on and off at the trip point.

(8) The final mode is the **SAG HALF CYCLES**. This sets the number of mains half-cycles over which the brownout voltage must stay below the SAG Level before a brownout is detected.

This factor is adjustable from 1-255 half-cycles in steps of one half-cycle. The default value is 100 (equivalent to a period of 1s for 50Hz mains), which means that the mains voltage must stay below the SAG Level for 100 half-cycles before a brownout is detected.

If the brownout facility is not required, the SAG LEVEL can be set to 0V (or to a very low voltage). This will effectively disable brownout detection and power will always be applied to the appliance.

Once all the calibration modes have been cycled through, pressing the Function switch again returns the display to its 'normal' mode – ie, so that it shows the measured values.

plug and quickly measure the resistance of the elements by connecting the multimeter probes between the Live and Neutral pins on the plug.

Note that this resistance will begin to drop as the elements cool. Make a note of the highest reading and repeat the procedure by heating the elements up again.

(b). Now measure the resistance the meter shows when the two probes are connected together. This may be around 0.1Ω and this value should be subtracted from the heater element reading to obtain the true heater resistance value.

(c). Carefully measure the mains voltage using suitable mains-rated multimeter probes, with the meter set to measure 250V AC.

(d). Using a calculator, square the mains voltage reading (eg, 230V ×230V = 52,900) and divide the result by the true resistance of the heater (eg, 52,900/50.0 =1058W). The result is the wattage drawn by the heater.

(e). Plug the heater into the Energy Meter's socket and adjust the POWER calibration value until the display shows the calculated wattage value. Pressing the Up switch will give a higher wattage reading on the display, while the Down switch will give a lower wattage reading. Be sure to wait 11 seconds after each adjustment, so that the display has time to update.

The actual value may change on each wattage update but it should average out to the calculated value. The calibration should be accurate to better than 0.5%, providing the mains voltage has not altered and the multimeter is accurate.

Note that the kWh calibration is also set by calibrating the wattage reading and is effectively locked to this calibration. Typically, the wattage measured each second is divided by 3600 (the number of seconds in one hour). This divided value is then added every second to the existing kWh value.

Note also that to convert from watt-hours to kWh, the value is divided by 1000. In the Energy Meter, we are obtaining the wattage over a 10.986328-second period and so we do not divide by 3600 and then by 1000. Instead we divide by 32,768 and then by 10. The result is the same.

(4). PHASE SHIFT: this adjustment is not required for most purposes. This is because we have used resistive current and voltage sensing and this will not alter the phase by any significant amount.

However, phase compensation will be required if a different current sensor is used that introduces a phase error. For example if a current transformer is used in place of the 0.01Ω resistor (R1) and it introduces a phase lag of 0.2°, then a phase correction of 0.2° will be needed.

The phase correction is made in the amplifier 2 signal chain. This means that a phase lag in channel 1 will require that a similar phase lag be introduced into the second channel. Note that this phase lag (or delay) in channel 2 is a positive value.

Alternatively, if the current transducer introduces a phase lead, then the delay in channel 2 will need to be a negative value.

The conversion from phase shift in degrees to phase shift in microseconds is made using the equation: *shift in degrees* = *360* × *phase value in seconds* × *50Hz*. Alternatively, *phase shift in seconds* = *shift in degrees/(360 × 50)*.

For example, a 0.2° phase shift is equivalent to an 11.1µs shift. In this case, we use the closest setting which is 13.4µs (the phase settings are in 4.47µs steps).

(5). BROWNOUT: four parameters must be set here: SAG LEVEL, SAG LEVEL CALibration, SAG HYSTERESIS and SAG CYCLES.

The SAG LEVEL and SAG HYSTERESIS should both initially be at 0V, while SAG CYCLES should be set to 100 cycles. If these are not already set to these values, select the required mode using the Function switch and adjust the value using the Up and Down switches.

If brownout detection isn't required, simply set the SAG LEVEL to 0V and skip the following procedure by pressing the Function switch until the display shows the hours, wattage and energy consumption.

For brownout calibration, just follow this step-by-step procedure:

(a). Select the SAG LEVEL mode, then carefully measure the mains voltage using a multimeter with mains-rated probes (and set to read 250V AC).

(b). Set the SAG LEVEL voltage using the Up switch until the SAG indicator shows. Check that this is the correct SAG threshold by stepping down in value to check if the SAG indication goes off. Note that these changes must be done slowly since there will be a 1-second lag for SAG detection.

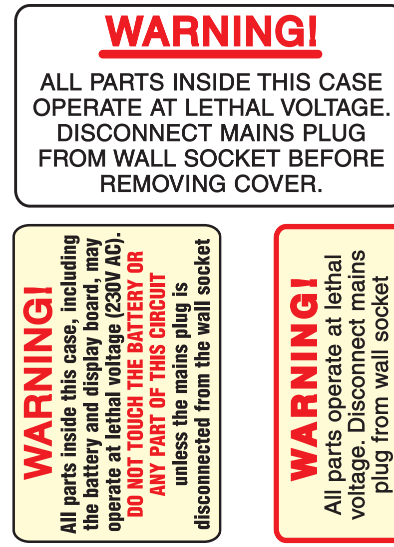
Note also that the voltage reading will probably not be the same as the measured mains voltage. This can be corrected by accessing the SAG LEVEL CAL mode and adjusting the reading shown on the lower line to be as close as possible to the measured mains voltage.

(c). Reduce the SAG LEVEL to a suitable value for brownout detection. Setting a low voltage will reduce the likelihood of a brownout indication and if set at below 50V, will completely prevent brownout detection. Conversely, setting the SAG LEVEL voltage too high will cause nuisance brownout detection.

A setting between 200V and 180V should be suitable.

(d). Adjust the SAG HYSTERESIS (brownout hysteresis). This sets the voltage that the mains must rise above the SAG LEVEL before the brownout indication switches off. In other words, the mains voltage must rise by the SAG Hysteresis value above the SAG Level in order to reapply power to the appliance.

Generally, a setting of about 5-15V would be suitable here but make sure that when you add this hysteresis voltage to the SAG level, the result is less than the normal mains voltage. If not, the brownout detection (and indication) will remain in force after the power returns to normal (and the appliance will remain off).



The top warning label must be laminated and securely attached to the outside of the case. The bottom two labels go inside the case (see photos for locations)

(e). Finally, set the SAG HALF CYCLES. You should use a value greater than 50 here, to ensure that any momentary drops in the supply voltage are not detected as a brownout.

A value of 100 should be suitable. This means that the brownout must last at least one second before the relay switches off to disconnect power.

That's it – your new Energy Meter is now ready for use. *EPE*

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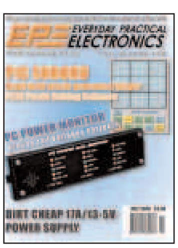

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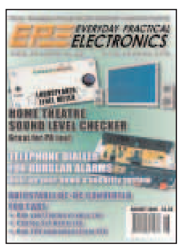

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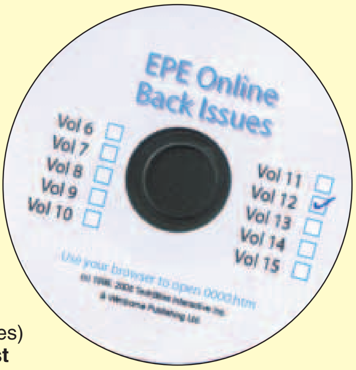

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Email: john.becker@wimborne.co.uk

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All letters quoted here have previously been replied to directly.

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

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

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★ LETTER OF THE MONTH ★

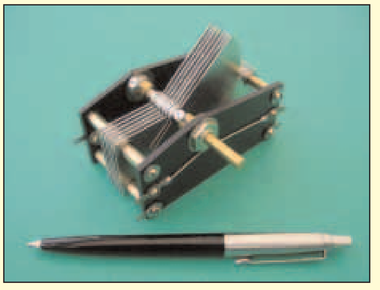
DIY Variable Capacitor

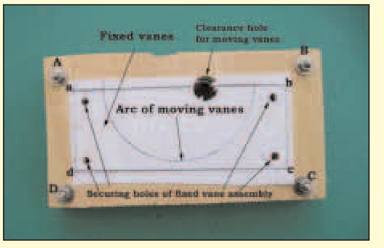
Recently on our Chat Zone *(via* ***www.epemag.co.uk****), the topic of RF chokes and their sources arose. As part of the discussion one reader showed a photograph of a variable capacitor he had made for himself. I thought you would be interested. He commented:*

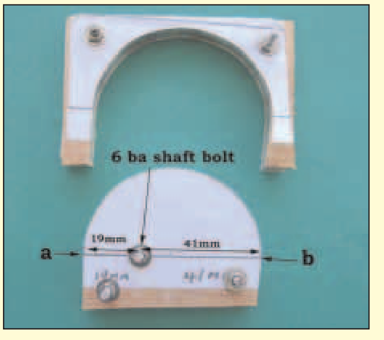
Chokes are not such a problem in themselves. However, I write articles on building small valve radio sets and my main aim was to find a source of chokes for the benefit of my readers. I have found of late that small components (capacitors, resistors etc) are getting harder to find. Ironically enough, the valves themselves are still no problem. Cheap variable capacitors are also becoming scarce, but I have been experimenting successfully with making my own 0-300pF air-spaced one.

For the shape of the vanes, I didn't try anything clever or use any formula. I decided on a vane width of 60mm simply because that was the physical size that I wanted. The vanes have a radius of 30mm and the shaft is simply offset to one side. Cutting them out seemed an insurmountable problem for some time. The solution was to sandwich all the pieces of aluminium between two pieces of plywood and bolt the whole lot together. I then stuck a paper drawing on top and cut them out using a small hobby type bandsaw.

The fixed plates are sandwiched between two pieces of plywood. A plan is







pasted on top. Drill in the securing holes and clearance holes first. Using a small hobby bandsaw, cut along D and C. Move bolts D and C into lower two securing holes to maintain clamping. Cut along A and B. Move bolts A and B into upper securing holes to maintain clamping. Cut off sides along A and D and also B and C.

Cut out moving vanes in similar manner. Cut the circumference out first, then cut along A and B, manoeuvring saw around a washer on the 6BA shaft bolt. This method makes very flat vanes which only need a bit of trimming with a file or wet and dry paper. Cut and drill acyrlic end supports. Assemby is self-explantory after that.

Robert Wilson (CZ name Shipbuilder).
Browse home page
www.miniatureships.blogspot.com/

Geothermal Energy

Dear EPE,

As any scuba diver knows, 0.3% is the average concentration of carbon dioxide in the atmosphere. Until recently, we never thought that the small amount of extra CO_2 production from human activity could permanently damage the environment. Now we know better and it's reassuring that this fact is becoming common knowledge, thanks to various efforts to which recent editorials and other correspondence in *EPE* have contributed.

In tackling this problem, let's take care to think through our actions. Making more efficient use of insulation seems logical, the Sun will shine anyway and it's nature's source of energy on our planet. That's why plants evolved photosynthesis. On the other hand, should we extract heat from the core of our planet?

Once again we have the situation where a little perturbation of the natural order, this time the premature loss of geothermal energy, doesn't seem significant. But that's what we once said about adding a 'little extra' CO_2 to the atmosphere. If the earth's core is cooling at a particular rate then this is likely to be in long-term balance with the natural environment.

Will our attempts to tap this heat cause faster cooling, even by an apparently tiny amount? If so, will that have any effect? We now realise that our 'tiny' interventions are actually significant. Let's not take a risk that will cause harm for the next generation. We should concentrate on energy sources that, as far as we can tell, have the lowest risk, not take further chances with our delicate environmental equilibrium.

Godfrey Manning G4GLM, Edgware, Middlesex, via email

That's a significant observation Godfrey. Probably one that not many people will have thought of.

Perhaps, though, a distinction must be drawn between types of geothermal source. There are those which are being created by the movement of the Earth itself – the rocks rubbing together by natural tectonic movement, possibly aided by the Sun's gravitional pull.

Iceland, for example, benefits from this thermal source. It is positioned across two of the Earth's plates, which are gradually seperating, causing friction, and thus heat, as they do. You can see where this is happening at locations in Iceland. The Icelanders harness this heat and use it as their principal energy source. On the face of it, I can't see why our extracting that renewable heat could be a long term problem. Or does any one think any different?

BTW, Matthew Parris, who writes for The Times *has a website you might be interested in. The address quoted in* The Times *is* ***timesonline.co.uk/ecowarrior****, though I could not access it, so I did a Google on* The Times*, and found the site. The article that took my interest, installing heat extraction from the earth for his house, was published on 7 April.*

Alternative Energy Projects

Dear EPE,

With regard to the editorial 'Windy!' in the February issue, I agree with your comments about a complete wind generator project being a non-starter. As I'm sure you know, there is a wealth of good information on the internet, and my site at **http://beehive.thisisgrimsby.co.uk/ALPS** gives a fair round up of some of the better ones. There are some ancillary electronic projects for alternative energy systems. I have had well over 400 hits already in two months!

I built your solar hot water controller in the early eighties. This worked very well for fifteen years until the flat roof started leaking. I've built several versions of your *Wind-up Torch,* which I am finding very useful. I am involved with building various generators based on easy-to-find parts, perhaps even a solar controller, or wind generator charge controller. I am considering putting in a link to your magazine on my website.

Paul Thompson, via email

Thanks Paul

Engineers' Creed

Dear EPE,

I refer to the letter by Ken Wood in the January issue. I can offer a little help, but only a little. The creed is very old, circa 1965, and relates to the invention of the planar technology for making transistors, invented by Fairchild.

In the early days, there were umpteen different ways of making transistors, and companies such as RCA and Texas Instruments made much of their technologies. A big problem was getting the real life junctions to look like the neat drawings in the text books, that is, flat, and some technologies were what we would now regard as bizarre.

For example, the grown junction transistor was made by pulling the crystal slowly out of molten material and changing the doping as the crystal was drawn out. Even more bizarre, the process worked and produced some transistors that were regarded at the time as amazingly good.

Another technology was the mesa. In practice, it was easy to get the middle of the transistor right, but there were all sorts of problems round the edges, so these were etched away leaving the transistor looking like a mesa of the American deserts. These also worked, and mesa transistors were noted for being wonderfully rugged, relative to other transistors available. I think the early 2N3055 used this technology.

Fairchild more or less creamed the opposition by using gas diffusion to produce transistors with flat junctions. *Planar* was a much more technical and marketable name than *flat*, so nearly everything from Fairchild was *planar*.

The competing technologies persisted for quite some time, and for low frequency power use, the mesa technology in particular had some benefits over the planar technology, but once the integrated circuit appeared, the planar technology became so commonplace that it ceased to be special or noteworthy.

Sadly, I too can't remember the rest of the creed.

Keith Anderson, Kingston, Tasmania, via email

Thanks Keith. Can anyone remember any more?

Punched Paper

Dear EPE,

Reading John's piece on the *Polyphonium* in the March '07 issue, I thought you might like to know that perforated paper rolls were first used by Basile Bouchon in 1725 to try to control a draw loom for producing the pattern. (A draw loom has many strings to control the warp threads for the pattern. An assistant, a draw boy, was needed by the weaver to pull the strings as needed.)

In 1728 Falcon used cardboard rectangles laced together. Vaucanson, famous for marvellous automata, in 1744 reverted to the paper roll. In 1775 Philippe de Lasalle improved the cardboard rectangle system.

In 1806 Jacquard improved the system and many believe he made it workable, although many believe that it was not until 1817 that Antoine Breton perfected it, even though it is always now known as the Jacquard loom. Charles Babbage in 1833 developed the idea of his Analytical Engine which would have used Jacquard type punched cards for its program control.

Automatic musical instruments used drums with pins in them until perforated rolls started appearing as late as around 1876 onwards. Many of these devices sensed the holes mechanically, although most later music machines seem to have worked pneumatically. Hollerith used punched cards from about 1889, but I have not yet found when the sensing of the holes changed from mechanical to electrical.

Alan S. Raistrick, via email

Thank you Alan, that's fascinating. I had no idea.

Electrolytic Capacitors

Dear EPE,

In response to Bill Stiles' letter in the March issue, I would like to comment on the voltage ratings of electrolytic capacitors. General purpose electrolytics are rated for a working temperature of up to 85 degrees Celcius, and higher temperature ones at 105 degrees. At lower temperatures they can withstand greater voltages, so for equipment in a domestic environment where the temperature is unlikely to exceed say 40 degrees C, there is an additional safety margin. So the capacitor rated at 75V would be quite satisfactory in the *Studio 350* amplifier (see Oct/Nov '06).

David Sharp. via email

Thank you David

IR Remote Checking

Dear EPE,

Your March '07 issue features an article on an *IR Remote Checker* which was interesting to see how to detect IR, but I thought you may also be interested in another way of checking to see if your TV remote is working. If you have a mobile phone that is equiped with a camera, if you press a button on your remote and point it at your camera phone then you should see the IR LED flickering on the image that the camera sees.

I realise that this may 'defeat the object' of your article, but it is always a useful tip for those that like to buy your magazine but don't have the resources to build every project they like.

Mark Hickman, via email

Thanks Mark, and Editor Mike confirms that your technique works.

Net Work

Alan Winstanley

A fistful of dollars

One of the many ‘bees in my bonnet’ is the often deplorable standards of service and advice that Britain’s high-tech retail chainstores mete out to customers, who should really demand a better deal and vote with their feet. The independent sector often shows larger rivals the meaning of good service and how to build a trustworthy reputation, which will bring customers back again and again – the same is now true of e-commerce web sites.

UK readers will know that the US dollar exchange rate has hit about two dollars to the pound sterling, which is great news for those who import merchandise priced in dollars or who visit the USA. Bad news for American tourists though: the UK is even more expensive than usual.

Armed with a tantalising exchange rate, this month’s *Net Work* offers some timely advice for Internet surfers who are considering buying from the USA. In search of some replacement digital camera equipment and thoroughly depressed by the offerings in the UK High Street, I decided to pop over to New York to see what’s available there.

I did my homework beforehand on the particular equipment that I needed to buy, reading reviews and websites along the way before settling down to the job of comparing prices. Before rushing online to snap up a bargain, one very important aspect relates to operating voltages: would 110V 60Hz USA equipment work in the UK? The manufacturer’s web site confirmed that it would, using a suitable figure-8 mains lead on the worldwide power supply (great!). Would any necessary software be compatible?

Also, bear in mind that equipment warranties will be US-only and EU Distance Selling Directives do not apply, so there is no seven day change of mind. Buying at arm’s length this way will always be a bit of a gamble and larger purchases are only for confident buyers who have done their research first.

I travelled to New York in the virtual sense of course, and after some intensive ‘googling’ I devised a shortlist of suppliers. I judged these American shopping sites using the same sort of criteria I apply to bricks and mortar stores. Do they look and feel sincere and reputable? Are they easy to search and compare? What was the response to Emails like? Why should I trust them?

I quickly eliminated some rivals and settled on the website operated by B&H Photographic (**www.bhphotovideo.com**). They claim to be the world’s largest retail vendors of imaging equipment, and it was extremely refreshing to see ‘England (UK)’ appear in the dropdown list of destinations available. In the event, however, it was important to swot up beforehand on their International web help section, as there is a sting in the tail….

With the US dollar so attractive, B & H Photo of New York provides a huge high quality website dedicated to international photo and video sales. See ***www.bhphotovideo.com***

A few dollars, more

Dollar prices were sometimes half of those in the UK, cementing in my view that the UK’s deserved reputation for ‘Rip Off Britain’. However, there are some hidden extras to be wary of – import duty in the low percentage points will be levied along with 17.5% VAT, and the couriers will also charge their own duty deferment fees for handling the duties on your behalf. On small items, the couriers’ fees are a significant cost that makes the operation less worthwhile. (I award a black mark to UPS UK who previously threatened to sue the writer for import duty that I had already paid to their driver. So keep a record!)

The B&H website also showed cumulative overseas shipping costs in real time as items were added to the cart – a reassuring feature. After the best part of an hour spent online, the shopping cart was brimming with bargains and it was time to head over to the checkout. The usual personal details were registered and a credit card number was typed in – and then the web browser crashed!

At such times one wonders whether the order has been entered properly, if at all, or will a credit card be charged twice? Using the browser History (available via the Favorites menu on IE7) it is easy to trace steps and re-open the cart. Logging in to B&H My Account to check Pending orders revealed… an empty account! However, the contents of the cart had been remembered so I picked up where I left off and completed the payment phase. (Usually, this is the case unless cookies have been disabled in the browser.) The order then appeared as Pending.

Or at least I thought I had completed the payment procedure: an email confirmation was received promptly from B&H but having processed the order and charged my credit card, the sting in the tail was that additional credit card verification steps were now required for first-time buyers, as outlined beforehand in the FAQ. This involved scanning both sides of the credit card and emailing the images to B&H by insecure mail or uploading via a non-secure web link. In the small print of credit card agreements you will find that credit details can only be transmitted by secure servers (**https**://), so this final hurdle is somewhat of concern as it opens an opportunity for credit card theft with no recourse of action to the credit card company.

Nevertheless, taking a balanced view based on reputation and the general ‘look and feel’ of trustworthiness meant that two JPGs were soon on their way. Anyway, there was no option. The lesson for short-sighted British retailers is that rather than buy from them, I have ordered $1500 worth at arm’s length from a company halfway round the world that I had never heard of. The next question is – did the order go through and did the goods arrive? More next month!

You can contact the writer at **alan@epemag.demon.co.uk**

DIRECT BOOK SERVICE

The books listed have been selected by *Everyday Practical Electronics* editorial staff as being of special interest to everyone involved in electronics and computing. They are supplied by mail order direct to your door. Full ordering details are given on the last book page.

FOR A FURTHER SELECTION OF BOOKS AND CDROMS SEE THE SHOP ON OUR UK WEBSITE – www.epemag.co.uk

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NEW

Electronics Teach-In + Free CD-ROM

Mike Tooley

A broad-based introduction to electronics – find out how circuits work and what goes on inside them. Plus 15 easy-to-build projects. The 152 page A4 book comes with a free CD-ROM containing the whole *Teach-In 2006* series (originally published in *EPE*) in PDF form, interactive quizzes to test your knowledge, TINA circuit simulation software (a limited version – plus a specially written TINA Tutorial), together with simulations of the circuits in the Teach-In series, plus Flowcode (a limited version) a high level programming system for PIC microcontrollers based on flowcharts.

The *Teach-In* series covers everything from Electric Current through to Microprocessors and Microcontrollers and each part includes demonstration circuits to build on breadboards or to simulate on your PC.

In addition to the *Teach-In* series, the book includes 15 CMOS-based simple projects from the *Back-To-Basics* series by Bart Trepak, these are: Fridge/Freezer Alarm, Water Level Detector, Burglar Alarm, Scarecrow, Digital Lock, Doorchime, Electronic Dice, Kitchen Timer, Room Thermometer, Daily Reminder, Whistle Switch, Parking Radar, Telephone Switch, Noughts and Crosses Enigma and a Weather Vane. There is also a MW/LW Radio project in the *Teach-In* series.

152 pages + CD-ROM **Order code ETI** **£8.50**

THE AMATEUR SCIENTIST 3·0 CD-ROM

CD-ROM

The complete collection of The Amateur Scientist articles from *Scientific American* magazine. Over 1,000 classic science projects from a renowned source of winning projects. All projects are rated for cost, difficulty and possible hazards.
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Exciting science projects in: Astronomy; Earth Science; Biology; Physics; Chemistry; Weather . . . and much more! The most complete resource ever assembled for hobbyists, and professionals looking for novel solutions to research problems.
Includes extensive Science Software Library with even more science tools.
Suitable for Mac, Windows, Linux or UNIX. 32MB RAM minimum, Netscape 4.0 or higher or Internet Explorer 4.0 or higher.
Over 1,000 projects

CD-ROM **Order code ASICD-ROM** **£19.95**

PROJECT CONSTRUCTION

IC 555 PROJECTS
E. A. Parr

Every so often a device appears that is so useful that one wonders how life went on before without it. The 555 timer is such a device. Included in this book are over 70 circuit diagrams and descriptions covering basic and general circuits, motor car and model railway circuits, alarms and noise makers as well as a section on 556, 558 and 559 timers. (Note. No construction details are given.) A reference book of invaluable use to all those who have any interest in electronics, be they professional engineers or designers, students or hobbyists.

167 pages **Order code BP44** **£5.49**

POWER SUPPLY PROJECTS
R. A. Penfold

This book offers a number of power supply designs, including simple unstabilised types, and variable voltage stabilised designs, the latter being primarily intended for use as bench power supplies for the electronics workshop. The designs provided are all low voltage types for semiconductor circuits. The information in this book should also help the reader to design his own power supplies. Includes cassette PSU, Ni-Cad charger, voltage step-up circuit and a simple inverter.

91 pages **Order code BP76** **£5.49**

HOW TO USE OSCILLOSCOPES AND OTHER TEST EQUIPMENT
R. A. Penfold

This book explains the basic function of an oscilloscope, gives a detailed explanation of all the standard controls, and provides advice on buying. A separate chapter deals with using an oscilloscope for fault finding on linear and logic circuits, plenty of example waveforms help to illustrate the control functions and the effects of various fault conditions. The function and use of various other pieces of test equipment are also covered, including signal generators, logic probes, logic pulsers and crystal calibrators.

104 pages **Order code BP267** **£5.49**

ELECTRONIC PROJECT BUILDING FOR BEGINNERS
R. A. Penfold

This book is for complete beginners to electronic project building. It provides a complete introduction to the practical side of this fascinating hobby, including the following topics:

Component identification, and buying the right parts; resistor colour codes, capacitor value markings, etc; advice on buying the right tools for the job; soldering; making easy work of the hard wiring; construction methods, including stripboard, custom printed circuit boards, plain matrix boards, surface mount boards and wire-wrapping; finishing off, and adding panel labels; getting "problem" projects to work, including simple methods of fault-finding.

In fact everything you need to know in order to get started in this absorbing and creative hobby.

135 pages **Order code BP392** **£5.49**

TEST EQUIPMENT CONSTRUCTION
R. A. Penfold

This book describes in detail how to construct some simple and inexpensive but extremely useful, pieces of test equipment. Stripboard layouts are provided for all designs, together with wiring diagrams where appropriate, plus notes on construction and use.

The following designs are included:-

AF Generator, Capacitance Meter, Test Bench Amplifier, AF Frequency Meter, Audio Mullivoltmeter, Analogue Probe, High Resistance Voltmeter, CMOS Probe, Transistor Tester, TTL Probe. The designs are suitable for both newcomers and more experienced hobbyists.

104 pages **Order code BP248** **£4.49**

COMPUTING

COMPUTING FOR THE OLDER GENERATION
Jim Gatenby

Especially written for the over 50s, using plain English and avoiding technical jargon. Large clear type for easy reading.

Among the many practical and useful ideas for using your PC that are covered in this book are: Choosing, setting up and understanding your computer and its main components. Writing letters, leaflets, invitations, etc., and other word processing jobs. Keeping track of your finances using a spreadsheet. Recording details of holidays and other ideas using a database. Using the Internet to find useful information, and email to keep in touch with family and friends. Making 'back-up' copies of your work and checking for viruses. How to use Windows XP to help people with impaired vision, hearing or mobility.

Provides the basic knowledge so you can gain enough confidence to join the local computer class.

308 pages **Order code BP601** **£8.99**

THE INTERNET FOR THE OLDER GENERATION
Jim Gatenby

Especially written for the over 50s. Uses only clear and easy-to-understand language. Larger type size for easy reading. Provides basic knowledge to give you confidence to join the local computer class.

This book explains how to use your PC on the Internet and covers amongst other things: Choosing and setting up your computer for the Internet. Getting connected to the Internet. Sending and receiving emails, photographs, etc., so that you can keep in touch with family and friends all over the world. Searching for and saving information on any subject. On-line shopping and home banking. Setting up your own simple web site.

228 pages **Order code BP600** **£8.99**

RADIO

SETTING UP AN AMATEUR RADIO STATION
I. D. Poole

The aim of this book is to give guidance on the decisions which have to be made when setting up any amateur radio or short wave listening station. Often the experience which is needed is learned by one's mistakes, however, this can be expensive. To help overcome this, guidance is given on many aspects of setting up and running an efficient station. It then proceeds to the steps that need to be taken in gaining a full transmitting licence.

Topics covered include: The equipment that is needed; Setting up the shack; Which aerials to use; Methods of construction; Preparing for the licence.

86 pages **Order code BP300** **£4.45**

EXPERIMENTAL ANTENNA TOPICS
H. C. Wright

Although nearly a century has passed since Marconi's first demonstration or radio communication, there is still research and experiment to be carried out in the field of antenna design and behaviour.

The aim of the experimenter will be to make a measurement or confirm a principle, and this can be done with relatively fragile, short-life apparatus. Because of this, devices described in this book make liberal use of cardboard, cooking foil, plastic bottles, cat food tins, etc.

Although primarily a practical book with text closely supported by diagrams, some formulae which can be used by straightforward substitution and some simple graphs have also been included.

72 pages **Order code BP278** **£4.00**

25 SIMPLE INDOOR AND WINDOW AERIALS
E. M. Noll

Many people live in flats and apartments or other types of accommodation where outdoor aerials are prohibited, or a lack of garden space etc. prevents aerials from being erected. This does not mean you have to forgo shortwave-listening, for even a 20-foot length of wire stretched out along the skirting board of a room can produce acceptable results. However, with some additional effort and experimentation one may well be able to improve performance further.

This concise book tells the story, and shows the reader how to construct and use 25 indoor and window aerials that the author has proven to be sure performers.

50 pages **Order code BP136** **£2.25**

TICKLING THE CRYSTAL Domestic British Crystal Sets of the 1920's
Ian L. Sanders

The first book dedicated to the topic of British crystal sets to be published in the last 25 years. For a very brief period during the early 1920's, these simple receivers played a crucial role in the expansion of domestic wireless throughout the United Kingdom. For many families, rich and poor, the crystal set provided an introduction to the new pastime of listening-in to broadcast programmes. Rapidly made obsolete from homes as suddenly as it had arrived, but not without leaving its mark on the history of wireless.

Written by a long-time authority and enthusiast, *Tickling the Crystal* is the most comprehensive work on the subject ever assembled. Containing almost two hundred excellent quality photographs and a wealth of previously unpublished material, it cannot fail to be an invaluable reference for anyone interested in the history of early wireless receivers.

256 pages hardback **Order code TC1** **£34.00**

THEORY AND REFERENCE

BEBOP TO THE BOOLEAN BOOGIE
Second Edition
Clive (call me Max) Maxfield

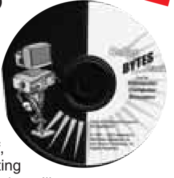
This book gives the "big picture" of digital electronics. This indepth, highly readable, up-to-the-minute guide shows you how electronic devices work and how they're made. You'll discover how transistors operate, how printed circuit boards are fabricated, and what the innards of memory ICs look like. You'll also gain a working knowledge of Boolean Algebra and Karnaugh Maps, and understand what Reed-Muller logic is and how it's used. And there's much, MUCH more. The author's tongue-in-cheek humour makes it a delight to read, but this is a REAL technical book, extremely detailed and accurate.

Contents: Fundamental concepts; Analog versus digital; Conductors and insulators; Voltage, current, resistance, capacitance and inductance; Semiconductors; Primitive logic functions; Binary arithmetic; Boolean algebra; Karnaugh maps; State diagrams, tables and machines; Analog-to-digital and digital-to-analog; Integrated circuits (ICs); Memory ICs; Programmable ICs; Application-specific integrated circuits (ASICs); Circuit boards (PWBs and DWBs); Hybrids; Multichip modules (MCMs); Alternative and future technologies.

470 pages – large format **Order code BEB1** **£26.95**

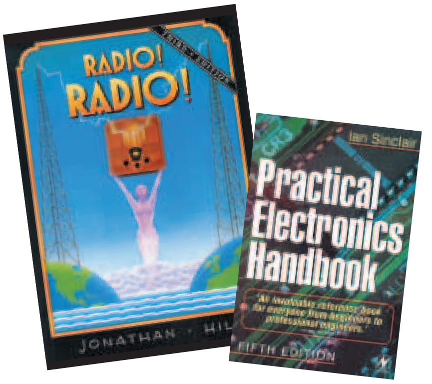
CD-ROM

BEBOP BYTES BACK (and the Bebopuer Computer Simulator) CD-ROM
Clive (Max) Maxfield and Alvin Brown



This follow-on to *Bebop to the Boolean Boogie* is a multimedia extravaganza of information about how computers work. It picks up where "Bebop I" left off, guiding you through the fascinating world of computer design . . . and you'll have a few chuckles, if not belly laughs, along the way. In addition to over 200 megabytes of mega-cool multimedia, the CD-ROM contains a virtual microcomputer, simulating the motherboard and standard computer peripherals in an extremely realistic manner. In addition to a wealth of technical information, myriad nuggets of trivia, and hundreds of carefully drawn illustrations, the CD-ROM contains a set of lab experiments for the virtual microcomputer that let you recreate the experiences of early computer pioneers. If you're the slightest bit interested in the inner workings of computers, then don't dare to miss this!
Over 800 pages in Adobe Acrobat format

CD-ROM **Order code BEB2 CD-ROM** **£21.95**



RADIO! RADIO! (Third Edition)
Jonathan Hill

A celebration in words and pictures of the development of the British wireless set from it's experimental beginnings in Victorian England, to the foundation of a domestic wireless manufacturing industry and the inception of broadcasting in the early 1920's. The story continues on throught the design-conscious 1930's (where the radio really came into it's own as a piece of furniture), to the war-torn and austere days of the 1940's.

The first transistor radios began to appear in the second half of the 1950s and in this new edition, this rather neglected area has been fully covered by a section all of it's own which includes a directory listing of nearly 3,000 different transistor models. The book finishes after the 1960s, by which time our long established and once great radio industry had all but been destroyed by foreign imports.

Now with 320 pages and over 1,000 illustrations, informative captions and carefully researched text *Radio! Radio!* is the first and still the only truly comprehensive book of its kind ever to be published.

320 pages (A4 Hardback) **Order code RR1** **£40.95**

GETTING THE MOST FROM YOUR MULTIMETER
R. A. Penfold

This book is primarily aimed at beginners and those of limited experience of electronics. Chapter 1 covers the basics of analogue and digital multimeters, discussing the relative merits and the limitations of the two types. In Chapter 2 various methods of component checking are described, including tests for transistors, thyristors, resistors, capacitors and diodes. Circuit testing is covered in Chapter 3, with subjects such as voltage, current and continuity checks being discussed.

In the main little or no previous knowledge or experience is assumed. Using these simple component and circuit testing techniques the reader should be able to confidently tackle servicing of most electronic projects.

96 pages **Order code BP239** **£5.49**

DIGITAL GATES AND FLIP-FLOPS
Ian R. SInclair

This book, intended for enthusiasts, students and technicians, seeks to establish a firm foundation in digital electronics by treating the topics of gates and flip-flops thoroughly and from the beginning.

No background other than a basic knowledge of electronics is assumed, and the more theoretical topics are explained from the beginning, as also are many working practices. The book concludes with an explanation of microprocessor techniques as applied to digital logic.

200 pages **Order code PC106** **£9.95**

OPERATIONAL AMPLIFIER USER'S HANDBOOK
R. A. Penfold

The first part of this book covers standard operational amplifer based "building blocks" (integrator, precision rectifier, function generator, amplifiers, etc), and considers the ways in which modern devices can be used to give superior performance in each one. The second part describes a number of practical circuits that exploit modern operational amplifiers, such as high slew-rate, ultra low noise, and low input offset devices. The projects include: Low noise tape preamplifier, low noise RIAA preamplifier, audio power amplifiers, d.c. power controllers, opto-isolator audio link, audio millivolt meter, temperature monitor, low distortion audio signalgenerator, simple video fader, and many more.

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